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CURRENCY SUBSTITUTION IN BOLIVIA

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by

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I. INTRODUCTION

Currency substitution is defined as the use of multiple currencies as a medium of exchange by domestic residents. Many developing countries, in particular in Latin America, have been subject to currency substitution in the last two decades.

The literature on currency substitution for developed countries (see for example McKinnon (1985), Miles (1978)) assume that currencies are reciprocally demanded, that is to say that the currency substitution is symmetric among these countries.

However, taking into account the lack of development of the developing countries financial markets, unstable macroeconomic environment (especially their previous inflationary history) and their principal trade-partners, the currency substitution phenomenon for these countries is different. It turns out to be asymmetrical because domestic residents are willing to include foreign currency assets in their portfolios but overseas agents do not demand domestic currency in theirs. In addition, in these countries foreign currency acts not only as mean of exchange but also as unit of account and as store of value, in Latin American countries this phenomenon is known as dollarization.

Many factors have influenced Latin American residents to use American Dollars instead of other foreign currencies. First, because of the importance of the United States as trade-partner, most of the international trade invoices are denominated in American Dollars. Second, since geographically USA is the closest developed country, it has enormous political and economical influence on internal policies of Latin American countries. Finally, as pointed out by Savastano (1992), institutional factors caused by internal economic policies have played an important role in the dollarization process in Latin America, namely, American Dollar deposits were allowed more than once in these countries as an economic policy tool in order to avoid capital flight.

The effects of currency substitution on monetary and exchange rate policy have been widely analyzed in the literature e.g. Calvo and Rodriguez (1977), Gitron and Roper (1981), Cuddington (1989) and Calvo and Vegh (1992) but there are still some issues unsolved, especially for Latin American countries where successful stabilization programs have been carried out but have exacerbated currency substitution rather than mitigate it. That is the case of Bolivia.
Located in the heart of South America, Bolivia has experienced and stopped two hyperinflations in the last forty years. The first took place in 1954-1956 and the second in 1984-1985. The latter reached an inflation rate of 21,000 percent (annual rate from August 1984 to August 1985) and it is one of highest in the world and the only one in our century that did not result from the dislocations of war or revolution. As a result of the stabilization program implemented in August 1985, the average inflation rate in the last ten years is about 13%.

However, foreign currency deposits increased in the post stabilization period from SUS. 185 millions in January 1987 to SUS. 2,131 millions in December 1996. This fact suggests a closer examination of the Bolivian case in order to uncover the real factors that influence the currency substitution process in this country.

Previous research suggest that Bolivia’s dollarization is driven by inertial factors and is irreversible. Clements and Schwartz (1993) using a partial adjustment model and monthly data found that the degree of inertia, measured by the dollarization proxy variable lagged one period, is statistically more significant than economic variables during the period January 1986 to September 1991. Guidotti and Rodriguez (1992) using the Engle-Granger Cointegration test with quarterly data for the period 1986 to 1990, did not find cointegration between the dollarization proxy variable and the inflation differential (Bolivia-USA), they argue that the dollarization displays hysteresis and shocks to the level of dollarization have permanent effects while shocks to the inflation differential are of a transitory nature.

The aim of this paper is to address the factors that drive dollarization in Bolivia using a different theoretical and empirical approach than previous work. Based on the dynamic optimization approach and using Johansen-Juselius cointegration procedure, we find that in the long run the real exchange rate is an important variable explaining the Bolivian dollarization process and that real depreciation of the exchange rate encourages currency substitution even under stability.

This Dissertation is divided into four sections. Following this Introduction, the second section explores the source of the problem and reviews the theoretical and empirical approaches used to address the currency substitution phenomenon. Section two concludes with a brief discussion about currency substitution in Latin America. The third section explains briefly the Bolivian currency substitution
process in the period 1987-1996, formulates an analytical model and presents empirical results. In the last section we present some conclusions.

II. LITERATURE REVIEW

II. 1 THE BEGINNING OF THE PROBLEM

The collapse of the Bretton Woods fixed exchange system and advent of generalized floating of currencies in the early 1970s are the starting points of what is known as currency substitution.

During the gold standard there was no reason to substitute between national currencies so long as there was a commitment to back them with gold, that is currencies were perfectly substitutable on the supply side.

After the second World War the Bretton Woods system was set up (also known as the gold exchange standard), in this system each of the member countries defined its currency relative to gold. Nevertheless, only the U.S. dollar was committed to converting into gold because of its predominant international medium of exchange and store of value at that time.

This system collapsed in the early 1970s and was followed by generalized floating of exchange rates which were not tied to any externality. Since that time, the international monetary system has been based on a fiat money rather than a commodity standard.

At the same time, international trade was increasing in the global economy and many changes in the financial world were occurring, e.g., financial deregulations and new financial instruments which together with the floating system allowed for a reduction in portfolio risk and encouraged diversification.

This phenomenon also included location diversification, that is to say capital movements from one country to another were observed and people started to get used to it and to operating in different currencies to settle transactions. It may be said that the internationalization of the financial system caused the portfolio diversification and the currency substitution phenomenon.
The consequences of currency substitution for monetary and exchange rate policy are many. First, when residents of a country demand foreign currency, inflation tax and seigniorage are reduced since people can avoid this tax by substituting their domestic currency demand for foreign currency. A positive consequence of currency substitution is that it forces a country to improve its fiscal position. Second, the stability of the demand for domestic money is altered, for similar reasons it is now more difficult for the monetary authority to achieve monetary targets as well as to calculate the demand for money because of portfolio diversification.

Moreover, if the demand for domestic currency is strongly influenced by foreign variables and even if the monetary authority is following a consistent monetary-exchange rate policy, the domestic economy will endure instability “imported” from abroad. Third, when there are free capital movements and a free floating system, reallocations of currencies undermine the independence of the exchange rate policy and domestic monetary policy (Miles 1978), that is to say that under this international monetary system there is interdependence among nations.

Monetary policy will be ineffective in a country where foreign currencies are regarded as good substitutes for domestic currency.

II.2 ABOUT THE CONCEPT OF CURRENCY SUBSTITUTION

The precise concept and definition of what is known as currency substitution is still unresolved and there is little literature about this theoretical problem. Nevertheless, McKinnon (1985), Cuddington (1989), Calvo and Vegh (1992) and Giovannini and Turtelboom (1994) give some useful insights.

McKinnon proposes two concepts of currency substitution: direct and indirect currency substitution. The former applies when two (or more) currencies compete as a means of payment and people switch between domestic and foreign currency. The latter occurs when domestic residents attempt to become more (less) liquid and agents switch between non monetary financial assets denominated in different currencies and currency (notes and coins).

These concepts allow us to distinguish between demand for currency and demand for any other asset which yields interest. People can exchange domestic currency for foreign currency and then foreign currency for asset A (eg. gold or bonds).
it would be difficult to distinguish each stage. In other words, the relation domestic currency - foreign currency - asset in foreign currency can take place in a very small fraction of time so that to distinguish when we are facing a direct or indirect currency substitution would be complex. In particular, this problem arises in empirical work where the researcher faces a constraint in statistical information.

On the other hand, in Cuddington (1989) and Calvo and Rodriguez (1977) the concept of currency substitution is used not only when there is a switch between currency and assets but also and primarily to refer to the switching between domestic and foreign currencies. They distinguish this concept from the term capital mobility which is used when there is a switch between domestic and foreign interest-bearing assets.

Figure No. 1

```
I. Domestic Currency
   CS
   DCS
   CS
   CM
   II. Foreign Currency

III. Domestic Assets (interest-bearing)
   III. Foreign Assets (interest-bearing)

where:
DCS = Direct Currency Substitution (McKinnon)
ICS = Indirect Currency Substitution (McKinnon)
CS = Currency Substitution
CM = Capital Mobility
```

Figure 1 helps to understand the differences between these two approaches. According to McKinnon movements from I to II (or vice versa) should be regarded as direct currency substitution and movements from II to IV (or vice versa) indirect currency substitution. On the other hand, for
Cuddington and Calvo and Rodriguez, only movements from I to II and from I to IV should be considered as currency substitution, and movements from III to IV are capital mobility.

Besides this, Giovannini and Turtelboom (1994) argue that the concept “substitution” is not sufficiently accurate to describe the problem, and they introduce a differentiation between “currency substitution” and “currency substitutability”. Currency substitution occurs when there is complete replacement of one currency by another, and currency substitutability takes place when one currency becomes a substitute of another one, but does not completely replace it. They stress the fact that currencies are substitutable but not substituted, thus, two currencies may be substitutes but the residents may prefer to hold only one currency. In this case both currencies are substitutable but not substitutes. To put it simply, substitutability is the capability of a currency to be exchanged by another but substitution is the act of replacement.

In addition, it is important to distinguish between symmetrical and asymmetrical currency substitution. In most empirical and theoretical papers about currency substitution in developed countries it is assumed that the domestic currency is also demanded by the other country, however, this is not the case for developing countries where an asymmetrical currency substitution occurs, that is, domestic agents demand foreign currency but foreign agents do not demand domestic money reciprocally.

On the other hand, it is important to realize that domestic residents may hold foreign money simply because they need it for tourism, international trade or other common transactions. The demand for foreign currency which goes beyond the necessities of these transactions, is a particular case of currency substitution, known as dollarization in Latin America, and it is the subject of this paper.

For empirical purposes, holdings of foreign money should cover foreign deposits in the domestic financial system, foreign currency held abroad by domestic residents and foreign notes and coins circulating within the home country’s boundaries but data is often not available on all of these.

1 This replacement occurs in the three traditional roles of money: transactions, unit of account and store of value.
II.3 THEORETICAL AND EMPIRICAL MODELS OF CURRENCY SUBSTITUTION

II.3.1. Theoretical Models.- Following Giovannini and Turtelboom (1994) theoretical models of currency substitution can be classified into three categories: Cash-in-advance models, transaction-cost models and ad-hoc models. In the following sections, we carry out a brief review of the first two models.

II.3.1. A) Cash-in-advance Models

In the cash-in-advance models, agents maximize their utility function subject to a budget constraint and cash-in-advance constraints which bind all the time and do not allow any substitution between currencies for consumption purposes. These models assume that agents do not accumulate any asset, prices of goods are determined in the goods market and the quantity equation for money holds.

In these models, currency substitution only appears when agents demand foreign goods and/or domestic goods are demanded by other countries, that is to say currency substitution is an indirect effect caused by consumption which derives from the way the two goods enter the representative agent’s utility function. These models assume that consumption of both the domestic good and the foreign good are included in the utility function so that their marginal rate of substitution is equal to their relative prices.

\[
\frac{eP^*}{P} = \frac{dU}{dC} = \frac{dU}{dC^*}
\]

Assuming constant elasticity of substitution, these models show how an increase in domestic output causes an increase in money demand which in turn calls for an appreciation of domestic currency.

Bearing in mind that the quantity equation holds, the increase in prices due to the increase in domestic output also affects relative prices, but the latter effect can be diminished by the elasticity of substitution. The larger the elasticity of substitution the smaller the change in their relative price in response to a change in output.

