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The Elasticity of Substitution in Demand for Non-Tradable Goods in Bolivia

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Abstract

This paper uses a CES function to estimate the constant elasticity of substitution in consumption for non-tradables relative to tradables in a dependent economy framework. The methodology for generating data on real consumption of tradable and non-tradable goods, real prices of tradable and non-tradable goods and real absorption is based on the Bolivian Input-Output Matrix, producing quarterly data for the period 1990.1 to 2002.4. The data identify Bolivia as a country highly open to trade, with an average ratio of 55 percent in the value of exports and imports relative to GDP, non-tradable production accounting for 52 percent of GDP, and differences in the behavior of the internal and external real exchange rates. The HEGY test is used to identify and separate out seasonal unit roots in the data. A cointegration relationship was found between real absorption, the non-tradable to tradable consumption ratio and the non-tradable to tradable price ratio, suggesting inelasticity of substitution.

1. Introduction

In developing countries there is considerable interest in learning the elasticity of substitution in the demand for non-tradable goods relative to tradable goods. This elasticity is known to play a critical role in the analysis of several key economic phenomena that affect macroeconomic structure. The elasticity of substitution in demand is a measure of the extent to which the consumption of non-tradable goods substitutes for the consumption of tradable goods, for a given utility level. The extent to which non-tradables and tradables substitute for each other in consumption helps to explain the consumer response to changing relative prices between non-tradable and tradable goods (the real exchange rate) by adjusting the combination or mix of non-tradable and tradable goods that are consumed.

A substantial literature in open-economy macroeconomics has shown that the elasticity of substitution in the demand for non-tradable relative to tradable goods is an important determinant of the short-run response of the real exchange rate to shocks affecting the economy, and that in turn the real exchange-rate response is critical in determining the responses of macroeconomic variables to those same shocks.

Understanding the elasticity of substitution in demand for non-tradables relative to tradables is crucial in several areas. These include the following:

1. The response of the trade balance and the current account to terms-of-trade shocks (the Harberger-Laursen-Metzler effect) or more generally the response of the external accounts, consumption, saving and investment to terms-of-trade shocks (Ostry and Reinhart, 1992; Mendoza, 1995; and Engel and Kletzer, 1989).
2. The analysis of deviations from real interest rate parity (Dornbusch, 1983).
3. The business cycle dynamics of emerging economies facing devaluation risk (Calvo and Végh, 1993; and Mendoza and Uribe, 2000).
4. Sudden Stops of capital inflows into emerging markets driven by borrowing constraints and liability dollarization (Aghion, Baccheta and Banerjee, 2002; and Mendoza, 2002).
5. The effects of Sudden Stops on the real exchange rate and fiscal sustainability (Calvo, Izquierdo and Talvi, 2002).

6. The long-run real effects of economic reform (Fernández de Córdoba and Kehoe, 2000).
7. The home bias in investment portfolios of the residents of industrial nations (Baxter, Jermann and King, 1998).

Despite the central role that the elasticity of substitution for demand of non-tradables plays in many areas of international macroeconomics, there is little empirical work showing estimates of the value of this elasticity in developing countries. The objective of this paper is to provide an estimate of the elasticity of substitution in the demand for non-tradable relative to tradable goods for Bolivia.

Following this introduction, the second section explains the research methodology and strategy used, and the third section implements the methodology for producing the time-series data required for analysis and econometric estimation. The fourth section estimates the elasticity of substitution for the Bolivian case based on cointegration and an error correction model. Finally, the fifth section summarizes the findings and their implications.

2. Research Methodology and Strategy

2.1 Methodology

Consider an open economy with constant elasticity-of-substitution preferences with respect to the consumption of tradables (*CT*) and non-tradables (*CN*): *U*(*C*(*CT*,*CN*)), where *U*(.) could be the standard constant-relative-risk aversion utility function in terms of the composite good *C*(.), and *C*(.) is a CES aggregator of *CT* and *CN*. In this environment and without need of full characterization of the utility function, utility maximization by households subject to a standard budget constraint can be expressed in the following form:

$$\text{Maximize: } [\omega(CT_t)^{-\eta} + (1-\omega)(CN_t)^{-\eta}]^{-1/\eta}$$

$$\text{Subject to: } PTt*CTt + PNt*CNt = Mt$$

The parameter η determines the elasticity of substitution between consumption of tradable goods and consumption of non-tradable goods, which is given by $v = 1/(1+\eta)$; which is given by $v = 1/(1+ \eta)$; ω is the standard CES weighing factor; *PT* is the price of tradable goods; *PN* is the price of non-tradable goods; *M* is a budget constraint; and *t* is time.

Solving the maximization problem yields the following optimality condition for the allocation of consumption across *CT* and *CN*:

$$CN_t/CT_t = [(\omega/(1-\omega))*(PN_t/PT_t)]^{-1/(\eta+1)}$$

This is the key relationship that must be used to produce the estimates of *v*. Using logarithms, the condition discussed above reduces to the following log-linear testable relationships:

$$ln(rt) = a0 + a1\ ln(pt)$$

$$\text{where}\quad \alpha_0 = -v\ ln(\omega/(1-\omega)) \quad\text{and}\quad \alpha_1 = -v$$

and

$$ln(nt) = \beta 0 + \beta 1\ ln(pt)$$

$$\text{where}\quad \beta_0 = -v\ ln(\omega/(1-\omega)) \quad\text{and}\quad \beta 1 = -(v+1)$$

where *p* is the relative price of non-tradable goods in units of tradable goods (*p*= *PN*/*PT*), which is our definition of real exchange rate. Given that consumption data can be measured in real and current prices (*NCN*=*PN***RCN* and *NCT*=*PT***RCT*), *r* is the non-tradable to tradable real consumption ratio (*RCN*/*RCT*) and *n* is the non-tradable to tradable nominal consumption ratio (*NCN*/*NCT*). It should be noted from the relationships discussed above that $\beta 1 = a1 + 1$ must hold.

In a more general framework, the choice behavior of non-tradable in relation to tradable goods will depend upon total absorption as well as relative prices. The dependent economy model originally introduced by Salter and Swan, and presented in Agenor and Montiel (1996), suggests the following relationships:

$$AT = AT(p, A),\ 0<dAT/dA<1\ \ dAT/\mathrm{dp}>0$$

and

$$AN = AN(p, A),\ 0<dAN/dA=1-dAT/dA<1\ \ dAN/dp<0$$

where *A* is total absorption, *AT* is demand for tradable goods and *AN* is demand for non-tradable goods. Thus the above testable relationship can be expanded in order to control for potential expenditure effects in the following way:

$$ln(rt) = a0 + a1\ ln(pt) + a2\ ln(A)$$

2.2 Data Collection Procedures

Econometric estimation of the above log-linear relationships requires nominal and real time-series data for prices and consumption of non-tradables and tradables. There are three standard approaches that have been proposed for breaking down macroeconomic and price data into tradables and non-tradables: the National Accounts Procedure, the Expenditure Survey Procedure and the Consumer Price Index Procedure. While the existence of three procedures implies that three sets of measures could be used for validation, in practice the value of using more than one procedure depends on data availability, with the hope that at least one procedure can be fully performed. The rest of this section explains each of the three procedures.

National Accounts Procedure

This procedure requires gathering data from National Accounts by decomposition of the components of aggregate demand and supply in terms of the major sectors of economic activity. Data for the following items are needed both at current prices (*N*) and at constant prices (*R*) for each sector i ($i = n$ sectors): Gross production (*NYi* and *RYi*), exports (*NXi* and *RXi*), imports (*NIMi* and *RIMi*) and private consumption (*NCi* and *RCi*).

The data are used to determine which sectors represent non-tradable goods and which sectors represent tradable goods. To do this, exports and imports data at current prices are added up to measure total trade in each sector: $NTTi = NXi + NIMi$. Total trade and gross production data at current prices are then used to compute, by sector, ratios of total trade to gross output: $TTYi = NTTi/NYi$. Threshold values z are selected for this ratio, where z = 0.01,0.05, or 0.1. A sector i is then classified as part of the tradable goods industry (according to threshold z) if $TTYi > z$; otherwise the sector is classified as part of the non-tradable goods industry.

After the major industrial sectors have been classified as tradable or non-tradable, private consumption data are used to create measures of consumption expenditures on tradable and non-tradable goods and the corresponding prices. Data at current prices are used to define “nominal” consumption of tradable *NCT* and non-tradable *NCN*. The data at constant prices are used to define “real” consumption of tradable and non-tradables, *RCT* and *RCN*, respectively.

Finally, the combined nominal and real data are used to construct implicit deflators that represent the price indices of tradable and non-tradable goods as $PT = NCT/RCT$ and

PN=NCN/RCN. These indices have the same base year as the data at constant prices gathered from the National Accounts.

Expenditure Survey Procedure

This procedure requires current and constant prices data from either National Accounts or an Expenditure Survey for the following variables: private consumption of non-durable goods (*NCNDUR* and *RCNDUR*), private consumption of services (*NCSER* and *RCSER*) and private consumption of durable goods (*NCDUR* and *RCDUR*). The procedure is based on the assumption that consumption of services is identical to the total consumption of non-tradables and that consumption of non-durable and/or durable goods represents the total consumption of tradables.

