Essays on Argentina’s growth cycle and the world economy

Nicolini-Llosa, J.L.

Publication date
2008

Chapter 3 Estimating Argentina's Import Elasticities♣

Because of their close connection to balance of payment and trade policies, estimates of import elasticities have become a relevant issue in applied international economics. For Argentina, high income and low price elasticities of the demand for imports are central topics to explaining structurally constrained economic growth (Olivera 1924, Olivera 1962, Diaz Alejandro 1963, Ferrer 1963, Eshag and Thorp 1965 and Braun & Joy 1968). Chapter 4 shows that these elasticities are also important in Argentina's growth cycle.

Previous estimates of Argentina's import demand elasticities can be found in Diaz Alejandro (1970), Cline (1989) and Heymann & Ramos (2003). Until very recently, however, the estimation of these elasticities had suffered from a number of econometric problems such as dynamic specification, parameter stability, and links between short-run adjustment and long-run equilibrium (see Catao and Falcetti 2002). Our aim in this chapter is to overcome these problems. In particular, we will provide new estimates of the demand for imports in Argentina over the period 1970:1-2005:4. We apply recent developments in dynamic modelling and estimate the long-run income and exchange rate elasticities of the demand for imports in Argentina along with short-run linear and non-linear speeds of adjustment.

The structure of this chapter is as follows. Section 1 provides a brief theoretical framework and relevant methodological issues related to the specification and estimation of the demand for imports. Section 2 presents the econometric evidence. This section starts exploring the unit root properties of the data and then applies linear and non-linear methods of estimation. The linear approach uses the two-step procedure suggested by Engle-Granger and the Johansen methodology for estimating and testing cointegrated vectors. The non-linear approach concentrates on the Smooth Transition Error Correction Model as recently proposed by Kapetanios et al. (2006). What the econometric evidence

♣ This chapter is under consideration for publication in the *Journal of Policy Modelling*, Elsevier Science. It has also been circulated as a *Working Paper (2007/009)* of Lancaster University Management School. It was jointly written with Agustín Duarte (University of Alicante) and Ivan Payá (Lancaster University). I am grateful to Prof. Ken Holden at Liverpool John Moores University for his helpful suggestions. Errors and omissions to my account.

suggests is that the non-linear approach is better suited to capture the dynamic of adjustment of the demand for imports in Argentina than the linear approaches. Section 3 provides a brief economic interpretation of the results, and Section 4 summarises the major conclusions.

1. Methodological issues

The familiar and widely used Marshallian function of aggregate demand for imports is:

$$(1) \qquad M_t = Y_t^{\beta} \left(\frac{P_t^f \ E_t}{P_t^d} \right)^{\delta}$$

where M_t is the quantity of imports demanded, P^f_t are import prices, P^d_t are domestic prices, E_t is the nominal exchange rate, that is the price of domestic currency per unit of foreign currency, and Y_t is real income or real expenditure. This expression simply says that imports in volume terms is an exponential function (multiplicative) of real income and a measure of relative prices of imports and substitutes domestic goods. In applied work, the real exchange rate ($REX_t = P^f_t \ E_t \ /P^d_t$), has been frequently used to capture the decisions made by economic agents in favour of either imports or domestic goods. In (1), δ and β represent the price and income elasticity of the demand for imports respectively.

For a number of reasons (e.g., incomplete information, adjustment costs, inertia, habits, lags in perceiving changes) imports do not immediately adjust to their long-run level, following a change in any of their determinants. To describe these effects our analysis will distinguish between two time frames: the long-run path of the demand for imports and the short-run adjustment response of economic agents to changes in the explanatory variables.

As far as the specification of the long run equation is concerned, it is well known that economic theory does not provide any specific suggestion on the best functional form nor the most appropriate variables (Gandolfo & Petit 1983). In this chapter we shall adopt the following standard model which is the logarithmic version of (1):

$$(2) \qquad \text{Log } M_t = \alpha + \beta \log Y_t + \delta \log REX_t$$

Before proceeding to the estimation process, we should recall that the traditional approach to measure foreign trade elasticities has a number of econometric problems and pitfalls. Dynamic specification and parameter stability over time are outstanding examples. To avoid these shortcomings, in this chapter we shall apply a parametric error-correction methodology. First, we will use two well-known methodologies to estimate the long-run function; one is the Engle-Granger Ordinary Least Square (EG-OLS) cointegration regression and the other is the Johansen-Juselius Full Information Maximum Likelihood (JJ-FIML). Then, the result for the long run will be modelled as an error correction mechanism to incorporate the estimates of the short-run dynamic model.