Currency substitution becomes more evident when the two goods are more substitutable, namely, when agents demand more and more foreign goods they demand more and more foreign currency to purchase them.
These models shed light about what determines the substitutability of two currencies but they do not explain how these currencies can work as store of value.

II.3.1.B) Transactions Costs Models.-

In contrast to cash-in-advance models, transactions costs models allow substitution between currencies and agents can hold not only money but also financial assets, so that the consumer’s problem is to maximize his utility function subject to a budget constraint in which foreign currency as well as foreign assets are included.

As pointed out by Giovannini and Turtelboom (1994) these models assume that money facilitates purchases of goods. In addition, in every period agents need to acquire the cash balances they plan to use next period for goods purchases, that is to say that money is more liquid than the other assets.

The first order conditions that come out by solving the representative agent’s problem give the main features of these models. First, the demand for domestic and foreign currency is determined by their expected liquidity services (represented by the partial derivative of the liquidity function with respect to the real money stock). Second, agents trade off money and other assets in their portfolio by comparing their expected returns. Third the presence of liquidity costs induces a wedge between the marginal rate of substitution of the two goods (domestic and foreign) and the real exchange rate. Overall, these models show the determinants of the demand for different currencies as stores of value.

This fact is important for our purposes because in developing countries like Bolivia, where the financial markets are underdeveloped, the liquidity services of money are quite significant and foreign currency may become a good substitute for domestic currency as a store of value.

II.3.2. Empirical Models.-

Most of the empirical literature about currency substitution is based on the theoretical models reviewed in the last section. However according to their particular features, empirical literature can be divided

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3 In the Bolivian case of currency substitution, American dollars have been used as a store of value as well as a medium of exchange.
4 See for example Poloz (1984).
into three groups: the portfolio balance approach (unrestricted), the money services approach (restricted) and the dynamic optimization problem.

II.3.2. A Portfolio Balance Approach.

This approach was developed based on the seminal paper of Tobin (1958) for assets demand in a closed economy and the transaction costs models. It emphasizes the demand for money for precautionary purposes and currency is viewed as a substitute for any other asset.

Branson and Henderson (1985) and Zervoyiani (1992), among others\(^5\), use this approach to model currency substitution, assuming that agents maximize returns of their wealth subject to a given level of risk but where domestic currency is riskless.

The portfolio balance approach is unrestricted in the sense that agents can hold four different assets\(^6\) and switch among them simultaneously.

As long as interest rates (domestic and foreign) increase (decrease) and as long as inflation (domestic and foreign) increase (decrease), bonds become more (less) attractive relative to money, thus, agents would hold relatively more (less) bonds in their portfolio\(^7\).

For empirical purposes, we can write the asset demand system for a resident agent in a log linear form assuming that he holds two domestic and two foreign assets. Some papers measure the relative returns on domestic and foreign currency by the expected inflation differential between the two currencies, in the following equations the forward exchange rate is used.

\[
\log\left(\frac{M}{P}\right) = \alpha_0 + \alpha_1 \log Y + \alpha_2 i + \alpha_3 (i*+e^*) + \alpha_4 e^* \quad (i)
\]

\[
\log\left(\frac{eM^*}{P^*}\right) = \beta_0 + \beta_1 \log Y + \beta_2 i + \beta_3 (i*+e^*) + \beta_4 e^* \quad (ii)
\]

\[
\log\left(\frac{B}{P}\right) = \gamma_0 + \gamma_1 \log Y + \gamma_2 i + \gamma_3 (i*+e^*) + \gamma_4 e^* \quad (iii)
\]


\(^6\) Usually, these assets are domestic and foreign currency and domestic and foreign bonds.

\(^7\) The rate of return on foreign bonds is the rate of interest plus the expected depreciation of the domestic currency.
\[ \log \left( \frac{eB^*}{p^*} \right) = \delta_0 + \delta_1 \log Y + \delta_2 i + \delta_3 (i^* + e^*) + \delta_4 e^* \]  

(iv)

where:  
\[ \alpha_i > 0 ; \alpha_2, \alpha_3, \alpha_4 < 0 \]
\[ \beta_1, \beta_2 > 0 ; \beta_3, \beta_4 < 0 \]
\[ \gamma_1, \gamma_2 < 0 ; \gamma_3, \gamma_4 > 0 \]
\[ \delta_1, \delta_2 < 0 ; \delta_3, \delta_4 > 0 \]

and

- \( M \) = Domestic money
- \( M^* \) = Foreign money
- \( B \) = Domestic bonds
- \( B^* \) = Foreign bonds
- \( P \) = Domestic prices
- \( P^* \) = Foreign prices
- \( Y \) = Domestic output
- \( i \) = Domestic interest rate
- \( i^* \) = Foreign interest rate.
- \( e^* \) = Expected change in the exchange rate
- \( e \) = Nominal exchange rate

From the point of view of the domestic resident, currency substitution would be reflected in the coefficient \( \alpha_4 \) which is expected to be negative since an increase in the expected exchange rate will bring about a reduction in domestic currency demand, that is to say the degree in which domestic currency is replaced with foreign currency in response to a change in their relative rate of return. Thus, many empirical works only estimate the first equation to estimate the coefficient of currency substitution.

Notice that an increase in the domestic interest rate raises the demand for domestic bonds but at the same time lowers the demand for their substitutes in the agent's portfolio.

These equations also help us to illustrate the concepts of currency substitution discussed earlier. The indirect currency substitution proposed by McKinnon is reflected in the coefficients \( \gamma_3 \) and \( \delta_2 \) since they mirror changes in the foreign interest rate relative to holdings of domestic and foreign assets; on the other hand, \( \alpha_4 \) is the coefficient which reflects the a part of the concept of currency substitution for Calvo and Rodriguez (1977) and Cuddington (1983).^8

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^8 In section II.2 we pointed out that for these authors, currency substitution is not only the exchange between domestic and foreign currency but also it is the exchange from domestic currency to foreign assets.
However, notice that this model does not take into account the demand for foreign currency for trade transactions motives and it is difficult to estimate when researchers face a constraint in statistical information. Moreover, this approach does not allow us to distinguish between currency substitutability and capital mobility and it assumes that financial markets are well developed which is not applicable to developing countries.

Finally, in order to assess currency substitution, empirical works only estimate equation (i) in which is difficult to distinguish between $\alpha_3$ and $\alpha_4$.

II.3.2.B The Money Services Approach. 

This approach is based on a two stage decision framework, where in the first stage agents divide their wealth between liquid and non-liquid assets and in the second stage agents divide each of these two portfolios between other currencies and assets respectively. In this sense the model is restricted with respect to the Portfolio Balance Approach where agents could change currency and assets freely from the beginning of the process. This approach is also known as the sequential portfolio balance approach.¹

Addressing the problem of monetary independence under flexible and fixed exchange rate regimes, Miles (1978) using an homothetic constant elasticity of substitution (CES) production function for the services of money, derives a model of currency substitution which is tested empirically for the Canadian case. In this paper Miles makes use of the static optimization technique in order to maximize the representative agent’s demand for money.

Also in this paper, Miles discusses the problem that arises using a Cobb-Douglas money demand function arguing that it constrains the elasticity of substitution to one. He argues that the most important question in empirical work is the estimation of this elasticity, and specifies the following money services production function:

$$\frac{MS}{P_d} = \left[ \alpha_1 \left( \frac{M_d}{P_d} \right)^{-\rho} + \alpha_2 \left( \frac{M_f}{P_f} \right)^{-\rho} \right]^{\frac{1}{\rho}}$$

where: $MS = \text{Level of money services}$
$M_d, M_f = \text{Domestic and Foreign currency}$

¹ See for example Giovannini and Turtelboom (1994).
\[ P_d, P_f \quad = \quad \text{Domestic and Foreign currency prices} \]
\[ \alpha_1, \alpha_2 \quad = \quad \text{Weights reflecting the efficiency of domestic and foreign real balances in producing money services.} \]

This money services function is maximized subject to the following asset constraint:

\[ \frac{M_o}{P_d} = \frac{M_d}{P_d}(1 + i_d) + \frac{M_f}{P_f}(1 + i_f) \]

where: \( M_0 = \text{Desired level of money services fixed in the first stage.} \)

\( i_d, i_f = \text{domestic and foreign interest rates} \)

Agent allocates money between the two currencies depending on their relative opportunity costs and their relative efficiency in providing money services.

Solving this problem, taking logarithms of both sides, rearranging terms and adding a disturbance term, Miles arrives at the following estimating equation:

\[ \log \frac{M_d}{eM_f} = \frac{1}{1 + \rho} \log \left( \frac{\alpha_1}{\alpha_2} \right) + \frac{1}{1 + \rho} \log \left( \frac{1 + i_f}{1 + i_d} \right) + u \]

This functional form allows the direct estimation of the elasticity of substitution between domestic and foreign currency \( (\sigma = \frac{1}{1 + \rho}) \) and the ratio of the coefficients \( \alpha_1 \) and \( \alpha_2 \).

In his empirical work for Canada, Miles found that foreign and domestic currencies are substitutes and that the Cobb-Douglas is not the proper money services production function.

In spite of that, this model is not able to distinguish empirically between capital mobility and currency substitution, for example a rise in the foreign interest rate \( (i_f) \) not only may lead to an increased demand for domestic money \( (M_d) \) but also for foreign money \( (M_f) \) since bond prices are expected to fall. In addition, it has two other limitations, demand for money in this model does not depend on output and it assumes that parity purchasing power holds all the time.

Also, using the static optimization technique, Miles constrains agent's consumption and therefore money demand decisions to one period, omitting the fact that agents can switch between currencies and bonds over time.
II.3.2. C The Dynamic Optimization Approach

These models use the dynamic optimization technique to maximize a representative agent’s utility function subject to flow and stock constraints.

This approach is based on transaction costs models and it assumes that domestic and foreign currency facilitate the transactions that are required for consumption, that is, it emphasizes the demand for money as a medium of exchange. See for example Milner, et al (1996).

It is assumed that an agent maximizes his utility function subject to real asset stock and asset accumulation constraints. One important feature of the dynamic optimization approach is that the services of money do not appear directly in the utility function.

The representative agent problem is

Maximize $U = \int_0^\infty u(c_t)e^{-\delta t} dt$

subject to:

$$\alpha = \frac{M_d}{P_d} + S^* \frac{M_f}{P_d} + \frac{B_d}{P_d} + S^* \frac{B_f}{P_d}$$

and

$$\frac{da}{dt} = y - c \left[ 1 + V \left( m, \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi, \theta \right) \right) \right] - \pi_d \left( \frac{M_d}{P_d} \right) + \left( \varepsilon - \pi_d \right) \frac{SM_f}{P_d} + \left( r_d - \pi_d \right) \frac{B_d}{P_d} + \left[ \varepsilon (1 + r_f) + r_f - \pi_d \right] \frac{SB_f}{P_d}$$

where:

$c_t =$ real consumption

$U =$ Utility function

$\delta =$ Discount factor

$\alpha =$ Total assets

$y =$ Real income

$M_d =$ Nominal holding of domestic money

$M_f =$ Nominal holding of foreign money

$P_d =$ Domestic price level

$P_f =$ Foreign price level

$\pi_d =$ domestic inflation rate

$r_d =$ domestic interest rate

$r_f =$ foreign interest rate

---

10 Since we take this approach to analyze the dollarization problem in Bolivia, this approach is developed in detail in the mathematical appendix.
\( \varepsilon \) = expected rate of depreciation
\( \phi \) = Factors influencing the choice of relative money holdings (such as trade)
\( \theta \) = technological and institutional factors that affect the level of money services

Solving this optimizing problem, assuming a CES money services function, rearranging terms and taking logarithms gives the following estimating equation:

\[
\log\left( \frac{M_d}{SM_f} \right) = \sigma \log\left( \frac{\beta_1}{\beta_2} \right) - \sigma \log\left( \frac{P_d}{SP_f} \right) - \sigma \log\left( \frac{r_d}{r_f(1+\varepsilon)} \right)
\]

where:

\[
\sigma = \frac{1}{1+\rho} \quad \text{the elasticity of currency substitution.}
\]

Similarly to the money services approach, it is assumed that it is possible to measure the degree of currency substitution either by the real exchange rate or by the uncovered interest rate.