The robustness of this assumption needs to be evaluated by examining the total trade ratios computed by the National Accounts Procedure. The procedure adopts three alternative definitions of tradable consumption at current prices: NCT1 (*NCNDUR*), NCT2 (*NCDUR*) or NCT3 (*NCNDUR*+*NCDUR*), and one definition of non-tradable consumption at current prices: NCN (*NCSER*). Accordingly, there are three alternative definitions of real tradable consumption RCT1 (*RCNDUR*), RCT2 (*RCDUR*) or RCT3 (*RCNDUR*+*RCDUR*) and one definition of real non-tradable consumption RCN (*RCSER*). These generated time-series can be used to construct implicit deflators that represent prices of tradables and non-tradables. The price of non-tradables is *PN*=*NCN*/*RCN*, and there are three alternative definitions of the price of tradables (PT1=NCT1/RCT1, PT2=NCT2/RCT2, PT3=NCT3/RCT3).

CPI Procedure

The CPI procedure takes advantage of the direct, final consumer price data collected in the process of computing the consumer price index. Time-series data for two price indexes need to be retrieved: the CPI for durables (PD) and the CPI for services (PS). The procedure is based on the assumptions that the price of durables is equal to the price of tradables and that the price of services is equal to the price of non-tradables. The robustness of this assumption needs to be evaluated by examining the total trade ratios computed by the national accounts procedure.

The drawback of the CPI procedure is that corresponding data for consumption expenditures are generally not available. The weights of the CPI are derived and revised using infrequent expenditure surveys, but the recurrent surveys on which CPI data are based are price surveys, not expenditure surveys. Hence, the data on consumption of services and durables gathered for the expenditure survey procedure can be used as proxies.

3. The Bolivian Data

The source for the national accounts data used in the research is the quarterly Input-Output Matrix (IOM), processed and produced by the Instituto Nacional de Estadística (INE). The IOM has the following structure:

Table 1. Structure of the Bolivian Input-Output Matrix

XX	MM	DM	IP	MG	OT	Product/Industry	1 2 3…..35	CIP	CH	CGT	FK	VE	EE	DT
						1								
						2								
						….								
						….								
						35								
						CIR								
						ZZ								
						VA								

Note:
XX = Gross Production Value
MM = Imports at CIF values
DM = Import Tariffs
IP = Indirect Taxes
OT = Total Supply
CIP = Intermediate Consumption
CH = Final Household Consumption
MG = Commerce and Transportation Margins
CGT = Final Consumption of Public Adm.
FK = Gross Formation of Fixed Capital
VE = Stock Variation
EE = Exports
CIR = Sector Intermediate Consumption
VA = Sector Value Added
ZZ = Sector Production
DT = Final Demand

Source: Instituto Nacional de Estadística.

Data in the IOM are divided into 35 products/sectors: 1) non-industrial agricultural products; 2) industrial agricultural products; 3) coca leaf; 4) cattle products; 5) forestry, hunting and fishing; 6) crude oil and natural gas; 7) metal and non-metal minerals; 8) fresh and processed meats; 9) milk products; 10) mill and bakery products; 11) sugar and confectionery products; 12) miscellaneous food products; 13) beverages; 14) processed tobacco; 15) textiles, clothing and leather products; 16) wood and wood products; 17) paper and paper products; 18) chemical substances and products; 19) petroleum refinery products; 20) non-metal mineral products; 21) basic metal products; 22) metal products, machinery and equipment; 23) miscellaneous manufactured products; 24) electricity, gas and water; 25) construction and public works; 26) commerce; 27) storage and transportation; 28) communications; 29) financial services; 30) services to firms; 31) housing property; 32) social, personal and community services; 33) hotels and restaurants; 34) household services; and 35) public administration services.

INE produces the IOM on a quarterly basis, and time series (base 1990) for all of its components are available from 1990 to the fourth quarter of 2002 in nominal and real terms. In other words, 52 observations are available for each of the variables and sectors that make up the IOM. This includes gross production (*NY* and *RY*), exports (*NX* and *RX*), imports (*NM* and *RM*) and private household consumption (*NC* and *RC*). Data on exports appear as *EE* in the demand quadrant (right side) of the IOM. Data for imports appear as *MM* in the supply quadrant (left side) of the IOM. The column next to imports in the IOM (*DM*) was added to imports to approximate values at market prices. Price deflators for each sector and variable are obtained dividing quarterly nominal and real IOM data.

The IOM matrix is neither an "industry-industry" nor a "product-product" type; it is instead the combination of both: "product-industry." A discussion of the basis for the structure and definitions of variables are found in the Bolivian IOM methodological document (INE, 2000). Summary statistics based on the IOM are published by INE under the title "Producto Interno Bruto Trimestral." These statistics include data on macroeconomic aggregates and sector aggregates, nominal terms, real terms and price deflators. There is also the traditional *Anuario Estadístico* that contains annual GDP by type of expenditure, GDP by sectors and price deflators, among other general economic information, which is also available on the Internet.

The following steps describe the computations based on the national accounts procedure described above:

Step 1: Computation of total trade in each sector in nominal terms $NTT = NX + NM + DM$ and computation of sector ratios of nominal total trade to nominal gross output $TTY = NTT/NY$.

Step 2: Classification of each sector as tradable or non-tradable according to a threshold value z. The classification uses the criteria of defining a sector as tradable if TTY > z, and non-tradable otherwise. Three values of z were used, z = 0.01, 0.05 and 0.1. This way a non-tradable sector was characterized by a very low (close to zero) proportion of exports and imports compared to its gross production. Visual inspection of each figure led to the classification of each sector as tradable or non-tradable. Table 2 presents the final classification.

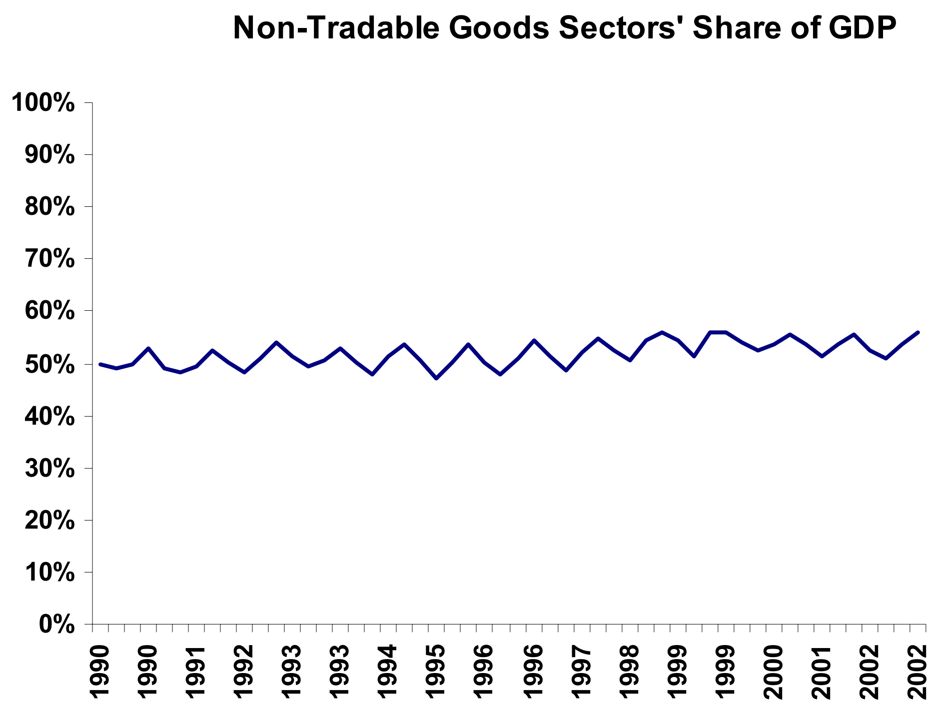
Table 2. Bolivian Tradable and Non-Tradable Goods Industries

Tradable Goods Industries	Non-Tradable Goods Industries
1 Non-industrial agricultural products	**For z<=0.01:**
2 Industrial agricultural products	**24** Electricity, gas and water
3 Coca leaf	**25** Construction and public works
5 Forestry, hunting and fishing	**26** Commerce
6 Crude oil and natural gas	**31** Housing property
7 Metal and non-metal minerals	**34** Household services
9 Milk products	**35** Public administration services
10 Mill and bakery products	
11 Sugar and confectionery products	**In addition, for 0.01<z<=0.05:**
12 Miscellaneous food products	**4** Cattle products
14 Processed tobacco	**8** Fresh and processed meats
15 Textiles, clothing and leather products	**32** Social, personal and community services
16 Wood and wood products	
17 Paper and paper products	**In addition, for 0.05<z<=0.10:**
18 Chemical substances and products	**13** Beverages
19 Petroleum refinery products	**29** Financial services
20 Non-metal mineral products	**30** Services to firms
21 Basic metal products	
22 Metal products, machinery, equipment	
23 Miscellaneous manufactured products	
27 Storage and transportation	
28 Communications	
33 Hotels and restaurants	

A total of 12 sectors out of the 35 were classified as non-tradable: six under the threshold criteria of strictly *z*<=0.01, three more under *z*<=0.05 and three more sectors under *z*<=0.10. The inequality sign is not strict, however, given the observed behavior of the sector ratios over time. There are cases in which some points in time are below *z*<=0.05, but most points are below z<=0.01. In other cases, some points in time are below z<=0.05 and others above z>0.10, but most of the observations fall in the range 0.05<*z*<=0.10. In these special cases, the study adopted the classification criteria according to the range where most of the observations lay, regardless of period of time.