In addition to the above mentioned methodologies, we shall consider some recent developments in time series econometrics to estimate cointegrated models subject to non-linear dynamics (Balke and Fomby 1997 and Michael et al. 1997). In particular we will use a non-linear Smooth Transition Error Correction Model as recently proposed by Kapetanios et al. (2006). Three notable features that make the use of this methodology an appealing one are: first, it is in line with recent research on non-stationarity and non-linearity in economics, where it is argued that the assumption of linear adjustment is likely to be too limited in situations where transaction costs and policy interventions are present. Second, its implementation is relatively simple, in the sense that it follows a two step residual-based approach as in Engle and Granger (1987). Third, the model considers a process where higher disequilibrium errors can be associated with larger ECM adjustment parameters and faster rates of error correction towards the long-run function.

2. Empirical estimates

2.1 The properties of the data

A preliminary analysis to explore the time-series properties of the variables is needed before applying the cointegration and ECM methodology. The data used are quarterly from 1970:1 to 2005:4, and the main sources are the Instituto Nacional de Estadísticas y Censos (INDEC) of Argentina, the Economic Commission for Latina America and the Caribbean (ECLA), and the IMF's International Financial Statistics (IFS). The quarterly imports volume data are from INDEC (1986-2005) and ECLA (1970-1985). Real GDP data (at 1993 market prices) are from INDEC and the seasonal component was removed using X-12. The source for nominal free market exchange rate data is the Central Bank of Argentina as quoted in the IFS during free floating exchange rate periods, and from the off-shore market (Montevideo, Uruguay) during the fixed and/or controlled exchange rate periods as presented by Fundación de Investigaciones Económicas Latinoamericana[31] (FIEL). The nominal exchange rate was deflated with INDEC and US Bureau of Labour Statistics consumer price index. The data used in the estimations are in natural logarithms.

The series were tested using the augmented Dickey-Fuller (ADF)[32] test where the null hypothesis of a unit root is tested against the alternative that the process is stationary. **Table 3.1** shows the results of the tests where it can be seen that the null hypothesis of a unit root in the level series under consideration cannot be rejected. Also, the results of the ADF tests applied to the first difference in logs of the time series indicate that the presence of a unit root can be easily rejected. In sum, the first differences of all the series under consideration are stationary, confirming that the series are non-stationary or I(1) in (log) level, and contain a stochastic trend over the 1970:1-2005:4 sample. Thus, in what follows we shall first test for the presence of cointegration among the volume of imports (M_t), real income (Y_t) and the real exchange rate (REX), and then alternative linear and non-linear error-correction dynamic models will be formulated.

Table 3.1: Unit Root Tests for the Series Employed (1970:1 – 2005:4)

Variables	With trend	Without trend
Log M	-3.27 (0.07)	
Log Y	-2.16 (0.51)	
Log REX	-1.87 (0.66)	
ΔLog M	-10.43 (0.00)	-10.45 (0.00)
ΔLog Y	-9.04 (0.00)	-9.05 (0.00)
ΔLog REX	-10.13 (0.00)	-10.15 (0.00)

Notes: In computing the tests we have employed up to four lags to whiten the residuals, given the use of quarterly data. The estimated equations for the ADF tests were: $\Delta X_t = \alpha + \beta X_{t-1} + \Sigma\ \phi_l \Delta X_{t-l} + \delta t$. P-values are reported in parenthesis and critical values are those of MacKinnon (1996) one sided.

[31] www.fiel.org Av. Cordoba 637 4th floor, Buenos Aires, Argentina

[32] For a survey on new extensions of the Dickey-Fuller procedure and alternative tests such as that of Phillips and Perron PP, see Maddala and Kim (1998). Please note that PP tests yielded similar results to the ADF tests.

2.2 The long-run function

Two estimation procedures with the corresponding cointegration test will be carried out. One is the residual-based approach proposed by Engle and Granger (1987) (EG), and the other is the Johansen (1988, 1992) and Juselius (1992) (JJ) maximum likelihood technique.