However, this approach does not allow to distinguish currency substitution from capital mobility.

Moreover, the dynamic optimization model assumes that the uncovered interest parity hold and income does not appear in the estimating equation as the scale variable for money demand.

II.4 CURRENCY SUBSTITUTION IN LATIN AMERICA

The pattern of currency substitution in Latin America is related to macroeconomic policies and institutional framework. Furthermore, an important feature of the process of currency substitution in some Latin American countries is the absence of restrictions on maintaining foreign currency deposits in their domestic financial system. These were allowed by monetary authorities in order to improve the external position of the central banks, strengthen domestic financial intermediation and encourage the repatriation of capital that had flown from these countries previously. These policy measures were adopted after the collapse of the Bretton Woods system and bestow on the private sector a new and alternative financial asset.

Indeed, these economies do not have well developed financial markets offering a rich set of liquid and high yield instruments denominated in domestic currency as an alternative to foreign assets.
According to Savastano (1992)\textsuperscript{11}, the consent to the private sector to hold foreign currency deposits in their domestic financial systems in the 1970’s was accompanied by a nominal devaluation which increased the amount of foreign currency assets by domestic agents\textsuperscript{12}.

Nevertheless, in the early 1980s when these countries faced macroeconomic imbalances and new political processes, these policy measures were reversed and monetary authorities de facto converted into domestic currency all foreign currency deposits held by the private sector, these new measures were also accompanied by foreign exchange controls and large nominal devaluations\textsuperscript{13}.

Years later, as a consequence of the implementation of successful stabilization programs in these countries\textsuperscript{14}, foreign currency deposits were allowed again as a part of the whole program. In spite of that, the process of currency substitution still remains regardless of low inflation rates and a relatively stable and favorable macroeconomic environment.

One answer to this problem was given by Guidotti and Rodriguez (1992) who argue that dollarization in Latin America arises from competition between different currencies and the financial liberalization process implemented during the 1970s and 1980s. They found a significant fall in real balances in countries where currency substitution was observed\textsuperscript{15}, which together with the dollarization process, are unrelated to changes in inflation or interest rates. That is, they argue for a hysteresis in the dollarization process in Latin America.

In addition, the elimination of foreign exchange controls and the license granted to residents to hold foreign currency have allowed dollarization to expand from its traditional role of store of value to that of unit of account and of medium of exchange.

\textsuperscript{11} In this paper the author analyzes the cases of dollarization in Bolivia, Mexico, Peru and Uruguay up to 1986 and emphasizes on institutional factors, stability of money demand and exchange rate regimes.

\textsuperscript{12} In Bolivia all restrictions on the domestic holding of foreign currency deposits were eliminated in October 1973. Mexico did the same in March 1977; Peru did in 1978 and Uruguay in October 1974.

\textsuperscript{13} In Bolivia this took place in November 1982, in Mexico in August 1982 and Peru in July 1985. Uruguay is the exception.

\textsuperscript{14} Bolivia in August 1985, Peru in December 1990, Mexico late 1980s.

\textsuperscript{15} Guidotti and Rodriguez (1992) analyze the cases of Bolivia, Mexico, Peru and Uruguay. In all of them using Dickey-Fuller and Engle-Granger test they found out unit roots in the dollarization proxy and no cointegration with inflation differential.
What is being discussed under the heading of dollarization as a economic policy issue in Latin America is the survival of national monies in the face of the competitive challenge posed by other “superior” currencies such as the dollar which in all the cases has shown to be preferred by domestic residents as a store of value.

In empirical works about currency substitution in Latin America such as Ortiz (1983), Ramirez-Rojas (1985) and Clements and Schwartz (1993) the ratio of domestic money to foreign currency deposits is used as a proxy for currency substitution, and we follow the same practice.

III CURRENCY SUBSTITUTION IN BOLIVIA

III.1 BRIEF RECENT ECONOMIC PERFORMANCE.

Bolivia succeeded in controlling inflation by carrying out an orthodox stabilization program in August 1985 which is lauded as one of the most successful of all time. One of the most important objectives of this plan was to eliminate the fiscal deficit.

The principal measures taken in this program were: increase in public sector prices, tax reform aimed at reestablishing the tax base, freezing of public sector wages, reduction of the public sector, exchange rate adjustment (which meant a strong devaluation of the domestic currency) and switch to a crawling peg regime together with daily dollar auctions in the Central Bank and free market prices.

As pointed out in the previous section, the stabilization program authorized foreign currency deposits in the financial system and free transactions in foreign money neither of which were not allowed before.

As a result of the stabilization program, the fiscal deficit was reduced from 30.6% (as a percentage of GDP) in 1984 to about 1.5% on average over the last ten years, which demanded a forceful fiscal discipline. What is more, for the last eleven years Bolivia has experienced some of the lowest inflation rates in Latin America and a moderate recovery of output. In 1996 the average inflation for Latin American countries rate was 19.3% while Bolivia registered only 8%.

Table 1

<table>
<thead>
<tr>
<th>Years</th>
<th>GDP Growth</th>
<th>Fiscal Deficit(*)</th>
<th>Inflation</th>
<th>Exchange</th>
<th>Nominal Interest Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>2.6</td>
<td>+0.66</td>
<td>14.6</td>
<td>2.2</td>
<td>18.98</td>
</tr>
<tr>
<td>1988</td>
<td>2.9</td>
<td>-0.67</td>
<td>16.0</td>
<td>2.5</td>
<td>18.95</td>
</tr>
<tr>
<td>1989</td>
<td>3.8</td>
<td>-1.32</td>
<td>15.2</td>
<td>3.0</td>
<td>18.98</td>
</tr>
<tr>
<td>1990</td>
<td>4.6</td>
<td>-1.69</td>
<td>17.1</td>
<td>3.4</td>
<td>18.95</td>
</tr>
<tr>
<td>1991</td>
<td>5.3</td>
<td>-0.06</td>
<td>21.4</td>
<td>3.7</td>
<td>17.60</td>
</tr>
<tr>
<td>1992</td>
<td>1.7</td>
<td>-2.04</td>
<td>12.1</td>
<td>4.1</td>
<td>21.78</td>
</tr>
<tr>
<td>1993</td>
<td>4.3</td>
<td>-1.86</td>
<td>8.5</td>
<td>4.5</td>
<td>18.40</td>
</tr>
<tr>
<td>1994</td>
<td>4.6</td>
<td>-3.11</td>
<td>7.9</td>
<td>4.7</td>
<td>14.81</td>
</tr>
<tr>
<td>1995</td>
<td>3.3</td>
<td>-2.03</td>
<td>12.6</td>
<td>4.9</td>
<td>20.42</td>
</tr>
<tr>
<td>1996</td>
<td>3.9</td>
<td>-2.10</td>
<td>8.0</td>
<td>5.2</td>
<td>15.54</td>
</tr>
</tbody>
</table>

Source: International Financial Statistics (IMF) and Central Bank of Bolivia.  
(*) As percentage of GDP

As shown in Table 1, the average inflation rate in the last 10 years is about 13% and in 1993, 1994 and 1996 Bolivia enjoyed a single digit inflation rate. Besides the fluctuation in the early 1990s, which was basically caused by adjustments in internal petrol prices and drought, in general Bolivia reveals a decreasing tendency in inflation. The percentage of fiscal deficit with respect to GDP is within the standard macroeconomic parameters of stability, thus during the period 1987-1996 it was not greater than 3.1%.

On the other hand, with exception of 1992 which was a peculiar year because of the previous year’s drought, during the period 1987-1996 the growth rate showed a slow recovery and it seems that it is achieving its steady state rate. The figures in Table 1 contrast with the deep recession in Bolivia in the early 1980s.

The exchange rate policy has not changed since the stabilization program was implemented, that is to say the Central Bank follows a crawling peg regime where the exchange rate is determined by daily public auctions where agents can buy dollars freely through the banking system. This policy was aimed at achieving a real effective exchange rate in order to encourage domestic exports.

III.2 DOLLARIZATION IN BOLIVIA

In spite of the auspicious macroeconomic environment achieved by the stabilization program, the currency substitution problem, to be precise the dollarization, has increased over this period.

The analysis of currency substitution generally has assumed that causality runs from economic instability, namely high rates of inflation and large exchange rate devaluation, to currency substitution.
However, at least for the Bolivian case, macroeconomic stability was not sufficient to stop the dollarization process, moreover, it seems that low inflation encourages it.

Figure 2 shows the evolution in the period 1987-1996 of the ratio Quasi Money denominated in dollars to total Quasi Money (bolivianos and dollars). It can be seen from the graph that from about 50% in January 1997 this ratio rises to 70% in December 1996, an increase of twenty percentage points over this period.

In the sub-period January 1987 - October 1989 this ratio shows a gradual rise but in the fourth quarter of 1989 a sharp increase up to 70% and then it remains over this level until December 1996. The expansion in the second quarter of 1989 seems to respond to a rise in the foreign currency deposits interest rate which differed, at that time, from the decreasing international interest rate.

Nevertheless, in the sub-period January 1990 - December 1996 regardless of the reduction in the foreign currency interest rate and inflation, the ratio Foreign Quasi Money/ Total Quasi Money still remains over 70%. As can be seen from Figure 2, this ratio seems to be stationary from 1990 onwards, however, both the ratio and the utilized dollarization proxy can be treated as I(1)\textsuperscript{17}.

The dollarization process in the particular case of Bolivia has advantages and disadvantages for economic policy.

On the one hand, dollarization helped the banking system to recover from the 1984-1985 hyperinflation process, foreign currency deposits increased quickly and banks recovered their role of financial intermediary. Another advantage is that the Bolivian government can collect some revenue from foreign

\textsuperscript{17} See Figure B1 in the econometric appendix.
currency reserve requirements which can be invested in the international financial system. It also encourages fiscal policy to be cautious.

On the other hand, low levels of monetization reduces the seigniorage collected by the government. Also, this high level of dollarization reduces “degrees of freedom” of monetary policy and leaves the economy vulnerable to external shocks. In addition, about 95% of financial system loans are in dollars but borrowers have no secure source of dollar earnings which increases unnecessarily the risk in financial markets.

Thus, there is no doubt about the implications of the dollarization process for the Bolivian economic policy, therefore the following part of this paper will be focused on tracing the factors that cause this process.