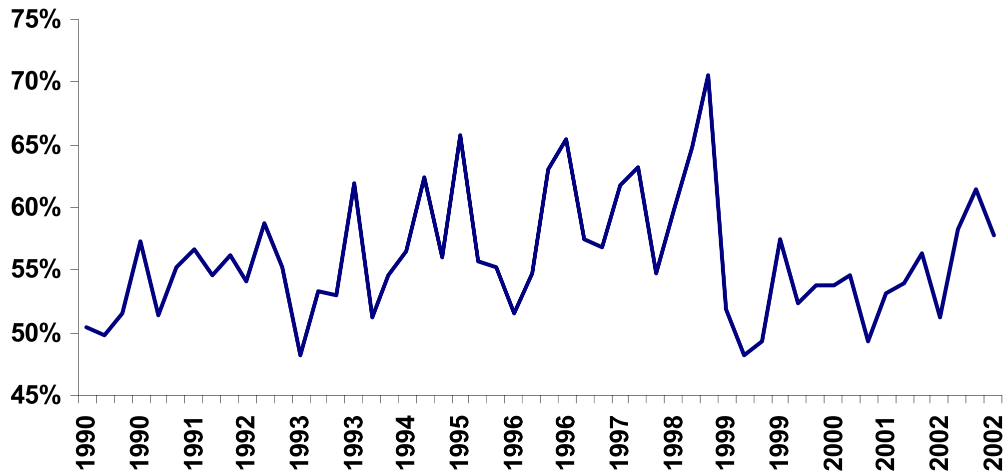
Once the classification was defined, the research study proceeded only for the case of 12 non-tradable sectors corresponding to *z*<=0.10. Figure 1 shows the share of non-tradable goods sectors in GDP; on average they account for 52 percent of GDP (minimum of 47 percent and maximum of 58 percent). Figure 2 summarizes the ratio of exports plus imports to gross production for the economy as a whole, showing the increasing degree of openness of the Bolivian economy to an average of about 55 percent until 1999, when the economy experienced an external shock and was forced into recession.

Figure 1.



Source: Calculations based on disaggregated Input-Output Matrix Data.

Figure 2.
Ratio of Exports plus Imports to Gross Production

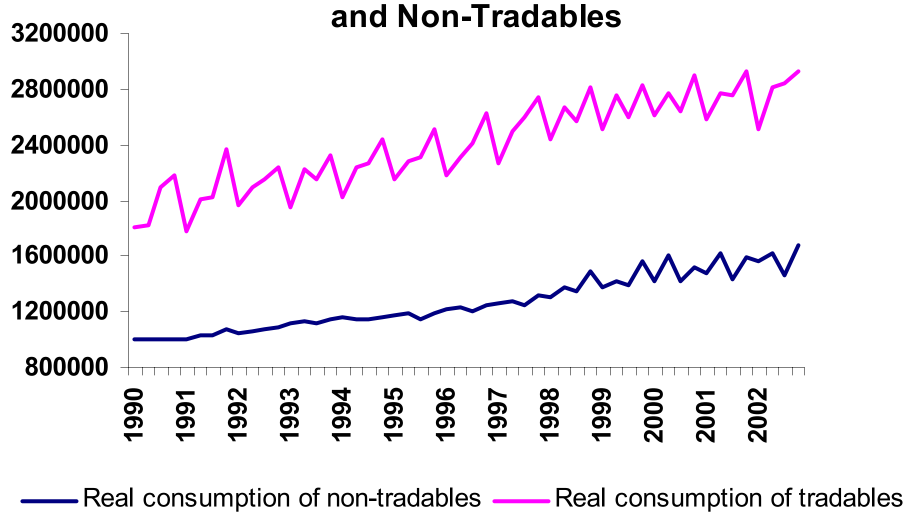


Source: Calculations based on disaggregated Input-Output Matrix Data.

Step 3: Computation of the nominal consumption of tradable (NCT) as the sum of the nominal consumption of sectors defined as tradable. Computation of the nominal private consumption of non-tradable (NCN) as the sum of the nominal consumption of sectors defined as non-tradable. Computation of the real consumption of tradable (RCT) as the sum of the real consumption of sectors defined as tradable. Computation of the real consumption of non-tradables (RCN) as the sum of the real consumption of sectors defined as non-tradable.

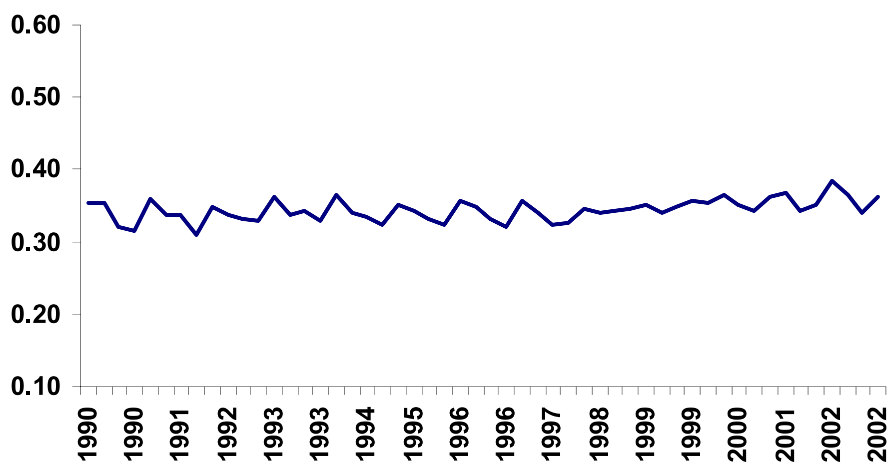
Figure 3 shows the time series of real consumption of tradables and non-tradables, both showing a similar tendency to increase over time, although the latter with greater volatility. Figure 4 is the ratio of non-tradable consumption relative to global consumption RCN/(RCN+RCT), showing that non-tradable real consumption averaged a 34 percent share of global consumption (minimum of 31 percent and maximum of 38 percent).

Figure 3.
Real Consumption of Tradables and Non-Tradables



Source : Computation based on disaggregated Input-Output Matrix Data.

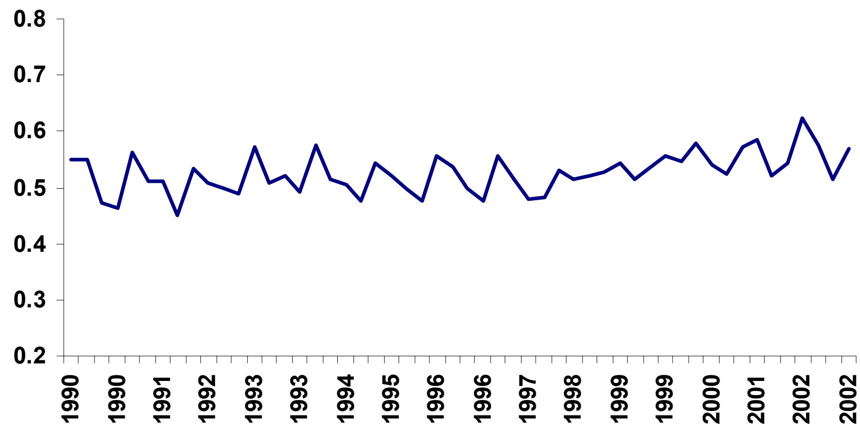
Figure 4.
Ratio of Non-Tradable Consumption Relative to Global Consumption



Source : Calculations based on disaggregated Input-Output Matrix Data.

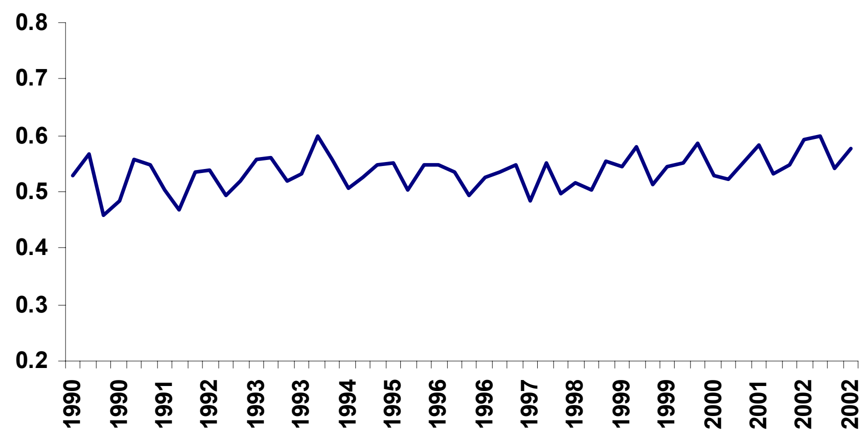
Step 4: Computation of the ratio of non-tradable to tradable consumption in nominal terms N=NCN/NCT and real terms R=RCN/RCT. Figures 5 and 6 show the time series of these ratios. These are the variables of interest as they reflect the choice behavior between tradable and non-tradable in Bolivian demand.