The outcome of the residual-based approach is:

$$\text{(3)} \qquad \log M_t = \underset{(1.41)}{-39.03} + \underset{(0.11)}{3.52} \log Y_t - \underset{(0.038)}{0.36} \log REX$$

$$R^2adj = 0.92 \qquad ADF(0) = -4.32 \qquad KPSS = 0.139$$

Numbers in parentheses below the coefficients are standard errors. In general, these results suggest that cointegration is present. The ADF test rejects the null of no co-integration and the same conclusion is achieved by means of the KPSS test (Kwiatkowski, et. al 1992), which does not reject the null of stationarity. However, two issues are worth mentioning. First, the residual-based approach, in the case of a finite sample, can be sensitive to the specific choice of the endogenous variable (see Dickey et al., 1991). Secondly, this approach ignores the situation of more than one co-integrating vector when more than two variables are included in the sample (Banerjee et al., 1993). In the light of these shortcomings, the Johansen FIML (Full-Information Maximum Likelihood) approach will also be used.

Table 3.2 shows the main results of the JJ Tests for the number of co-integrating vectors. The maximal eigenvalue statistic (0.150) and trace statistic (30.88) confirm the existence of only one co-integrating vector. The Johansen long-run co-integrating equation is[33]:

$$\text{(4)} \qquad \log M_t = -36.22 + \underset{(0.27)}{3.29} \log Y_t - \underset{(0.093)}{0.56} \log REX_t$$

[33] The selected equation has been chosen on the basis of the significance of the adjustment coefficients in the ECM VAR. Moreover, the adjustment coefficients of the other two equations were not significant highlighting the existence of only one co-integrating vector.

Table 3.2. Johansen Tests for the number of Co-integrating Vectors

No. Cointegrating Vectors	Eigenvalue	Trace Statistic	Critical Value 0.05	P-value
None	0.1504	30.87553	29.79707	0.0374
At most 1	0.0539	8.058388	15.49471	0.4592
At most 2	0.0021	0.289953	3.841466	0.5902

Standard errors are in parenthesis. It is worth noting that the estimated income elasticity in the cointegrated vector is similar to that obtained by the EG static in (3) while the exchange rate elasticity slightly differs.

2.3 Dynamic adjustment estimates

Table 3.3 shows the main results of the Error Correction Models (ECM). Taking into account the substantial fluctuation during the sample period (see **Figures 3.1** (a) and (b) below) it should be recognised that the model explains the changes in import demand rather accurately. An inspection of the diagnostic tests in **Table 3.3** suggests that the model specification is correct and that a satisfactory model for import demand has been reached.[34]

Considering that the equation explains the quarterly rate of change of the demand for imports, the R^2 values (0.53 and 0.52) can be interpreted as quite good. Recursive residuals and CUSUM tests have been conducted to test for the stability of the OLS vector and the FIML vector. **Figures 3.2** and **3.3** show the outcome of these tests and they confirm the goodness of fit. Note that all three of the extreme values shown in **Figure 3.2** correspond to severe recessive devaluations, namely:

a) In 1975, there was a sharp acceleration of inflation along with a run on the currency and a sharp recessive devaluation that led to the military coup in March 1976.

[34] As far as the estimation is concerned, we introduced four lags of the first differenced variables on the grounds that we are dealing with quarterly data, and, this would provide a sufficient representation of the data generating process. This was followed by a general to specific simplification procedure eliminating all negligible and insignificant effects. Following the approach suggested by Hendry & Mizon (1978) the process of simplification has been based on the grounds of statistics such as F statistic, Schwarz criterion and standard error of regression.

b) In 1988 there was hyperinflation along with a run on the currency and a sharp recessive devaluation that lead to the anticipated change of government (Alfonsin stepped down and Menen took over)

c) In 2002 there was a run on the currency and a sharp recessive devaluation along with an institutional crisis (four presidents between December 2001 and March 2002)

Table 3.3: **Error Correction Models for Aggregate Import Demand in Argentina. 1970:01-2005:04.**

Dependent variable: ΔM

Variables	OLS vector	FIML vector
Ecm (t-1)	-0.234	-0.206
	(0.000)	(0.000)
Δm (t-4)	0.317	0.293
	(0.000)	(0.000)
Δm (t-6)	-0.192	-0.22
	(0.001)	(0.000)
Δy (t)	2.375	2.36
	(0.000)	(0.000)
Δy (t-1)	1.20	1.23
	(0.003)	(0.002)
ΔREX(t)	-0.15	-0.17
	(0.004)	(0.002)
R^2 adj.	0.53	0.53
DW	2.00	2.07
SER	0.108	0.109
LM (2)	0.93	0.87
LM (3)	0.44	0.14
LM (4)	0.60	0.21
ARCH (1)	0.90	0.94
ARCH (2)	0.22	0.12
ARCH (3)	0.00	0.00
RESET	0.06	0.05

Notes: Figures in parenthesis below coefficient estimates are p-values. SER is the standard error of the regression. LM is the Lagrange multiplier test for up to fourth-order serial correlation. ARCH is test for autoregressive conditional heteroscedasticity. RESET is a regression error specification test.