In August 1994, the Central Bank of Bolivia used the differential in the interest rate for domestic currency deposits and foreign currency deposits as an economic policy instrument in order to reduce the dollarization in the financial system.

This policy consisted of encouraging deposits in domestic currency by offering treasury bills with higher interest rate in bolivianos than foreign currency. However, according to Figure 2 and Figure B1 in the appendix, this policy had short effects on the public decision of holding domestic or foreign currency.

III.3 THE MODEL

In order to set up an analytical model for the Bolivian currency substitution, we based our model on the transactions cost models and the dynamic optimization money services approach discussed previously. As pointed out in previous section, transactions cost models allow substitution between currencies and takes into account underdeveloped financial markets.

This analytical model helps us to understand the public’s decisions on different currency holdings by telling us the factors that affect currency substitution, and empirical evidence is presented in the next section which is aimed to estimate the proportion of their influence for the Bolivian case.
The dynamic approach has been chosen because under this framework agent's consumption and money demand decisions are intertemporal so that over time agents can switch between money and bonds overcoming the static optimization two-stage-decision framework of the monetary services approach. In addition, relative interest rates and relative prices can influence the relative domestic demand for foreign currency rather than the absolute amount of foreign currency.

Also this approach has been chosen bearing in mind that in Bolivia, the American Dollar is not only used as a store of value but also as medium of exchange. These models explicitly assume demand for money for exchange purposes. The model presupposes that currencies provide the liquidity services which are required as a medium of exchange for purchasing goods. Individuals must pay in the currency of the country from which they are buying goods. Hence a demand for domestic and foreign currency arises.

Simultaneously, demand for domestic and foreign assets is also assumed on which returns are paid in the currency of the country from which they have been bought. Again, demand for domestic and foreign currency arises. Therefore, if there is a net trade deficit between the domestic and foreign country, then an outflow of currency balances is expected which would affect the proportion of domestic currency relative to foreign currency.

However, as it is discussed in the next section, a problem emerges when we use a constant elasticity of substitution as the money services production function, namely, the model does not include any explanatory variable for other factors influencing relative money balances, which, as we will see later, is important for the Bolivian case. This suggests that this model is not fully appropriate.


An infinitely lived agent is assumed to maximize a utility function subject to a money services resource constraint.

A proportion V of total individual's wealth is devoted to obtaining monetary services for transactions.
\[ V = V(m^*, \theta) \quad V_{m^*} < 0 \]  

where \( m^* \) represents the level of money services and \( \theta \) technological and institutional factors that alter the level of money services. The negative partial derivative of \( V \) with respect to the money services implies that \( V \) is a convex function of \( m^* \).

The level of money services \( m^* \) is defined as:

\[ m^* = m^*\left( \frac{M_d}{P_d}, \frac{M_f}{P_d}, \psi, \phi \right) \quad \frac{\partial m^*_{Md}}{\partial P_d} \frac{\partial m^*_{Mf}}{\partial \psi} > 0 \]  

where \( M_d \) and \( M_f \) represent domestic and foreign nominal money balances respectively, \( P_d \) domestic price level, \( \psi \) is a price index and \( \phi \) represents other factors influencing the choice of relative money balances such as the extent of international trade. The choice of the price index depends on whether the agent values foreign money in terms of domestic price level or foreign price level. For simplicity \( \psi = P_f \) is assumed.

The domestic agent's stock of real assets expressed in domestic currency is given by

\[ a = \frac{M_d}{P_d} + S \frac{M_f}{P_d} + B_d + S \frac{B_f}{P_d} \]  

where \( S \) is the exchange rate measured as domestic money per unit of foreign currency, and \( B_d \) and \( B_f \) are holdings of domestic and foreign bonds in prices of each country.

The domestic agent can add to his stock of real assets his current savings or his earnings from domestic and foreign assets holdings. Thus, the asset accumulation equation is given by:

\[ \frac{da}{dt} = y - c \left[ 1 + V\left( m^*\left( \frac{M_d}{P_d}, \frac{M_f}{P_d}, \psi, \phi, \theta \right) \right) \right] - \pi_d \left( \frac{M_d}{P_d} \right) + (\varepsilon - \pi_d) \frac{S M_f}{P_d} \]  

\[ + (r_d - \pi_d) \frac{B_d}{P_d} + \left[ \varepsilon (1 + r_f) + r_f - \pi_d \right] \frac{S B_f}{P_d} \]
where \( \pi_d \) is the domestic inflation rate, \( r_d, r_f \) are domestic and foreign interest rates on assets (bonds), \( y \) is agent’s real income, \( c \) is agent’s real consumption and \( \varepsilon \) is the expected domestic currency rate of depreciation.

The agent’s utility function is given by

\[
U = \int_{0}^{\infty} u(c_t)e^{-\delta t} dt \quad u'(c_t) > 0, u''(c_t) < 0 \quad \text{and} \quad \delta > 0 \tag{5}
\]

where \( \delta \) is the discount factor.

The agent’s problem is to maximize (5) subject to the portfolio constraint (3) and the asset accumulation equation (4).

The resulting first order conditions are:\n
\[
\frac{\partial H}{\partial c_t} = u'(c_t) - q\left[1 + V\left[m^*\left(M_d, \frac{M_f}{P_f}, \phi, \theta\right)\right]\right] = 0 \tag{6}
\]

\[
\frac{\partial H}{\partial a} = -q \pi_d + \lambda = -\dot{q} \tag{7}
\]

\[
\frac{\partial H}{\partial q} = y - c\left[1 + V\left[m\left(M_d, \frac{M_f}{P_f}, \phi, \theta\right)\right]\theta\right] = \dot{y} \tag{8}
\]

\[
\frac{\partial H}{\partial M_d} = -qcV_m\left[m^*\left(M_d, \frac{M_f}{P_f}, \phi, \theta\right)\right]m^*\left(M_d, \frac{M_d}{P_d}, \phi, \theta\right)\left(1 - \frac{\lambda}{P_d}\right) = 0 \tag{9}
\]

\[
\frac{\partial H}{\partial M_f} = -qcV_m\left[m^*\left(M_d, \frac{M_f}{P_f}, \phi, \theta\right)\right]m^*\left(M_f, \frac{M_f}{P_f}, \phi, \theta\right)\left(1 + q \frac{\varepsilon}{P_f} - \frac{\lambda}{P_d}\right) = 0 \tag{10}
\]

\[
\frac{\partial H}{\partial B_d} = \frac{qr_d}{P_d} - \frac{\lambda}{P_d} = 0 \tag{11}
\]

\[
\frac{\partial H}{\partial B_f} = q\left[\varepsilon(1 + r_f) + r_f\right]S - \frac{S\lambda}{P_d} = 0 \tag{12}
\]

where \( q \) is the costate variable associated with the flow constraint and \( \lambda \) is the Lagrangian associated with the stock constraint.
From equation (11) and (12) we arrive at the uncovered interest parity condition

\[ r_d = \delta(1 + r_f) + r_f \]  

(13)

From equations (9), (10) and (13) we get

\[ \frac{m^*_{Md}(\frac{Md}{P_d}, \frac{Mf}{P_f}, \phi)}{m^*_{Mf}(\frac{Md}{P_d}, \frac{Mf}{P_f}, \phi)} = \frac{P_d}{SP_f r_f(1 + \varepsilon)} \]  

(14)

Equation (14) states that the marginal rate of substitution between the domestic and foreign currencies must be equal to the ratio of the opportunity cost of holding domestic currency \((P_d\) and \(r_d\), rather than domestic bonds, to the opportunity cost of holding foreign money \((SP_f\) and \(r_f(1+\varepsilon)\), rather than as foreign bonds.

This equation shows that the marginal utilities of domestic and foreign currencies depends on the real exchange rate and the uncovered interest parity condition.

Assuming an homothetic constant elasticity of substitution (CES) function for money services, taking logs and rearranging we achieve the following equation, as shown in the Appendix:

\[ \log\left(\frac{M_d}{SM_f}\right) = \sigma \log\left(\frac{\beta_1}{\beta_2}\right) + \sigma \log\left(\frac{SP_f}{P_d}\right) + \sigma \log\left(\frac{r_f(1+\varepsilon)}{r_d}\right) \]  

(15)

where \(\sigma = \frac{1}{1 + \rho}\) is the elasticity of substitution.

As equation (14) showed, the purchasing power parity and the uncovered interest parity conditions enter as a multiplicative term and taking logs enables us to split up these effects into two. Under these circumstances we could estimate the currency substitution either by the real exchange rate or the uncovered interest rate differential. However, the interest rate is interrelated with capital mobility so that we are not able to differentiate from currency substitution. This problem was pointed out in the previous section.

\[ \text{For details about the mathematical solution see Appendix A.} \]
Also, another weakness of this model is that if both the uncovered interest parity and the purchasing power parity hold in the long run, then domestic and foreign goods and assets are perfect substitutes. That is we could not estimate currency substitution.

III.4 SPECIFICATION AND EMPIRICAL EVIDENCE

III.4.1 Specification

The specified homothetic CES function for money services does not include any term for the variable φ in equations (2) to (14), therefore, in order to estimate the complete money services function we should include additional variables that might influence holdings of foreign currency.

One possibility would be to include the trade balance as de Vries (1988) suggests, another possibility would be to include income since it is an important determinant of the demand for money. Considering the availability of monthly data for income or a proxy, the imports level is used for the empirical analysis because in the Bolivian case, exporters are required to sell the dollars from their exports to the Central Bank. On the other hand, about 85% of the Bolivian international trade is invoiced in American dollars, therefore imports are an important determinant of the demand for foreign currency.

For empirical purposes, the equation to be estimated is a log-linear functional form for relative money holdings in the following way:

$$
\log \left( \frac{M_d}{SM_f} \right) = \gamma_0 + \gamma_1 \log \left( \frac{SP_f}{P_d} \right) + \gamma_2 \log \left( \frac{r_f(1 + \epsilon)}{r_d} \right) + \gamma_3 \log(IMP) + u 
$$

(16)

where IMP = Imports

$u_i$ = random error term

Notice that the coefficients of the real exchange rate and the uncovered parity condition are different from equation (15) because of the incorporation of the imports variable.

We expect:

---

19 We could think of the variable imports as the scale variable utilized in a demand for money estimation. Also, we could think of a wider money service function other than the homothetic CES, which allows the inclusion of more variables, in the right hand side of the equation, that affect the choice between domestic and foreign currency.
\( \gamma_1 < 0 \) that is, there is a direct relationship between the currency and its price level, thus, an increase in the foreign price level will lead to a rise in holdings of foreign currency relative to domestic currency.

\( \gamma_2 > 0 \) since it represents the relative opportunity cost of holding money rather than bonds, thus, a rise in the foreign interest rate will lead to a fall in foreign money holdings as the agents switch into foreign bonds or into domestic currency which now has lower opportunity cost.

\( \gamma_3 < 0 \) that is to say, that the elasticity of relative money holdings with respect to imports is negative.

Because of the unavailability of information, American dollar deposits in Bolivian banks are used as a proxy for foreign currency demand. Under these circumstances, all the estimation work underestimates the Bolivian currency substitution process because cash holdings and foreign currency deposits held abroad by Bolivian residents are not taken into account.