Figure 5.
Ratio of Non-Tradable to Tradable Consumption in Real Terms



Source: Calculations based on disaggregated Input-Output Matrix Data.

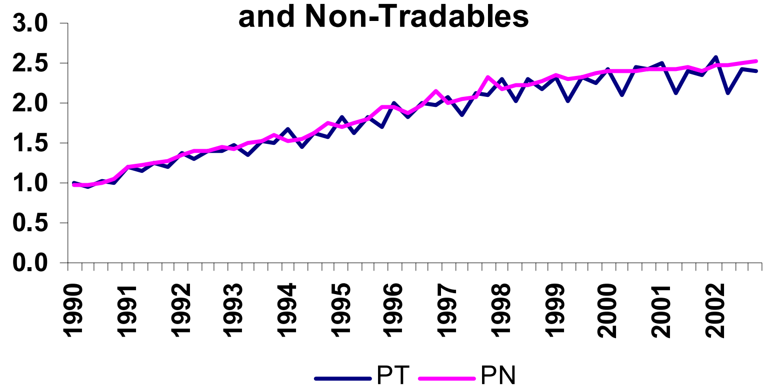
Figure 6.
Ratio of Non-Tradable to Tradable Consumption in Nominal Terms



Source: Calculations based on disaggregated Input-Output Matrix Data.

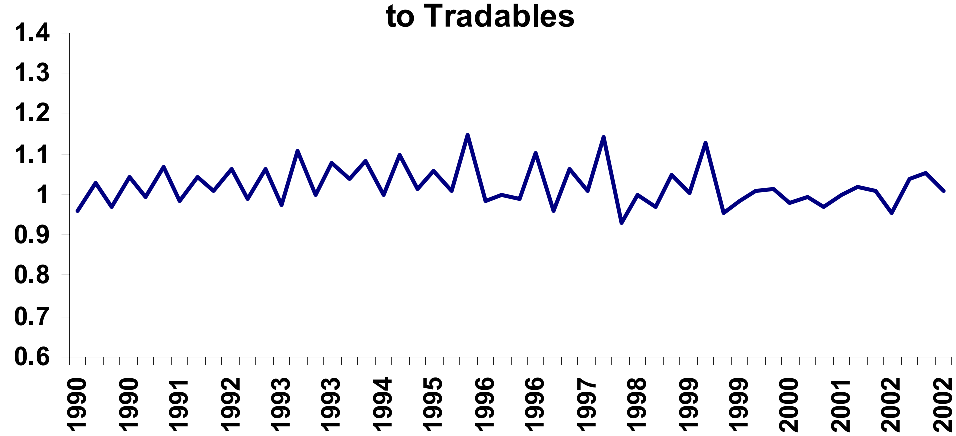
Step 5: Computation of the implicit price deflator for tradable goods industry, PT=NCT/RCT, and non-tradable goods industry, PN=NCN/RCN. With these, the relative price of non-tradable goods in units of tradables, P=PN/PT, was computed. Figure 7 shows the time series of the price index for tradable and non-tradable independently, and Figure 8 shows the ratio of the price index of non-tradable to tradable goods.

Figure 7.
Price Index for Tradables and Non-Tradables



Source: Calculations based on disaggregated Input-Output Matrix Data.

Figure 8.
Ratio of the Price Index of Non-Tradables to Tradables

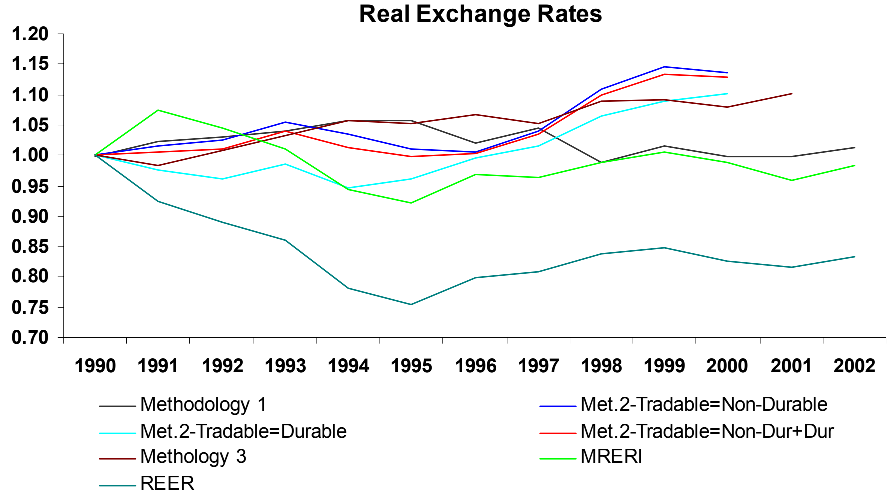


Source: Calculations based on disaggregated Input-Ouoput Matrix Data.

The variable *P* (real exchange rate) is of interest in explaining the consumption ratio; it corresponds to the main macroeconomic signal given for the choice decision in demand. Seen independently, both series PT and PN present a long-term tendency to increase, characterized by dominant short-term volatility around a changing mean. The ratio *P* shows that on average the real exchange rate has been fluctuating around one during the decade (minimum of 0.93 for depreciation and maximum of 1.15 for appreciation).

The expenditure survey procedure (method 2) and the CPI procedure (method 3) are presented in Appendices 1 and 3, respectively. Both explain the source of data, assumptions and computations. Figure 9 summarizes the output from these methods in computing the real exchange rate index and compares them to the national accounts procedure presented here (method 1). These methods for determining the real exchange rate can also be referred to as "internal" because they are strictly based on domestic data and therefore reflect domestic structure. The real exchange rate is more often computed from data that reflect price behavior and nominal exchange rates of countries with which a home has trade relations. These can be referred to as "external" real exchange rates. The Bolivian Central Bank computes real equilibrium exchange rate (REER) and the government's Unit of Economic and Social Policy Analysis computes the multilateral real exchange rate index (MRERI). The time series of these other measures are also included in Figure 9, which were adjusted to a common 1990 base.

Figure 9.
Comparison between Internal and External Real Exchange Rates



Source: Calculations based on disaggregated Input-Output Matrix Data, Bolivian Central Bank and the Unit of Economic and Social Policy Analysis.

Several observations can be derived from Figure 9. The different methods for computing the real exchange rate seem to present both divergence and convergence in some aspects. The rates computed by internal methods 2 and external methods REER and MRERI have moved together in the same direction, particularly after 1993. The rate computed by method 3 has also moved together in the same direction with method 2 and external methods, but only since 1995. However, method 2 and method 3 indicate that the real exchange rate has appreciated during the period, while the external methods indicate that it has mostly depreciated (MRERI) and strongly depreciated (REER) during the period, although the latter individually shows a tendency towards appreciation since 1995. Method 1 shows a real exchange rate fluctuating around one but in opposite movement as compared to all other methods, at least until 1998. While internal methods 2 and 3 suggest an appreciated rate during the period, external methods suggest the opposite of a depreciated rate during the period, and method 1 suggests neither. As explained by Hinkle and Nsengiyuoma (1999), however, internal and external methods of computing the exchange rate do not necessarily have to move in the same direction.

4. Econometric Procedure and Elasticity Estimation

4.1 Statistical Properties of Data

The following figures present the raw quarterly time-series data of interest generated from the Bolivian Input-Output Matrix (IOM), where LR is the log of the real consumption ratio of non-tradable relative to tradable goods, LP is the log of the price ratio of non-tradable relative to tradable goods and LA is the log of real absorption. Visual inspection shows high volatility in the data, particularly LR and LP, which may be due to seasonal effects alone or most probably a combination of seasonal effects and errors in variables. The latter might be related to INE's procedures in building the quarterly IOM given quarterly data constraints, resulting in the introduction of systematic rather than random measurement errors.

Seasonal differencing is often used to remove non-stationarity in seasonal data. In this case the quarterly difference operator is $\Delta_4 y_t = y_t - y_{t-4}$. Table 3 presents the standard ADF test applied to the quarterly difference of the data. While all three variables are non-stationary in levels, only LA is stationary in first differences, and *LR* and *LP* are stationary under quarterly seasonal differencing. The fact that Δ_4 *LR* and Δ_4 *LP* are stationary implies that these time series contain a non-seasonal unit root, a biannual unit root, an annual unit root, or a combination of two of these types of unit roots or all three types of unit roots. Use of the HEGY procedure introduced by Hylleberg et al. (1990) is appropriate to discern which types of unit roots are contained in the data.