However, an inspection of the RESET diagnostic test in **Table 3.3** suggests that the model specification might be nonlinear. In the next section we shall examine a nonlinear specification of the model.

Figure 3.1(a): Actual and fitted values of the ECM model obtained with EG procedure

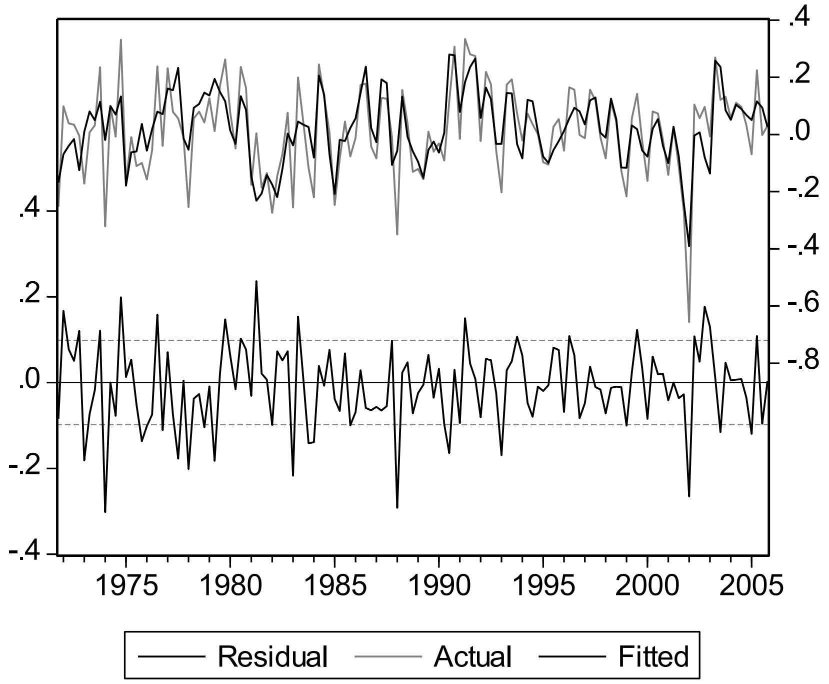


Figure 3.1(b): Actual and fitted values of the ECM model obtained with JJ procedure