III.4.2 Unit Root Test.

Table 2 shows the test of unit roots carried out in order to know the order of integration of the variables. The Dickey Fuller and the Augmented Dickey-Fuller test indicate that the variables can be treated as I(1) without trend.

<table>
<thead>
<tr>
<th></th>
<th>( \log \left( \frac{M_d}{SM_f} \right) )</th>
<th>( \log \left( \frac{SP_f}{P_d} \right) )</th>
<th>( \log \left( \frac{r_f(1+e)}{r_d} \right) )</th>
<th>( \log(IMP) )</th>
<th>Crit. Values at 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Levels</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \phi_1 )</td>
<td>2.32</td>
<td>5.08</td>
<td>5.34</td>
<td>4.63</td>
<td>6.49</td>
</tr>
<tr>
<td>( \phi_2 )</td>
<td>1.98</td>
<td>3.72</td>
<td>3.68</td>
<td>3.86</td>
<td>4.88</td>
</tr>
<tr>
<td>( \tau_r )</td>
<td>-1.85</td>
<td>-2.75</td>
<td>-3.27</td>
<td>-2.90</td>
<td>-4.04</td>
</tr>
<tr>
<td><strong>Differences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \phi_1 )</td>
<td>22.40</td>
<td>14.83</td>
<td>17.09</td>
<td>37.20</td>
<td>6.49</td>
</tr>
<tr>
<td>( \phi_2 )</td>
<td>15.00</td>
<td>9.90</td>
<td>11.43</td>
<td>24.80</td>
<td>4.88</td>
</tr>
<tr>
<td>( \tau_r )</td>
<td>-6.67</td>
<td>-5.44</td>
<td>-5.70</td>
<td>-8.65</td>
<td>-3.45</td>
</tr>
</tbody>
</table>

\( \phi_1 \) is the ADF statistic from \( \Delta Y_t = \alpha + \beta t + \rho Y_{t-1} + \Sigma \Delta Y_{t-1} + e_t \) testing \( \beta = 0, \rho = 0 \)

\( \phi_2 \) is the ADF statistic from \( \Delta Y_t = \alpha + \beta t + \rho Y_{t-1} + \Sigma \Delta Y_{t-1} + e_t \) testing \( \alpha = \beta = 0, \rho = 0 \)

\( \tau_r \) is the ADF statistic from \( \Delta Y_t = \alpha + \beta t + \rho Y_{t-1} + \Sigma \Delta Y_{t-1} + e_t \) testing \( \rho = 0 \) (using McKinnon critical values)

Table 2 reports results on the univariate time series properties of the data. Non-stationarity cannot be rejected for levels of all series at the 5% level of significance. Nevertheless, non-stationarity can be rejected for the first differences at the same level of significance.
The separate components of our dollarization proxy, namely $M_d$ and $M_f$, are integrated of order one $I(1)$ and they move together over time. This suggests that shocks to the level of the demand of domestic and foreign currency have permanent effects and maybe they are caused by the same factors.

According to the results of Table 2, the dollarization process in Bolivia is not stationary implying its irreversibility. Guidotti and Rodriguez (1992) found neither stationarity nor cointegration between the proxy of currency substitution and the inflation differential (Bolivia-USA). They suggest that dollarization is to a large extent an irreversible phenomenon (hysteric process). However, using the Johansen-Juselius procedure\textsuperscript{20}, as we will see, it is possible to find at least one cointegrating vector for our model.

III.4.3 Empirical Results.-

The Johansen-Juselius procedure estimates equation (16) with the hypothesis that the long run matrix has reduced rank.

On the basis of tables B2 and B3 in the Appendix B which for convenience we summarize here, it can be inferred that there is one cointegrated vector for our four variables in the cointegrating equation (16).

<table>
<thead>
<tr>
<th></th>
<th>r=0</th>
<th>r≤1</th>
<th>r≤2</th>
<th>r≤3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Eigenvalue</td>
<td>39.39</td>
<td>12.89</td>
<td>7.76</td>
<td>3.41</td>
</tr>
<tr>
<td>Crit. Value 5%</td>
<td>28.14</td>
<td>22.00</td>
<td>15.67</td>
<td>9.24</td>
</tr>
<tr>
<td>Trace Test</td>
<td>63.46</td>
<td>24.07</td>
<td>11.17</td>
<td>3.41</td>
</tr>
<tr>
<td>Crit. Value 5%</td>
<td>53.11</td>
<td>34.91</td>
<td>19.96</td>
<td>9.24</td>
</tr>
</tbody>
</table>

Both the trace and the maximum eigenvalue tests indicate that the null hypothesis that there are zero cointegrating vectors is rejected. On the other hand, the trace test indicates that the null hypothesis that there are one or zero cointegrating vectors is not rejected at 5% of confidence. The maximum eigenvalue test also indicates that there is one cointegrating vector.

These results and the cointegrating vector tell us that the steady-state form of (16) can be written as\textsuperscript{21}:

\textsuperscript{20} The theoretical reason to use Johansen-Juselius is that we face a four-variables regression, so that we cannot use the Engle-Granger two step procedure.

\textsuperscript{21} The cointegrated vector, eigenvalues, long run matrix are shown in Appendix B.
\[
\log\left( \frac{M_d}{SM_f} \right) = 6.22 - 4.29 \log\left( \frac{SP_f}{P_d} \right) + 0.27 \log\left( \frac{r_f(1+\varepsilon)}{r_d} \right) - 0.25 \log(IMP)
\] (17)

The sign of the explanatory variables concur with those expected. The size of the coefficients of interest rate and imports are small but the coefficient of the real exchange rate is quite significant, that is to say that the dollarization in Bolivia in the long run is affected significantly by the real exchange rate.

Nominal devaluation of the boliviano and/or increases in foreign prices (USA inflation) and/or reduction in prices in Bolivia increase the demand for American dollar increasing dollarization by approximately 4.3%. This fact explains why in Bolivia under a stabilization process dollarization has increased.

The presence of the imports variable in the cointegrating vector mirrors the importance of the demand for foreign currency in an small open economy as Bolivia. As shown in Figure B2 in the appendix, this variable has an upward trend which explains in part the ongoing dollarization process. As we see later, this variable does not enter the short-run dynamics.

Since we know that there is only one cointegrating vector, we also carried out a test for cointegration using Engle-Granger two step approach, which gives the following results for the long run estimation (standard errors in brackets):

\[
\log\left( \frac{M_d}{SM_f} \right) = 6.63 - 4.78 \log\left( \frac{SP_f}{P_d} \right) + 0.23 \log\left( \frac{r_f(1+\varepsilon)}{r_d} \right) - 0.24 \log(IMP)
\] (18)

Comparing (17) and (18) we notice that the results are similar reinforcing our conclusion about the importance in the long run of the real exchange rate in the dollarization process in Bolivia.

These results have enormous importance for monetary and exchange rate policy. To begin with, not all the individual components of the real exchange rate variable are instruments of economic policy and therefore cannot be utilized for achieving economic policy targets, for instance shortening the dollarization. Foreign prices is an exogenous variable, domestic prices depend not only on monetary policy but also on other exogenous factors. Only the nominal exchange rate, through the Central Bank’s daily auctions, can be utilized to achieve policy targets.
Furthermore, in order to diminishing the dollarization process in Bolivia, the Central Bank should follow a exchange rate policy such that an appreciation of the nominal exchange rate be achieved. As shown in equations (17) and (18), a nominal appreciation will improve the dollarization proxy variable. Nevertheless, this policy will affect Bolivian exports and encourage imports bringing about a deficit in the current account of the balance of payments.

On the other hand, using interest rate policy, the Central Bank not only could encourage currency substitution but also increase the expected change in exchange rate which in turn increases the risk in the financial market. As equations (17) and (18) suggest a reduction in the relative interest rates increases dollarization by about 0.23%.

Finally, under these circumstances coordination between monetary and exchange rate is needed in order to stabilize the real exchange rate. A devaluation of the real exchange rate causes an expansion in the dollarization process and an appreciation causes losses in competitiveness. Monetary and exchange rate policy should be aimed at compensate foreign prices fluctuations and maintain the real exchange rate.

Now we move on to the estimation of short-run dynamics. The error correction representation from the Johansen Juselius procedure can take the form of a system of simultaneous equations for the first difference of the variables in the model. Bearing in mind that we are interested in the currency substitution proxy as endogenous variable and in order to reduce the dynamic model to a parsimonious form, we estimate an unrestricted error correction model\textsuperscript{22}.

In order to capture particular information that affect our dollarization proxy variable we incorporate five dummy variables. D8712 is used to include the effects of the authorization to hold current account in foreign currency that took place in the last quarter of 1987. The variable D8908 measures the public's expectations caused by the change of government in August 1989. D9412 measures the public's expectations brought about by the lockout of two commercial banks in December 1994. The dummy variables D8901 and D8908 have no economic meaning but they were used to improve the normality of the residuals in Johansen Juselius cointegration procedure.

\textsuperscript{22} See Appendix B for more details.
Following the General-to-Specific method and on the basis of the goodness of fit $R^2$, t-ratio, DW, F, normality, heteroscedasticity, functional and autocorrelation tests, we arrived at the parsimonious form of Table 4.

| Dependent variable is $\Delta \log \left( \frac{M_d}{SM_f} \right)_{t}$ for the sample period April 1987 - December 1996 |
|---------------------------------------------------------------|-----------|----------------|
| **Coefficient** | **t-Statistic** |
| Intercept | -0.010261 | -2.7787(**) |
| $\Delta \log \left( \frac{r_f (1 + \varepsilon)}{r_d} \right)_{t}$ | 0.039064 | 2.0627(**) |
| EC$_{t-3}$ | -0.12253 | -3.4484(**) |
| $\Delta \log \left( \frac{M_d}{SM_f} \right)_{t-1}$ | -0.11742 | -1.8760(*) |
| $\Delta \log \left( \frac{r_f (1 + \varepsilon)}{r_d} \right)_{t-2}$ | 0.029187 | 1.4774 (*) |
| $\Delta \log \left( \frac{SP_f}{P_d} \right)_{t-2}$ | -0.64896 | -1.6420(**) |
| D8908 | -0.13960 | -6.0026(**) |
| D9412 | 0.29666 | 7.6344(**) |
| D8712 | 0.19199 | 4.9266(**) |
| D8901 | 0.16547 | 4.2010(**) |
| D9001 | -0.13032 | -3.3287(**) |

(*) significant at 10%, (**) significant at 5%.
Diagnostic Tests: $R^2=0.63$, Godfrey Autocorr.test $F(12,94)=0.94$, RESET $F(1,105)=0.36$, J-B Norm $\chi^2(2)=0.53$, Breusch-Pagan Heterosc. test $F(1,115)=2.04$, ADF(1) Residuals=-7.592

Almost all the coefficients are statistically significant at 5%. The overall significance of the model measured by the F-test is also ($F(10,106)=18.34$) strongly significant. As can be seen from Figure 3, the fitted values describe well enough the behaviour of the dollarization proxy in the period 1987-1996. In addition, the proxy variable of currency substitution only includes foreign deposits in Bolivian commercial banks and does not include domestic agents foreign currency cash holdings and deposits held abroad.