Table 3. ADF Unit Root Tests

Variable	Specification	Lag length	ADF statistic	Stationarity
LR	None	7	-1.55	Non-stationary
	Constant	7	-0.28	Non-stationary
	Constant, trend	7	-1.3	Non-stationary
LP	None	6	-0.88	Non-stationary
	Constant	6	-1.39	Non-stationary
	Constant, trend	6	-2.33	Non-stationary
LA	None	5	1.24	Non-stationary
	Constant	5	-1.71	Non-stationary
	Constant, trend	5	-1.37	Non-stationary
Δ_4 LR	None	4	-2.63***	Stationary
	Constant	4	-3.06**	Stationary
	Constant, trend	4	-3.17	Non-stationary
Δ_4 LP	None	4	-4.37***	Stationary
	Constant	4	-4.33***	Stationary
	Constant, trend	4	-4.36***	Stationary
Δ_4 LA	None	5	-1.37	Non-stationary
	Constant	5	-1.55	Non-stationary
	Constant, trend	5	-1.69	Non-stationary
Δ_1 LA	None	2	-7.53***	Stationary
	Constant	2	-8.93***	Stationary
	Constant, trend	2	-9.28***	Stationary

Notes: (*), (**) and (***) denotes rejection of the null hypothesis of unit root at 10%, 5% and 1% respectively. Except for Δ_1 LA, the lag length was selected by the Akaike Information Criterion (AIC). In all cases a shorter lag length was enough to produce white noise residuals. AIC suggests four lags for the case of Δ_1 LA, when stationarity is accepted at 5% level only when the specification does not contain constant or constant and trend.
Source: Authors' calculations.

Traditional unit root and cointegration tests were developed for non-seasonal or zero frequency data, which could also be applied to quarterly data if it is proven that unit roots at other frequencies are not present (half frequency or biannual unit root and one fourth frequency of annual unit root). It is important to notice that the elasticity of interest in this study corresponds to the long-run equilibrium relationship between *LR* and *LP*; that is, it is strictly a non-seasonal or zero frequency relationship in the data. The quarterly difference operator $\Delta_4 = (I-L^4)$ can be decomposed as

$$(I-L4) = (I-L)(I+L)(I+L2) = (I-L)(I+L+L2+L3)$$

which has four roots, one at zero frequency, one at two cycles per year and two complex pairs at one cycle per year. The HEGY procedure consists of the following testable regression model, which can be estimated by OLS,

$$y4t = \mu t + p1y1,t\text{-}1 + p2y2,t\text{-}1 + p3y3,t\text{-}2 + p4y3,t\text{-}1 + (\text{lags of } y4t) + et$$

where

$$y1t = (I+L)(I+L2)yt = yt + yt\text{-}1 + yt\text{-}2 + yt\text{-}3$$

$$y2t = -(I-L)(I+L2)yt = -(yt - yt\text{-}1 + yt\text{-}2 - yt\text{-}3)$$

$$y3t = -(I-L)(I+L)yt = -(I-L2)yt = -(yt - yt\text{-}2)$$

$$y_{4t} \equiv \Delta_4 y_t = y_t - y_{t-4}$$

μt = constant, trend and seasonal dummies

Lags of $y4t$ are included to ensure white noise residuals

et = i.i.d. residuals.

Based on the HEGY regression the following hypothesis can be tested using critical values computed by Hylleberg et al.:

HA: $p1=0$ or non-seasonal unit root

HB: $p2=0$ or biannual unit root

HC: $p3=p4=0$ or annual unit root

Table 4.2 presents estimated statistics from application of the HEGY regression to the LR and LP data. In the case of LR there is a consistent failure to reject HA, HB and HC, implying unit roots at all frequencies. In the case of LP there is consistent failure to reject HA, and HB, while HC is not rejected only when the model contains seasonal dummies.

Table 4. HEGY Testing Procedure for Seasonal Unit Roots

	Lag length	**"t"** $\pi_1=0$	**"t"** $\pi_2=0$	**"t"** $\pi_3=0$	**"t"** $\pi_4=0$	**"F"** $\pi_3=\pi_4=0$
LR						
None	0	-1.47	-1.43	-1.97**	1.09	2.56*
C	0	-0.06	-1.41	-1.94**	1.08	2.49*
C, t	0	-1.43	-1.4	-1.75*	1.12	2.19
C, q_1 q_2 q_3	0	-0.07	-1.65	-2.98	0.36	4.47
C, t, q_1 q_2 q_3	0	-1.02	-1.7	-2.85	0.47	4.15
LP						
None	0	-1.28	-1.28	-2.62*	-0.16	3.47**
C	0	-2.2	-1.26	-2.70****	-0.1	3.67**
c, t	0	-3.02	-1.19	-2.63***	-0.09	3.47**
c, q_1 q_2 q_3	0	-1.68	-1.56	-2.83	-0.21	4.04
c, t, q_1 q_2 q_3	0	-2.38	-1.75	-2.81	-0.01	3.96

Notes: Critical values where obtained from the HEGY tables for n=48.
For the HEGY "t" test (*), (**), (***) and (****) denote rejection of the null hypothesis at 10%, 5%, 2.5% and 1%, respectively. For the HEGY "F' test (*), (**), (***) and (****) denotes rejection of the null hypothesis at 90%, 95%, 97.5% and 99% respectively. Residuals of all regressions are white noise and approximately normally distributed without the addition of lags of *yt*4. The *q* are seasonal dummies.
Source: Authors' calculations.

Elasticity Estimation

One way to proceed from here is to estimate a relationship between *LR* and *L*P by OLS and then test the residuals for unit roots at all frequencies. If these residuals are stationary at zero frequency, then the estimated regression would correspond to a long-run relationship. This approach is suggested by Hylleberg et al. when the cointegrating coefficients are known, although one may think that known means previously estimated. The following was the estimated regression:

$$LR = -0.63 – 0.69\ LP + \text{Residuals}$$

$$t = (-70.66)(-4.13)$$

$$R2 = 0.25$$

Table 5 presents the unit root test using the HEGY procedure. Failure to reject the null of $p1=0$, which corresponds to the zero frequency, indicates there is no long-run relationship between *LR* and *LP*, at least when no other explanatory variables are included in the model. However, the null of $p2=0$ was rejected at the 5 percent level (cases when dummies were not included), implying the above equation is recognized as a valid cointegrating relationship at the biannual frequency. One problem with this procedure is that the presence of unit roots and cointegration at different frequencies in the data may not produce consistent OLS estimates of the coefficients; it is unclear which coefficient would be chosen by the static regression.

Table 5. HEGY Testing Procedure for Seasonal Unit Roots on Residuals

	Lag length	**"t"** $\pi_1=0$	**"t"** $\pi_2=0$	**"t"** $\pi_3=0$	**"t"** $\pi_4=0$	**"F"** $\pi_3=\pi_4=0$
Residuals						
None	0	-0.61	-2.35***	-2.39***	0.14	2.87*
C	0	-0.45	-2.25**	-2.35***	0.22	2.79*
C, t	0	-1.26	-2.27***	-2.28***	0.25	2.63*
C, q_1 q_2 q_3	0	-1.45	-2.23	-3.35*	-0.21	5.78*
C, t, q_1 q_2 q_3	0	-1.73	-2.22	-3.34*	-0.16	5.71*

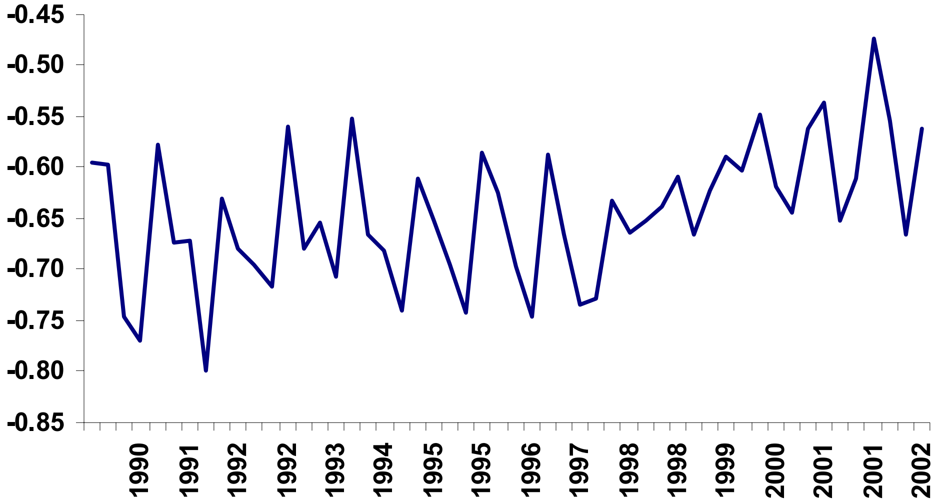
Notes: For the HEGY "t" test (*), (**), (***) and (****) denotes rejection of the null hypothesis at 10%, 5%, 2.5% and 1%, respectively. For the HEGY "F" test (*), (**), (***) and (****) denotes rejection of the null hypothesis at 90%, 95%, 97.5% and 99%, respectively. Residuals of all regressions are white noise and approximately normally distributed without the addition of lags of $yt4$. The q are seasonal dummies.
Source: Authors' calculations.