From the diagnostic statistics, the residuals of the estimated equation appear to be white noise, homoscedastic, non correlated, normally distributed and stationary as shown in Figure 4.
As shown in Table 4, all dummy variables are strongly significant. Moreover, in the short run, the public's expectations caused by either political events or institutional incidents seem to be a meaningful component of the dollarization process.

![Figure 3](image)

**Figure 3**
Plot of Actual and Fitted Values of short-run dynamics

![Figure 4](image)

**Figure 4**
Plot of Residuals of short-run equation

As can be seen from Table 4, the error correction coefficient suggests that in the short run, agents increase (decrease) their foreign currency holdings by 12% of the past three months' excess demand.

The most important determinant of changes in currency substitution, in the short run, comes from contemporaneous changes in relative interest rates, in addition, changes in interest rates affect the relative money holdings after two periods although in less proportion. On the other hand, two-period
lagged changes in the real exchange rate is also found important to explain the change in relative money holdings.

The one-period-lagged dependent variable suggests inertia in the process of currency substitution in Bolivia, although comparing with the rest of the variables it has relative less explanatory power. This fact contrasts with the high explanatory power of the one-period-lagged of the currency substitution proxy found by Clements and Schwartz (1993).

Notice that the short run results do not include any coefficient of the first difference in imports, all of them were statistically insignificant. Demand for dollars for imports purposes only influences the currency substitution proxy in the long run.

The expectation caused by the change of government in 1989 decreased foreign currency deposits since domestic agents had foreseen a de-dollarization like in 1982, which concurs with the negative sign of the dummy variable D8908. On the other hand, the variable D8712 shows a positive sign disclosing the advantageous effect on dollarization of the permission of holding current accounts in foreign currency.

The dynamic model help us to understand the Bolivian dollarization process and why the central bank policy described in section III.2 did not succeed in diminishing the level of dollarization in August 1994.

Looking again at Figure 2 and Figure B1 in Appendix B, we notice that after this measure was taken, there is a small decrease in the level of dollarization caused by the interest rate policy of the Central Bank, which in the model would be explained by the (contemporaneous) short run effect of this variable on the desired foreign currency holdings. That is to say that an increase in domestic interest rate led to a decrease in the dollarization because of the change in the opportunity cost variable as a primary effect. Bearing in mind that our domestic money demand proxy includes narrow money as well as quasi money, agents responded by increasing their demand for domestic quasi money rather than increasing their demand for foreign currency.

However, because of the lower opportunity cost of holding American Dollars, the lagged variables of interest and real exchange rates adjusted agents’ preferences offsetting the primary effect. In other
words, increasing domestic interest rate the Central Bank expanded the risk of devaluation (exchange rate expectations) giving as a result an undesirable increase in demand for foreign currency.

IV CONCLUSIONS

The subject of this paper has been the Bolivian phenomenon of currency substitution in the period 1987-1996. Currency substitution has been defined as the demand for foreign currency by domestic residents under asymmetrical considerations. The review of some previous empirical and theoretical studies confirmed the importance of currency substitution in Latin American countries and especially in Bolivia.

Unlike other papers about currency substitution in Bolivia reviewed for this Dissertation, the real exchange rate is found to be an important explanatory variable of the dollarization process.

Based on empirical evidence, it has been shown that the dollarization process in Bolivia is highly persistent which constraints the possibility of using economic policy instruments in order to overcome this problem. However, bearing in mind the behaviour of the dollarization proxy in the last four years, it seems to have settled down around a constant level. This could then open up the possibility of influencing the dollarization process through monetary and exchange rate policies.

These results tend to confirm the findings of Guidotti and Rodriguez (1992) and Clements and Schwartz (1993) about the ongoing dollarization process and the asymmetry between currency substitution under instability and currency substitution under stability.

Moreover, it is found that depreciations of the real exchange rate encourage currency substitution in Bolivia. While domestic inflation was reduced to a single digit, it brought about a real depreciation which in turn encouraged foreign currency holdings. This fact explains why under stability, currency substitution has increased.

Therefore, in order to diminish the level of dollarization in Bolivia, coordination between monetary and exchange rate policies aimed to avoid a real depreciation is necessary.
In the short run, expectations also play an important role in the dollarization process in the Bolivian case. The public's preferences are sensitive to possible changes in governmental economic policy and institutional factors.

The interest rate policy of the Central Bank implemented in August 1994 and aimed at encouraging domestic money holdings, had successful results as an initial effect but afterwards, as a secondary effect it became ineffective, by contrast it encouraged dollarization. One explanation of this is the fact that in the long run, the level of the real exchange rate is more important in explaining the public's preferences for domestic currency or foreign currency than the difference between interest rates.

Despite the satisfactory findings about the dollarization in Bolivia, the dynamic optimization approach used in this paper cannot distinguish between currency substitution and capital mobility. It may be advantageous to carry out further research on this topic.
MATHEMATICAL APPENDIX

A
MATHEMATICAL APPENDIX A

The representative consumer's problem is

\[ \text{Max } U = \int_0^\infty u(c_t)e^{-\alpha t} \, dt \tag{A1} \]

where \( u' > 0 \); \( u'' < 0 \)

Subject to

\[ a = \frac{M_d}{P_d} + S \frac{M_f}{P_d} + \frac{B_d}{P_d} + S \frac{B_f}{P_d} \tag{A2} \]

and

\[ \frac{da}{dt} = \frac{y - c}{1 + V \left( m \left( \frac{M_d}{P_d}, \frac{M_f}{\alpha}, \phi \right) \right) - \Pi_d \left( \frac{M_d}{P_d} \right) + \left( e - \Pi_d \right) \frac{SM_f}{P_d}} + \left( r_d - \Pi_d \right) \frac{B_d}{P_d} + \left[ e(1 + r_f) + r_f - \Pi_d \right] \frac{SB_f}{P_d} \tag{A3} \]

Where \( \epsilon = \frac{1}{S} \frac{\partial S}{\partial t} \)

So the Hamiltonian is:

\[ H = u(c_t) + q \left( \frac{y - c}{1 + V \left( m \left( \frac{M_d}{P_d}, \frac{M_f}{\alpha}, \phi \right) \right) - \Pi_d \left( \frac{M_d}{P_d} \right) + \left( e - \Pi_d \right) \frac{SM_f}{P_d}} + \left( r_d - \Pi_d \right) \frac{B_d}{P_d} + \left[ e(1 + r_f) + r_f - \Pi_d \right] \frac{SB_f}{P_d} \right) \]

\[ + \lambda \left( a - a \frac{M_d}{P_d} - \frac{SM_f}{P_d} - \frac{B_d}{P_d} - \frac{SB_f}{P_d} \right) \tag{A4} \]

Where \( q \) is the costate variable associated with the flow constraint and \( \lambda \) is the Lagrangian associated with the stock constraint.

Since \( \frac{M_d}{P_d} = a - \frac{SM_f}{P_d} - \frac{B_d}{P_d} - \frac{SB_f}{P_d} \) from (A2), we can write the Hamiltonian in the following way:
\[
H = u(c_t) + q \left\{ y - c \left[ \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi, \theta \right] \right. \\
\left. - \pi_d a + r_d \frac{B_d}{P_d} + \varepsilon \left( \frac{SM_f}{P_d} \right) + \right. \\
\left[ \varepsilon (1 + r_f) + r_f \right] \frac{SB_f}{P_d} \right\} \\
+ \lambda \left( a - \frac{M_d}{P_d} - \frac{SM_f}{P_d} - \frac{B_d}{P_d} - \frac{SB_f}{P_d} \right)
\]  
(A5)

The first order conditions are:

\[
\frac{\partial H}{\partial c_t} = u'(c_t) - q \left\{ 1 + V \left( \frac{m^* \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi, \theta \right)}{P_d} \right) \right\} = 0  
\]  
(A6)

\[
\frac{\partial H}{\partial a} = -q \pi_d + \lambda = -\varepsilon \lambda  
\]  
(A7)

\[
\frac{\partial H}{\partial q} = y - c \left\{ 1 + V \left[ \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi, \theta \right] \right\} = \varepsilon \lambda  
\]  
(A8)

\[
\frac{\partial H}{\partial M_d} = -qc \left[ m^* \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi, \theta \right) \right] m^* \left( \frac{Md}{P_d}, \frac{M_f}{P_f}, \phi \right) \left( \frac{1}{P_d} \right) - \frac{\lambda}{P_d} = 0  
\]  
(A9)

\[
\frac{\partial H}{\partial M_f} = -qc \left[ m^* \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi, \theta \right) \right] m^* \left( \frac{Md}{P_d}, \frac{M_f}{P_f}, \phi \right) \left( \frac{1}{P_f} \right) + q \frac{S\varepsilon}{P_d} - \frac{S\lambda}{P_d} = 0  
\]  
(A10)

\[
\frac{\partial H}{\partial B_d} = \frac{qr_d}{P_d} - \frac{\lambda}{P_d} = 0  
\]  
(A11)

\[
\frac{\partial H}{\partial B_f} = q \left[ \varepsilon (1 + r_f) + r_f \right] S \frac{\lambda}{P_d} - \frac{S\lambda}{P_d} = 0  
\]  
(A12)

From (A11) and (A12) we get the uncovered interest arbitrage condition as follows

\[
\frac{\lambda}{P_d} = \frac{qr_d}{P_d}  \\
\Rightarrow \lambda = qr_d
\]

\[
\frac{S\lambda}{P_d} = q \left[ \varepsilon (1 + r_f) + r_f \right] S  \\
\Rightarrow \lambda = q \left[ \varepsilon (1 + r_f) + r_f \right]
\]

\[
r_d = \varepsilon (1 + r_f) + r_f  
\]  
(A13)

From (A9) and (A10) respectively
\[
\frac{\lambda}{P_d} = -qcV_m \left[ m^* \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right), \theta \right] m^*_{Md} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right) \left( \frac{1}{P_d} \right)
\]

\[
\frac{S}{P_d} (\lambda - q \varepsilon) = -qcV_m \left[ m^* \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right), \theta \right] m^*_{Mf} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right) \frac{1}{P_f}
\]

From (A11) \( \frac{q r_d - \lambda}{P_d} = 0 \) \( \Rightarrow \) \( r_d = \frac{\lambda}{q} \) \( \text{(A11')} \)

Using (A13) \( r_d = \frac{\lambda}{q} = \varepsilon (1 + r_f) + r_f \) \( \text{(A13')} \)

Therefore

\[
-qcV_m \left[ m^* \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right), \theta \right] m^*_{Md} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right) = \lambda \] \( \text{(A9')} \)

\[
-qcV_m \left[ m^* \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right), \theta \right] m^*_{Mf} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right) = \frac{SP_f}{P_d} (\lambda - q \varepsilon) \] \( \text{(A10')} \)

Dividing (A9')/(A10')

\[
\frac{m^*_{Md} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right)}{m^*_{Mf} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right)} = \frac{P_d \lambda}{SP_f (\lambda - q \varepsilon)}
\]