An alternative strategy, also suggested by Hylleberg et al., is to filter out the unit root components other than the one of interest and apply the standard Johansen cointegration test to the filtered series. The filter to remove seasonal roots would be

$$(I\text{-}L4)/(I\text{-}L)yt = (I+L+L2+L3)\ yt = y1t$$

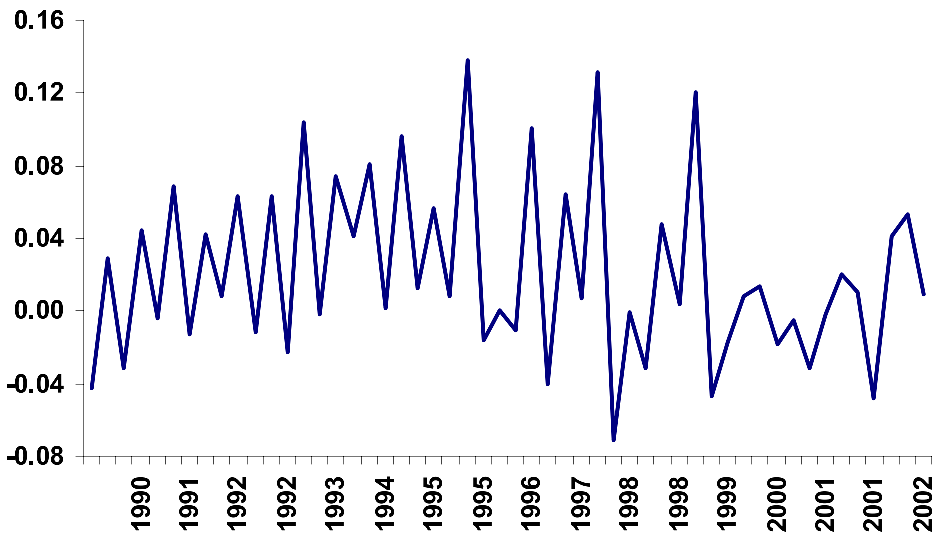
where $y1t$ is the filtered series calculated above. The filtered series for *LR* and *LP* are *LR*1 and *LP*1, as shown in Figures 10 and 11.

Figure 10.
Log of the Real Consumption Ratio of Non-Tradable Relative to Tradable Goods (LR)



Source: Calculations based on disaggregated Input-Output Matrix Data.

Figure 11.
Log of the Price Ratio of Non-Tradable Relative to Tradable Goods (LP)



Source: Calculations based on disaggregated Input-Output Matrix Data.

Testing for cointegration requires the following steps: 1) Unit root testing is necessary in order to verify if the series are integrated of first order *I*(1); this was performed using the Augmented Dickey-Fuller test (ADF) and the HEGY test. Notice that by construction *LR*1 and *LP*1 are *I*(1) series and *LA* was determined *I*(1). Now it is possible to estimate cointegrating relationships between *LR*1, *LP*1 and *LA*. 2) It is necessary to establish the lag order of the co-integration test; this is done using the Akaike Information Criterion. 3) Perform the cointegration test if the time series are *I*(1), using the optimum lag and considering different assumptions regarding trend and intercept.

The process involves estimating the following unrestricted VAR:

$$yt = A1\ \mathrm{yt}\text{-}1 + A2\ yt\text{-}2 + \ldots\ldots\ldots + Ap\ yt\text{-}p + Bxt + et$$

in order to compute: $\Pi = \sum (A_i - I)$ and $\Gamma_i = -\sum A_j$

where *yt* is a *k*-vector of non-stationary *I*(1) variables, *xt* is a *d*-vector of deterministic variables and *et* is a vector of innovations. The following are the Trace statistic (computed for the null hypothesis of *r* co-integrating relations against the alternative of *k* co-integrating relations) and the Maximum Eigenvalue statistic (computed for the null hypothesis of *r* co-integrating relations against the alternative of *r*+1 co-integrating relations):

$$LR_{tr}\ (r|k) = -T \sum \log(1-\lambda_i) \qquad LR_{max}\ (r|r+1) = -T \log(1-\lambda_{r+1})$$

The variables *LR*1, *LA* and *LP*1 were determined to be *I*(1) time series. An important issue was whether these variables were cointegrated—that is, if there is a linear combination of *LR*1, *LP*1 and *LA* that is stationary. If these variables were cointegrated, then the linear combination would express the long-term relationship among them.

Table 6 presents the cointegration test results and the coefficients of long-run relationships among the variables of interest. Model i) corresponds to a test between *LR*1 and *LP*1 alone, finding no cointegration. Models ii) and iii) correspond to tests among *LR*1, *LP*1 and *LA* where the hypothesis of no cointegration (*r*=0) is rejected at the 1 percent level. The difference between these last models is the inclusion or exclusion of a time trend in the cointegrating equation, which has an important impact on the estimated coefficients of *LA* and

*LP*1. In model ii) the elasticity of *LA* is not significant and the elasticity of *LP*1 is above one. In model iii) the elasticity of *LA* is significant and the coefficient of *LP*1 is below one.

Table 6. Johansen Cointegration Test

Variables and Specification	Lag length	H_0: rank=r	Trace Statistic	Max-Eigen Statistic	Normalized Coefficients
i) *LR*1, *LP*1		$r = 0$	8.42	8.41	No cointegration
c in CE and	1	$r <= 1$	0.01	0.01	
c in VAR					
ii) *LR*1, *LA*, *LP*1		$r = 0$	44.01**	29.16**	*LR*1 *LA* *LP*1
c in CE and	7	$r <= 1$	14.85	14	1 -0.24 1.60
c in VAR		$r <= 2$	0.84	0.84	(-1.13) (4.18)
iii) *LR*1, *LA*, *LP*1		$r = 0$	76.76**	51.44**	*LR*1 *LA* *LP*1 *t*
c, *t* in CE and	7	$r <= 1$	25.32*	17.61	1 1.29 0.72 -0.017
c in VAR		$r <= 2$	7.7	7.7	(9.36) (9.07)(12.85)

Notes: (*) and (**) indicates significance at the 5% and 1% level respectively. The lag length was determined by the Akaike Information Criterion. CE is cointegrating equation, VAR is vector autoregression.
Source: Authors' calculations.

To solve this issue and select a final model, a standard ADF test was performed on the residuals generated from the estimated cointegrating equations. Table 7 shows that residuals from both estimated cointegrating equations are stationary when no constant or trends are introduced into the test specification and the lag length is determined by AIC. The difference is that residuals from the cointegrating equation of model iii) are stationary at 1 percent, and of model ii) at 5 percent. A second difference is that in the first case stationarity is consistent with other lag order criteria, while the second is not.

Table 7. ADF Unit Root Tests on Residuals of Estimated Cointegrating Equations

Variable	Specification	Lag length	ADF statistic	Stationarity
Residuals of CE, model iii)	None	5 (AIC, SC)	-2.68***	Stationary at 1%
	Constant	5 (AIC, SC)	-2.91*	Stationary at 10%
	Constant, trend	5 (AIC, SC)	-2.86	Non-Stationary
Residuals of CE, model ii)	None	2 (AIC)	2.41**	Stationary at 5%
	Constant	2 (AIC)	-2.29	Non-Stationary
	Constant, trend	2 (AIC)	-2.3	Non-Stationary
Residuals of CE, model ii)	None	1 (SC)	1.80*	Stationary at 10%
	Constant	1 (SC)	-1.7	Non-Stationary
	Constant, trend	1 (SC)	-1.76	Non-Stationary

Notes: AIC is Akaike Information Criterion and SC is Schwarz Information Criterion.(*), (**) and (***) denotes rejection of the null hypothesis of unit root at 10%, 5% and 1% respectively.
Source: Authors' calculations.

Considering all of the above tests, we conclude that model iii) is the proper model because of its statistical precision. Appendix 6 presents the corresponding full error correction of model iii), where the estimated long term equilibrium relationship is

$$LR1 = 16.99 - 0.72\, LP1 - 1.29\, LA + 0.017\ \text{t}.$$

This result suggests on average an elasticity of substitution of 0.72 in the consumption of non-tradables relative to tradables. In terms of the quality of the error-correction model, Appendix F presents data on the residual autocorrelations that show white noise (with the possible exception of one cross-correlation at lag 10). The Portmanteau test suggests rejection of the null of no residual autocorrelation starting at lag 8 (which is not consistent with the previous data); the LM test, however, suggests failure to reject the null of no serial correlation. Regarding normality of residuals there is failure to reject the null of zero skewness. Nonetheless, there is rejection of the null of normally behaved kurtosis. That is, the distribution of residuals is symmetric but short tailed.

Overall, the Jarque-Bera test rejects the null that residuals are multivariate normal, which may be explained by the small sample size; however, it calls into question the validity of test statistics based on the assumption of normality.

5. Conclusions

1. Three cut-off criteria were used to identify tradable from non-tradable sectors in the Bolivian economy. Out of the 35 sectors contained in the Bolivian Input-Output Matrix, six were identified as non-tradable by the criterion of $z<=0.01$, three more by $z<=0.05$ and three more by $z<=0.10$, where z is the proportion of exports plus imports to GDP. The study concentrated on the latter case of twelve non-tradable sectors.

2. For the period of study (1990.1 to 2002.4), non-tradable goods industries represent on average 52 percent of GDP, and the economy's degree of openness has on average fluctuated around 55 percent, which confirms other studies (such as Agenor and Montiel, 1999).