Multiplying numerator and denominator by \( \frac{1}{q} \)

\[
\frac{m^*_{Md} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right)}{m^*_{Mf} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right)} = \frac{\frac{\lambda}{q}}{\frac{SP_f}{q} \frac{\lambda}{q} - \varepsilon}
\]

using (A11') and (A13')

\[
\frac{m^*_{Md} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right)}{m^*_{Mf} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right)} = \frac{P_d}{SP_f} \frac{r_d}{\varepsilon (1 + r_f) + r_f - \varepsilon}
\]

collecting terms we arrive to
\[
\frac{m^*}{m_{mf}} \left( \frac{M_d}{P_d}, \frac{M_f}{P_f}, \phi \right) \cdot \frac{r_d}{SP_f r_f (1 + \epsilon)} = \frac{P_d}{SP_f r_f (1 + \epsilon)}
\]  
(A14)

Assuming that the money service function is a homothetic CES then

\[
m^* = \left[ \beta_1 \left( \frac{M_d}{P_d} \right)^{-\rho} + \beta_2 \left( \frac{M_f}{P_f} \right)^{-\rho} \right]^{-\frac{1}{\rho}}
\]

where \(-1 \leq \rho \leq \infty\)

\[
\frac{\partial m^*}{\partial M_d} = -\frac{1}{\rho} \left[ \beta_1 \left( \frac{M_d}{P_d} \right)^{-\rho} + \beta_2 \left( \frac{M_f}{P_f} \right)^{-\rho} \right]^{-\frac{1}{\rho}} \left[ -\rho \beta_1 \left( \frac{M_d}{P_d} \right)^{-\rho - 1} \right]
\]

\[
\frac{\partial m^*}{\partial M_f} = -\frac{1}{\rho} \left[ \beta_1 \left( \frac{M_d}{P_d} \right)^{-\rho} + \beta_2 \left( \frac{M_f}{P_f} \right)^{-\rho} \right]^{-\frac{1}{\rho}} \left[ -\rho \beta_2 \left( \frac{M_f}{P_f} \right)^{-\rho - 1} \right]
\]

\[
\frac{\partial m^*}{\partial M_d} = \frac{\beta_1}{\beta_2} \left( \frac{M_d}{P_d} \right)^{-\frac{(1+\rho)}{\rho}} = \beta_1 \left( \frac{M_d}{P_d} \right)^{-\frac{(1+\rho)}{\rho}} \frac{P_d}{P_f} \left( \frac{P_f}{P_d} \right)^{-\frac{(1+\rho)}{\rho}}
\]

Assuming purchasing power parity, \( S = \frac{P_d}{P_f} \), we can write as

\[
\frac{\partial m^*}{\partial M_d} = \beta_1 \left( \frac{M_d}{SM_f} \right)^{-\frac{(1+\rho)}{\rho}}
\]

\[
\frac{\partial m^*}{\partial M_f} = \beta_2 \left( \frac{M_f}{SM_f} \right)^{-\frac{(1+\rho)}{\rho}}
\]

(A15)

Making equal (A14) and (A15)

\[
\frac{\beta_1}{\beta_2} \left( \frac{M_d}{SM_f} \right)^{-\frac{(1+\rho)}{\rho}} = \frac{P_d}{SP_f r_f (1 + \epsilon)}
\]

\[
\left( \frac{M_d}{SM_f} \right)^{\frac{(1+\rho)}{\rho}} = \frac{\beta_1}{\beta_2} \frac{SP_f r_f (1 + \epsilon)}{P_d r_d}
\]

taking logs and rearranging
\[
\log \left( \frac{M_d}{SM_f} \right) = \frac{1}{1+\rho} \log \left( \frac{\beta_1}{\beta_2} \right) + \frac{1}{1+\rho} \log \left( \frac{SP_f}{P_d} \right) + \frac{1}{1+\rho} \log \left( \frac{r_f(1+\varepsilon)}{r_d} \right) \quad (A16)
\]

Letting \( \sigma = \frac{1}{1+\rho} \)

we get the following expression

\[
\log \left( \frac{M_d}{SM_f} \right) = \sigma \log \left( \frac{\beta_1}{\beta_2} \right) + \sigma \log \left( \frac{SP_f}{P_d} \right) + \sigma \log \left( \frac{r_f(1+\varepsilon)}{r_d} \right) \quad (A17)
\]
ECONOMETRIC APPENDIX
B
ECONOMETRIC APPENDIX B

i) Definition and Construction of the variables.-

We use monthly non-seasonal adjusted data from January 1987 to December 1996. The source of information are International Financial Statistics of the International Monetary Fund and Central Bank of Bolivia.

\[ \log \left( \frac{M_d}{SM_f} \right) = \gamma_0 + \gamma_1 \log \left( \frac{SP}{P_d} \right) + \gamma_2 \log \left( \frac{r_f}{r_d} \right) \frac{1 + \varepsilon}{r_d} \gamma_3 \log(IMP) + u \]

In what follows our estimating equation becomes:

\[ LDOL = \gamma_0 + \gamma_1 LRS + \gamma_2 LINT + \gamma_3 LIMPORT + u \]

a) LDOL.- To construct this variable we used M2 (money and quasi money in bolivianos) as proxy of \( M_d \), American deposits in Bolivians banks for \( r_f \) and monthly average of the nominal exchange rate for \( S \).

Figure B1

Variable Proxy of Bolivian Dollarization (Md/sMf) in logs

As discussed in section II, using only foreign currency deposits as proxy of the dollarization underestimate the phenomenon because it does not include money holdings and deposits held abroad by residents.

Because of the way our proxy variable has been built, LDOL shows a downward trend instead of an upward trend showed in Figure 2 in the text, which displays the ratio quasi money in dollars to total quasi money (domestic and foreign).

b) LINT.- Domestic banks time deposits rates are used for \( r_f \), certificates of deposits rates in the United States for \( r_d \) and the differential between Bolivian and USA inflation as proxy of the expected exchange rate. The latter has been used in many papers such as Ramires-Rojas (1985) and Clements and Schwartz (1993)

Figure B2

Relative interest rates variable (rf(1+e)/rd) in logs
c) **LRS**: This variable has been built using the consumer price index of Bolivia and USA (Pd and Pf respectively) and monthly average of the nominal exchange rate for S.

![Figure B3](image)

**Real Exchange Rate (SPf/Pd) in logs**

![Figure B4](image)

**Imports variable (IMP) in logs**

- **d) LIMPORT**: Monthly Bolivian imports of goods.

- **e) Dummy Variables**: In order to capture some particular information that could affect the dollarization variable within the period 1986-1996, we include five dummy variables D8712, D8901, D8908, D9001 and D9412.

In the last quarter of 1987 in Bolivia current account in foreign currency were allowed, the dummy variable D8712 is used to incorporate this effect. D8908 measures the public's expectations caused by the change of government which took place in August 1989. D9412 measures the public's expectations caused by the lockout of two commercial banks in December 1994. The other two variables do not have economic meaning but they help to improve the normality of the residuals on which the Johansen-Juselis approach is based.

All the regressions and tests were obtained using MICROFIT v.3.0

**ii) Criteria for Selecting the Order of the VAR Model**

Based on 116 observations, using the unrestricted vector autoregression with five dummy variables (D9412, D8908, D8712, D8901 and D9001) and one constant the Log Likelihood and the LR Test suggest to use three lags.

<table>
<thead>
<tr>
<th>Order</th>
<th>LL</th>
<th>LR Test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>722.73</td>
<td>(\chi^2(16) = 23.44)</td>
<td>0.103</td>
</tr>
<tr>
<td>3</td>
<td>711.02</td>
<td>(\chi^2(32) = 47.39)</td>
<td>0.039</td>
</tr>
<tr>
<td>2</td>
<td>699.04</td>
<td>(\chi^2(48) = 72.92)</td>
<td>0.012</td>
</tr>
<tr>
<td>1</td>
<td>686.28</td>
<td>(\chi^2(64) = 995.16)</td>
<td>0.000</td>
</tr>
<tr>
<td>0</td>
<td>225.15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure B5
Histogram and Normal curve for the errors of the cointegrating vector

Table B2
Johansen Maximum Likelihood Procedure (Non-trended case)
Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

<table>
<thead>
<tr>
<th>r</th>
<th>Null Alternative</th>
<th>Statistic</th>
<th>95% Critical Value</th>
<th>90% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>r = 1</td>
<td>39.3903</td>
<td>28.1380</td>
<td>25.5590</td>
</tr>
<tr>
<td>≤ 1</td>
<td>r = 2</td>
<td>12.8972</td>
<td>22.0020</td>
<td>19.7660</td>
</tr>
<tr>
<td>≤ 2</td>
<td>r = 3</td>
<td>7.7584</td>
<td>15.6720</td>
<td>13.7520</td>
</tr>
<tr>
<td>≤ 3</td>
<td>r = 4</td>
<td>3.4152</td>
<td>9.2430</td>
<td>7.5250</td>
</tr>
</tbody>
</table>

Table B3
Johansen Maximum Likelihood Procedure (Non-trended case)
Cointegration LR Test Based on Trace of the Stochastic Matrix

<table>
<thead>
<tr>
<th>r</th>
<th>Null Alternative</th>
<th>Statistic</th>
<th>95% Critical Value</th>
<th>90% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>r ≥ 1</td>
<td>63.4611</td>
<td>53.1160</td>
<td>49.6480</td>
</tr>
<tr>
<td>≤ 1</td>
<td>r ≥ 2</td>
<td>24.0708</td>
<td>34.9100</td>
<td>32.0030</td>
</tr>
<tr>
<td>≤ 2</td>
<td>r ≥ 3</td>
<td>11.1736</td>
<td>19.9640</td>
<td>17.8520</td>
</tr>
<tr>
<td>≤ 3</td>
<td>r = 4</td>
<td>3.4152</td>
<td>9.2430</td>
<td>7.5250</td>
</tr>
</tbody>
</table>
Table B4
Estimated Cointegrated Vectors in Johansen Estimation (Normalized in Brackets) ($\beta$'s)

117 observations from 87M4 to 96M12. Maximum lag in VAR = 3, chosen $r = 1$.
List of additional I(0) variables included in the VAR:
D8908  D9412  D8712  D8901  D9001

<table>
<thead>
<tr>
<th>vector 1</th>
<th>Vector 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDOL</td>
<td>-1.0488</td>
</tr>
<tr>
<td></td>
<td>(.10000)</td>
</tr>
<tr>
<td>LINT10</td>
<td>.28128</td>
</tr>
<tr>
<td></td>
<td>(.26819)</td>
</tr>
<tr>
<td>LRS</td>
<td>-4.5010</td>
</tr>
<tr>
<td></td>
<td>(-4.2915)</td>
</tr>
<tr>
<td>LIMPORT</td>
<td>-.26705</td>
</tr>
<tr>
<td></td>
<td>(-.25462)</td>
</tr>
<tr>
<td>Intercept</td>
<td>6.5234</td>
</tr>
<tr>
<td></td>
<td>(6.2197)</td>
</tr>
</tbody>
</table>

Normalized values in brackets.