3. For exchange rate policy purposes, the conflicting behavior of internal and external real exchange rates indexes (due to different calculation methodologies) must be taken into account in order to avoid pervasive effects on internal consumption and production decisions, which confirms other studies (Hinkle and Nsengiyumoa, 1999).

4. Cointegration at zero frequency was found among the time series of real consumption ratio, price ratio (real exchange rate) and real absorption, implying the existence of a long-term equilibrium relationship among these variable, as predicted by theory. The corresponding error correction model also supports the existence of a correction mechanism in that the dependent variable (consumption ratio) will adjust according to the discrepancy between its current and equilibrium values.

5. Theory would suggest that depreciation of the real exchange rate, measured by the ratio of non-tradable prices relative to tradable prices, would discourage consumption of tradable goods and encourage consumption of non-tradable goods. The data support this result, expressed by the negative sign of the

coefficient of the real exchange rate when used as an explanatory variable for the behavior of the ratio of consumption of non-tradable relative to tradable goods. It has also been found that when the economy's absorption increases, it has the effect of discouraging consumption of non-tradable in favor of tradable goods.

6. The constant elasticity of substitution in consumption of non-tradable relative to tradable goods has been found to have a value of 0.72 on average, implying low-substitution behavior or inelasticity.

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Appendix A. Expenditure Survey Procedure

Private household consumption data are available in the Bolivian national accounts under a product classification with eight groups and 32 subgroups of goods. The classification and weights used come from the EPF applied to the private household consumption data from national accounts. The EPF is the Household Budget Survey made in 1990 with the purpose of building the basic structure of private household consumption of goods and services. The survey was conducted in the four main Bolivian cities. The definition of private household consumption, based on the EPF structure, is the same as that used in the IOM.

Private household consumption data, based on the 1990 EPF structure, are available at current and constant prices, from 1988 to 2002, at an annual frequency. Annual time series of price deflator series can also be obtained for the data based on the EPF structure, from 1990 to 2000.

The following steps describe the computations made at each point in time.

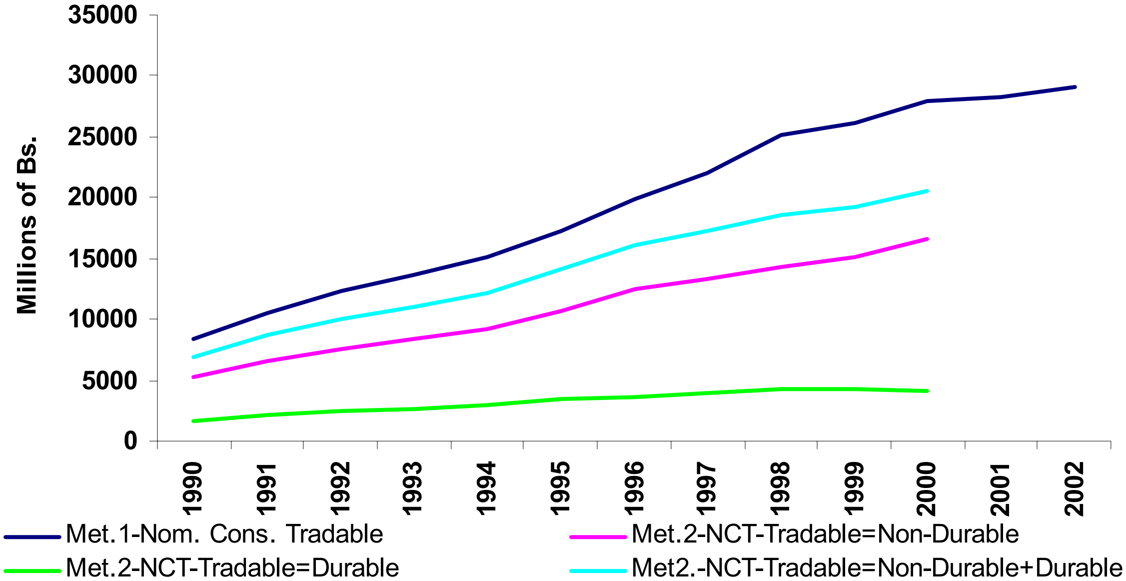
Step 1: The private household consumption data, based on the EPF, was reclassified into service and durable goods, obtaining non-durable goods by difference. The consumption of each service good was defined as consumption of a non-tradable, and all of the non-tradable were added to produce a time series of consumption of non-tradable goods. The consumption of each durable and non-durable good was defined as a tradable good, and then all tradable goods were added to produce a time series of consumption of tradable goods. All of these computations were done in nominal and real terms.

Step 2: Given that both series can be computed in nominal and real terms, then price deflators for tradable and non-tradable were computed, as well as the price ratio.

Step 3: Given that the time series produced are annual and short in length, then these are used as reference data to check the quality of data produced by the first methodology or national accounts procedure. The following figures compare the annual series of nominal and real consumption of tradables and non-tradable goods computed by the first and second methodologies.

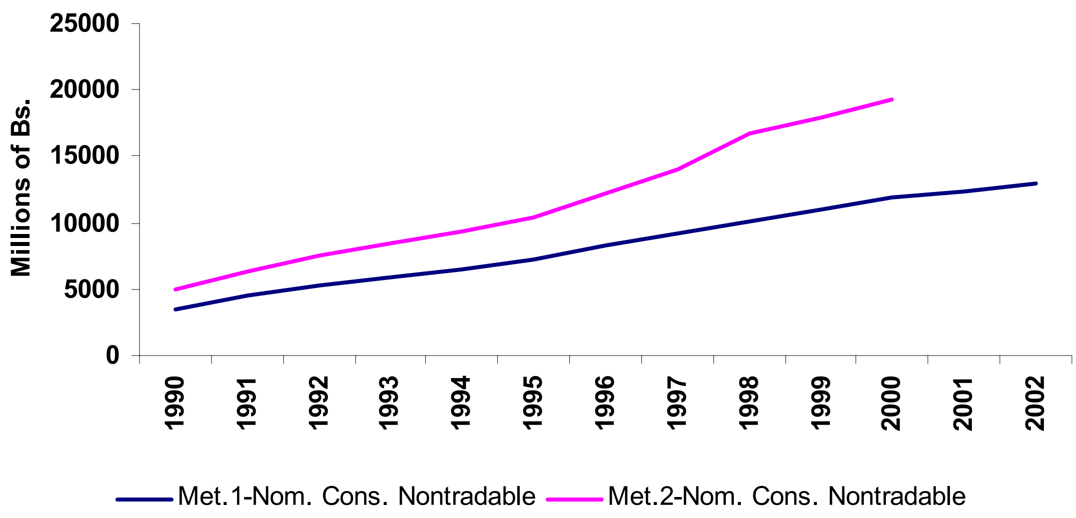
Appendix B. Comparing Annual Series Produced by First and Second Methodologies

Figure B.1.
Nominal Consumption of Tradables:
Comparison between Methodologies 1 and 2



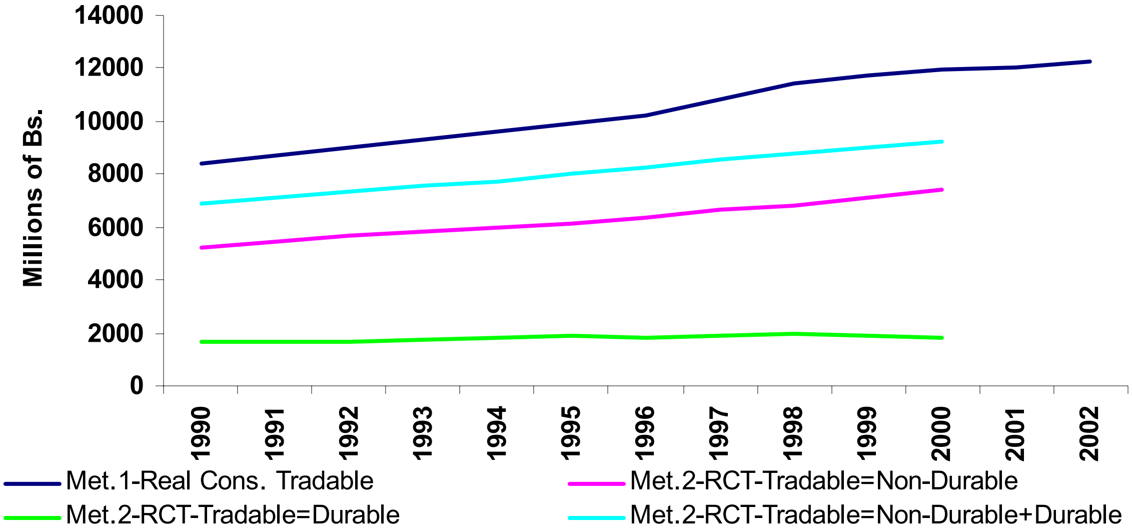
Source: Based on disaggregated Input-Output Matrix and private household consumption data.

Figure B.2.
Nominal Consumption of Non-Tradables:
Comparison between Methodologies 1 and 2



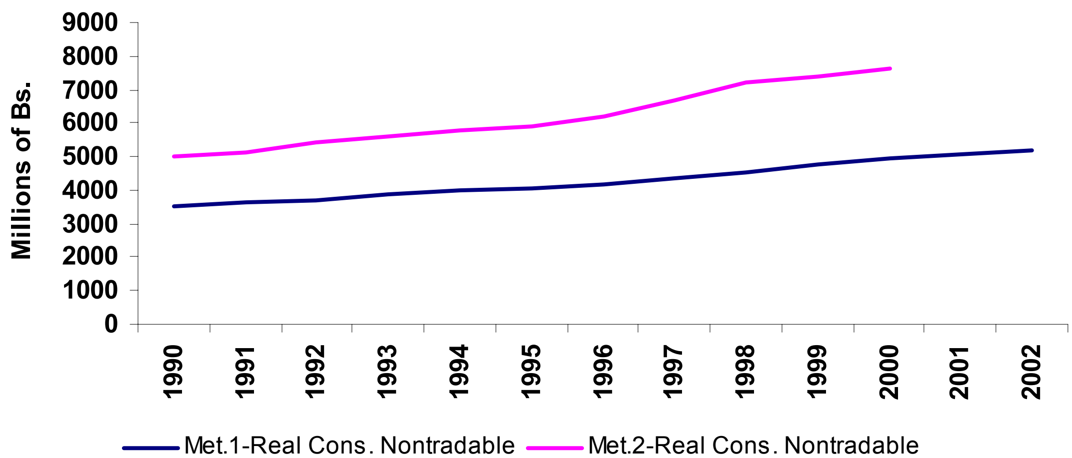
Source: Based on disaggregated Input-Output Matrix and private household consumption data.

Figure B.3.
Real Consumption of Tradables:
Comparison between Methodologies 1 and 2



Source : Based on disaggregated Input-Output Matrix and private household consumption data.

Figure B.4.
Real Consumption of Non-Tradables:
Comparison between Methodologies 1 and 2



Source : Based on disaggregated Input-Output Matrix and private household consumption data.

Appendix C. Consumer Price Index Procedure

The consumer price index (CPI, base year 1991) is computed by INE using the traditional methodology of the Laspeyres Index, based on a basket of goods and services classified into several levels of disaggregation: 9 chapters, 25 groups, 57 subgroups and a number of goods and services that varies by cities (257 in La Paz, 224 in El Alto, 258 in Cochabamba and 244 in Santa Cruz). The CPI covers the four largest Bolivian cities, which are home to most of the urban population. The basic basket for goods and services used in the CPI comes from the Household Budget Survey of 1990. Complementing that, another survey of specification was conducted in 1991 in order to define a detailed description of each good and service. The CPI time series is available on a monthly basis, for the coverage mentioned above, from 1991 to 2002, for each of the levels of classification: chapters, groups, subgroups and goods.

The CPI procedure for this research required reclassification of the CPI into a CPI of durables and CPI of services. The first is then defined as CPI for tradable and the second as CPI for non-tradable. These series are then used to produce the price ratio of non-tradable to tradable goods. These series were produced monthly from 1991 to present (base 1991) and transformed to quarterly and annual time series, which were used only as reference.

All goods listed in the CPI basket have also been classified into two groups by INE, tradable and non-tradable, allowing the production of price indexes for tradable and non-tradable, and therefore their price ratio. INE's definitions of tradable and non-tradable are the following: (i) non-tradables are all goods whose characteristics (highly perishable, high transportation costs, tariff barriers and specific to the local culture) determine that they do not trade in international markets and therefore correspond to those produced and consumed in the domestic market; (ii) tradables are all goods whose characteristics determine that they can be easily traded in international markets. These time series are available on a monthly basis and were transformed to quarterly and annual series to be used only as reference.

Appendix D. Vector Error Correction Model: Regression Estimates

Cointegrating Model	Equation		
LR1(-1)	1		
LA(-1)	1.2963		
	[9.36]		
LP1(-1)	0.7296		
	[9.07]		
t	-0.0175		
	[-12.85]		
C	-16.9977		
Error Correction Model	**D(LR1)**	**D(LA)**	**D(LP1)**
Error Correction variable	-0.985	-0.2207	0.3468
	[-3.43]	[-0.87]	[0.87]
D(LR1(-1))	0.6642	0.0047	0.3624
	[2.69]	[0.02]	[1.05]
D(LR1(-2))	0.0849	0.2389	0.1311
	[0.30]	[0.98]	[0.34]
D(LR1(-3))	0.9282	-0.5641	-0.2767
	[3.57]	[-2.48]	[-0.76]
D(LR1(-4))	0.0579	0.6938	-0.1393
	[0.20]	[2.74]	[-0.34]
D(LR1(-5))	0.4580	-0.2237	-0.1826
	[2.14]	[-1.19]	[-0.61]
D(LR1(-6))	0.2025	0.0280	0.1845
	[0.94]	[0.14]	[0.62]
D(LR1(-7))	0.0266	-0.118	0.1504
	[0.13]	[-0.68]	[0.55]
D(LA(-1))	0.1361	-0.2921	0.7781
	[0.35]	[-0.85]	[1.44]
D(LA(-2))	-0.5965	0.0258	0.546196
	[-2.13]	[0.10]	[1.40768]
D(LA(-3))	-0.1581	-0.1553	0.112601
	[-0.62]	[-0.69]	[0.31997]
D(LA(-4))	-0.2433	0.5661	0.22556
	[-1.15]	[3.05]	[0.76880]
D(LA(-5))	0.3126	0.0162	-0.487518
	[1.11]	[0.06]	[-1.25486]
D(LA(-6))	0.5978	-0.3493	-0.1979
	[2.94]	[-1.96]	[-0.70]
D(LA(-7))	-0.0115	-0.0253	-0.0452
	[-0.05]	[-0.13]	[-0.14]
D(LP1(-1))	0.5821	0.0201	0.1913
	[2.40]	[0.09]	[0.56]
D(LP1(-2))	0.1104	0.3208	-0.0669
	[0.45]	[1.50]	[-0.19]
D(LP1(-3))	0.5379	0.0331	-0.3364

Notes: LR1 is log of the consumption ratio of non-tradables to tradables (filtered series). LP1 is log of the price ratio of non-tradables to tradables (filtered series), LA is log of real absorption. D(.) is first difference of the variable. Numbers in [ ] are t-statistics. *Source*: Authors' calculations.

Appendix E. Vector Error Correction Normality Tests

Component	Skewness	Chi-sq	df	Prob.
1	0.0532	0.0193	1	0.8893
2	-0.0375	0.0096	1	0.9219
3	-0.0362	0.0089	1	0.9245
Joint		0.0379	3	0.9981
Component	**Kurtosis**	**Chi-sq**	**df**	**Prob.**
1	0.3623	11.8852	1	0.0006
2	0.5054	10.6308	1	0.0011
3	0.5478	10.2722	1	0.0014
Joint		32.7883	3	0
Component	**Jarque-Bera**	**Df**	**Prob.**	
1	11.9046	2	0.0026	
2	10.6404	2	0.0049	
3	10.2812	2	0.0059	
Joint	32.8262	6	0	

Notes: H0: residuals are multivariate normal.
Source: Authors' calculations.

Appendix F. Vector Error Correction Residual Tests for Autocorrelation

Portmanteau Tests							Serial Correlation LM Tests		
Lags	**Q-Stat**	**Prob.**	**Adj Q-Stat**	**Prob.**	**df**		**Lags**	**LM-Stat**	**Prob**
1	7.5285	-	7.7167	-	-		1	10.6446	0.3009
2	9.3931	-	9.677	-	-		2	2.6206	0.9775
3	15.6082	-	16.3827	-	-		3	4.1958	0.8981
4	23.7536	-	25.4086	-	-		4	12.6460	0.1793
5	34.7186	-	37.8966	-	-		5	10.1486	0.3386
6	41.5068	-	45.8485	-	-		6	6.0869	0.7312
7	43.8592	-	48.6852	-	-		7	2.5395	0.9798
8	48.7925	0.0000	54.8144	0	9		8	4.5868	0.8687
9	56.2027	0.0000	64.3088	0	18		9	7.227	0.6135
10	62.9200	0.0001	73.1929	0	27		10	6.8692	0.6507
11	68.0098	0.0010	80.149	0	36		11	6.2750	0.7121
12	78.8898	0.0013	95.5311	0	45		12	10.0875	0.3434
13	90.5699	0.0013	112.6341	0	54		13	10.7665	0.2921
14	100.5259	0.0019	127.7524	0	63		14	12.3757	0.1929
15	111.0290	0.0022	144.3151	0	72		15	13.7854	0.1302
16	117.5279	0.0050	154.9732	0	81		16	15.3509	0.0817
17	121.7047	0.0146	162.1086	0	90		17	10.879	0.2841
18	126.4706	0.0327	170.6042	0	99		18	8.6441	0.4708
19	128.4555	0.0874	174.3035	0.0001	108		19	6.5865	0.6801
20	129.9762	0.1943	177.2724	0.0003	117		20	4.1991	0.8978

Notes: For the Portmanteau tests H0: no residual autocorrelation up to lag *h*. The test is valid only for four lags larger than the VAR lag order, and *df* is degrees of freedom for (approximate) chi-square. For the Serial Correlation LM tests H0: no residual autocorrelation at to order *h*. Probs from chi-square with 9 *df*.
Source: Authors' calculations.
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