Table B5
Estimated Adjustment Matrix in Johansen Estimation (Normalized in Brackets) ($\alpha$'s)

117 observations from 87M4 to 96M12. Maximum lag in VAR = 3, chosen $r = 1$.
List of additional I(0) variables included in the VAR:
D8908  D9412  D8712  D8901  D9001

<table>
<thead>
<tr>
<th>vector 1</th>
<th>Vector 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDOL</td>
<td>.17236</td>
</tr>
<tr>
<td></td>
<td>(.18077)</td>
</tr>
<tr>
<td>LINT10</td>
<td>-.32426</td>
</tr>
<tr>
<td></td>
<td>(-.34009)</td>
</tr>
<tr>
<td>LRS</td>
<td>.010497</td>
</tr>
<tr>
<td></td>
<td>(.011009)</td>
</tr>
<tr>
<td>LIMPORT</td>
<td>.44019</td>
</tr>
<tr>
<td></td>
<td>(.46168)</td>
</tr>
</tbody>
</table>

Table B6
Estimated Long Run Matrix in Johansen Estimation (\pi)

117 observations from 87M4 to 96M12. Maximum lag in VAR = 3, chosen $r = 1$.
List of additional I(0) variables included in the VAR:
D8908  D9412  D8712  D8901  D9001

| LDOL     | -.18077  |
| LINT10   | .34009   |
| LRS      | -.011009 |
| LIMPORT  | -.46168  |
| Intercept| 1.1244   |
| LDOL     | .048482  |
| LINT10   | -.091210 |
| LRS      | .0029526 |
| LIMPORT  | .12382   |
| Intercept| -.77580  |
| LDOL     | -.046029 |
| LINT10   | 1.4595   |
| LRS      | -.047247 |
| LIMPORT  | -1.9813  |
| Intercept| .086595  |
| LDOL     | -.21153  |
| LINT10   | -.0028033|
| LRS      | .068476  |
| LIMPORT  | 2.8715   |
iv) Engle-Granger Two-Step Procedure.-

Table B7
Long Run Estimation
Ordinary Least Squares Estimation

Dependent variable is LDOL
120 observations used for estimation from 87M1 to 96M12

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6.6348</td>
<td>.25614</td>
<td>25.9026</td>
<td>[.000]</td>
</tr>
<tr>
<td>LINT10</td>
<td>.22532</td>
<td>.22828</td>
<td>9.8700</td>
<td>[.000]</td>
</tr>
<tr>
<td>LRS</td>
<td>-4.7851</td>
<td>.26008</td>
<td>-18.3987</td>
<td>[.000]</td>
</tr>
<tr>
<td>LIMPORT</td>
<td>-2.4174</td>
<td>.34523</td>
<td>-7.0022</td>
<td>[.000]</td>
</tr>
</tbody>
</table>

v) Short-run Dynamics.-

Table B8
Unrestricted ECM
Ordinary Least Squares Estimation

Dependent variable is DLDOL
116 observations used for estimation from 87M5 to 96M12

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio[Prob]</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-.011676</td>
<td>.0037402</td>
<td>-3.1219 [.002]</td>
</tr>
<tr>
<td>DLINT10</td>
<td>.043118</td>
<td>.021946</td>
<td>1.9647 [.052]</td>
</tr>
<tr>
<td>DLRS</td>
<td>-.12775</td>
<td>.43323</td>
<td>-2.9487 [.769]</td>
</tr>
<tr>
<td>DLIMPORT</td>
<td>.018741</td>
<td>.023006</td>
<td>.81461 [.417]</td>
</tr>
<tr>
<td>EC(-3)</td>
<td>-.18577</td>
<td>.048668</td>
<td>-3.8171 [.000]</td>
</tr>
<tr>
<td>DLDOL(-1)</td>
<td>-.14362</td>
<td>.068907</td>
<td>-2.0843 [.040]</td>
</tr>
<tr>
<td>DLINT10(-1)</td>
<td>.038465</td>
<td>.022229</td>
<td>1.7304 [.087]</td>
</tr>
<tr>
<td>DLSRS(-1)</td>
<td>-.57910</td>
<td>.45832</td>
<td>-1.2635 [.210]</td>
</tr>
<tr>
<td>DDLIMPORT(-1)</td>
<td>-.0020953</td>
<td>.024740</td>
<td>-0.84692 [.933]</td>
</tr>
<tr>
<td>DLDOL(-2)</td>
<td>-.082964</td>
<td>.071191</td>
<td>-1.1654 [.247]</td>
</tr>
<tr>
<td>DLINT10(-2)</td>
<td>.039481</td>
<td>.021354</td>
<td>1.8489 [.068]</td>
</tr>
<tr>
<td>DLSRS(-2)</td>
<td>-.88714</td>
<td>.42012</td>
<td>-2.1116 [.037]</td>
</tr>
<tr>
<td>DDLIMPORT(-2)</td>
<td>-.0012375</td>
<td>.025091</td>
<td>-0.49321 [.961]</td>
</tr>
<tr>
<td>DLDOL(-3)</td>
<td>.023730</td>
<td>.066469</td>
<td>.35701 [.722]</td>
</tr>
<tr>
<td>DLINT10(-3)</td>
<td>.0046857</td>
<td>.019735</td>
<td>.23743 [.813]</td>
</tr>
<tr>
<td>DLSRS(-3)</td>
<td>.79312</td>
<td>.42327</td>
<td>1.8738 [.064]</td>
</tr>
<tr>
<td>DDLIMPORT(-3)</td>
<td>.046246</td>
<td>.019550</td>
<td>2.3656 [.020]</td>
</tr>
<tr>
<td>D9808</td>
<td>-.14841</td>
<td>.026531</td>
<td>-5.5940 [.000]</td>
</tr>
<tr>
<td>D9412</td>
<td>.28617</td>
<td>.038490</td>
<td>7.4348 [.000]</td>
</tr>
<tr>
<td>D8712</td>
<td>.18491</td>
<td>.040280</td>
<td>4.5906 [.000]</td>
</tr>
<tr>
<td>D8901</td>
<td>.14106</td>
<td>.040311</td>
<td>3.9954 [.000]</td>
</tr>
<tr>
<td>D9001</td>
<td>-.14685</td>
<td>.046927</td>
<td>-3.5882 [.001]</td>
</tr>
</tbody>
</table>

R-Squared     .69125  F-statistic F(21, 94) 10.0217 [.000]
R-Bar-Squared .62228  S.E. of Regression .037355
Residual Sum of Squares .13117  Mean of Dependent Variable -.0061309
S.D. of Dependent Variable .060780  Maximum of Log-likelihood 228.9264
DW-statistic  2.00444
Diagnostic Tests

* Test Statistics * LM Version * F Version *

A: Serial Correlation *CHI-SQ( 12)= 9.1849[.687]*F( 12, 82)= .58759[.846]*
B: Functional Form *CHI-SQ( 1)= .015113[.902]*F( 1, 93)= .012118[.913]*
C: Normality *CHI-SQ( 2)= 1.3996[.497] Not applicable *
D: Heteroscedasticity *CHI-SQ( 1)= 1.7290[.189]*F( 1, 114)= 1.7249[.192]*

A: Lagrange multiplier test of residual serial correlation
B: Ramsey's RESET test using the square of the fitted values
C: Based on a test of skewness and kurtosis of residuals
D: Based on the regression of squared residuals on squared fitted values

Table B9
Parsimonious Error Correction Model
Ordinary Least Squares Estimation

Dependent variable is DLDOL
117 observations used for estimation from 87M4 to 96M12

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Ratio</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-.010261</td>
<td>.0036927</td>
<td>-2.7787</td>
<td>.006</td>
</tr>
<tr>
<td>DLINT10</td>
<td>.039064</td>
<td>.018938</td>
<td>2.0627</td>
<td>.042</td>
</tr>
<tr>
<td>EC(-3)</td>
<td>-.12253</td>
<td>.035532</td>
<td>-3.4484</td>
<td>.001</td>
</tr>
<tr>
<td>DLDOL(-1)</td>
<td>-.11742</td>
<td>.062589</td>
<td>-1.8760</td>
<td>.063</td>
</tr>
<tr>
<td>DLINT10(-2)</td>
<td>.029187</td>
<td>.019756</td>
<td>1.4774</td>
<td>.143</td>
</tr>
<tr>
<td>DLR(2)</td>
<td>-.64896</td>
<td>.39522</td>
<td>-1.6420</td>
<td>.104</td>
</tr>
<tr>
<td>D8908</td>
<td>-.13960</td>
<td>.023257</td>
<td>-6.0026</td>
<td>.000</td>
</tr>
<tr>
<td>D9412</td>
<td>.29666</td>
<td>.038858</td>
<td>7.6344</td>
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</tr>
<tr>
<td>D8712</td>
<td>.19199</td>
<td>.038970</td>
<td>4.9266</td>
<td>.000</td>
</tr>
<tr>
<td>D8901</td>
<td>.16547</td>
<td>.039389</td>
<td>4.2010</td>
<td>.000</td>
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<tr>
<td>D9001</td>
<td>-.13032</td>
<td>.039149</td>
<td>-3.3287</td>
<td>.001</td>
</tr>
</tbody>
</table>

R-Squared .63366 F-statistic F(10,106) 18.3352[.000]
R-Bar-Squared .59910 S.E. of Regression .038318
Residual Sum of Squares .15563 Mean of Dependent Variable -.0061538
S.D. of Dependent Variable .060518 Maximum of Log-likelihood 221.3961
DW-statistic 2.1234 Durbin's h-statistic -.90670[.365]

Diagnostic Tests

* Test Statistics * LM Version * F Version *

A: Serial Correlation *CHI-SQ( 12)= 12.5098[.406]*F( 12, 94)= .93783[.513]*
B: Functional Form *CHI-SQ( 1)= .40093[.527]*F( 1, 105)= .36104[.549]*
C: Normality *CHI-SQ( 2)= .53451[.765] Not applicable *
D: Heteroscedasticity *CHI-SQ( 1)= 2.0383[.153]*F( 1, 115)= 2.0390[.156]*

A: Lagrange multiplier test of residual serial correlation
B: Ramsey's RESET test using the square of the fitted values
C: Based on a test of skewness and kurtosis of residuals
D: Based on the regression of squared residuals on squared fitted values

Table B10
Unit root tests for residuals (Parsimonious ECM)
******************************************************************************
Based on OLS regression of DLDOL on:
A DLINT10 EC(-3) DLDOL(-1) DLINT10(-2)
DLRS(-2) D8908 D9412 D8712 D8901
D9001
117 observations used for estimation from 87M4 to 96M12
******************************************************************************

<table>
<thead>
<tr>
<th>statistic</th>
<th>sample</th>
<th>observations</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF</td>
<td>87M5</td>
<td>96M12</td>
<td>116</td>
</tr>
<tr>
<td>ADF(1)</td>
<td>87M6</td>
<td>96M12</td>
<td>115</td>
</tr>
<tr>
<td>ADF(2)</td>
<td>87M7</td>
<td>96M12</td>
<td>114</td>
</tr>
<tr>
<td>ADF(3)</td>
<td>87M8</td>
<td>96M12</td>
<td>113</td>
</tr>
<tr>
<td>ADF(4)</td>
<td>87M9</td>
<td>96M12</td>
<td>112</td>
</tr>
</tbody>
</table>
REFERENCES