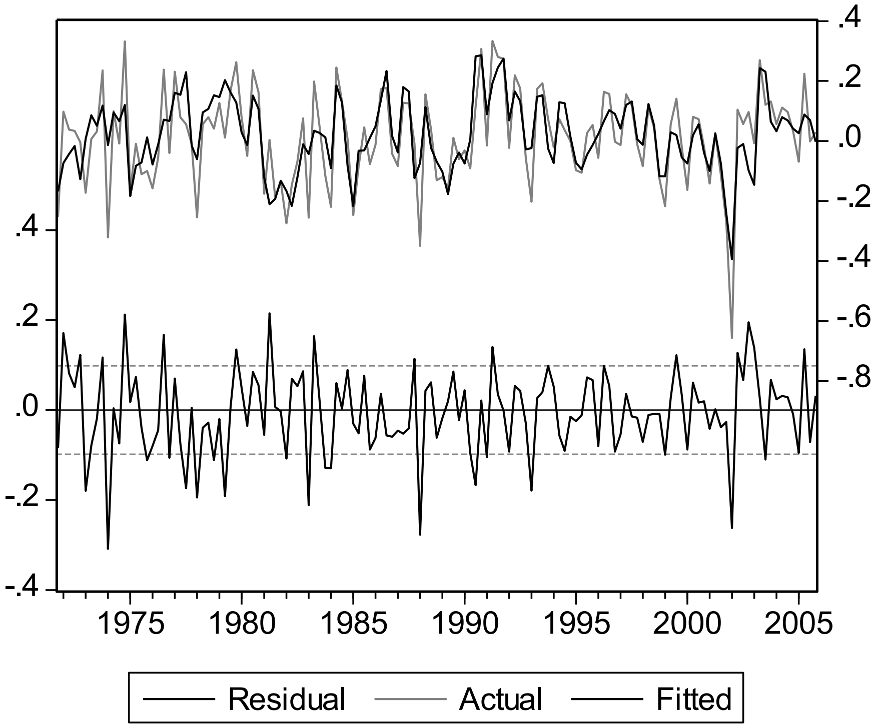
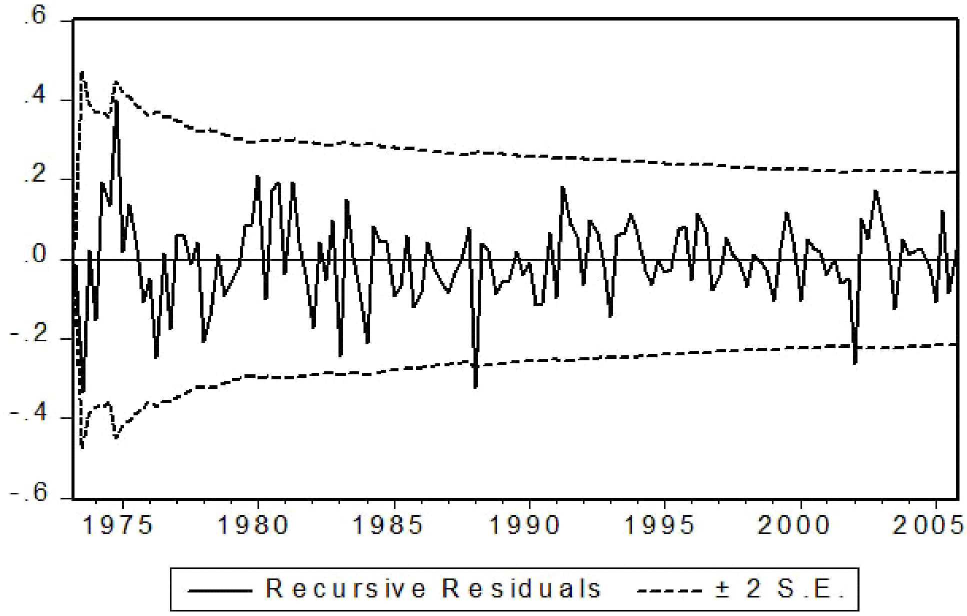


Figure 3. 2: Stability test

(a) OLS vector.



(b) FIML vector.

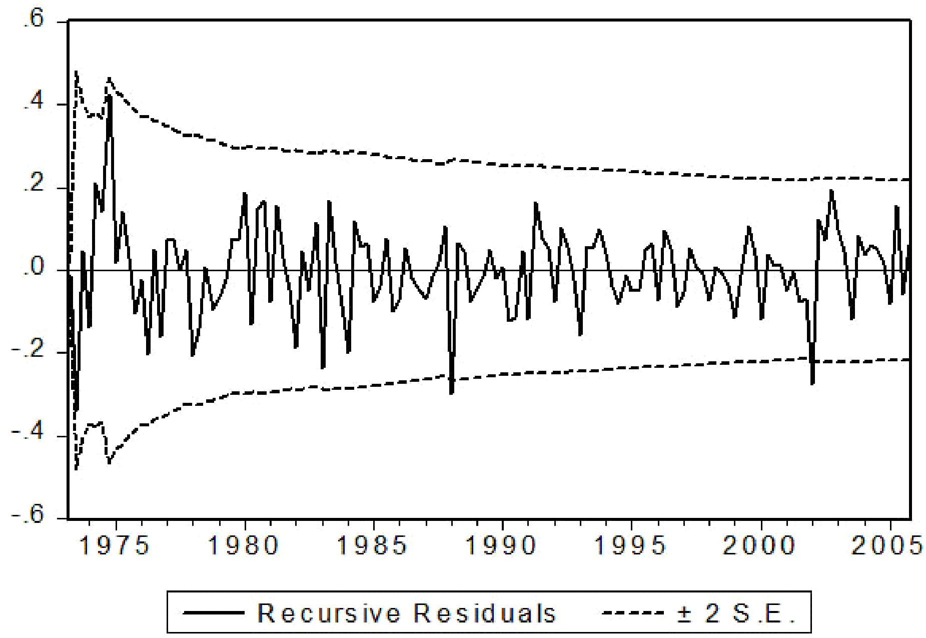
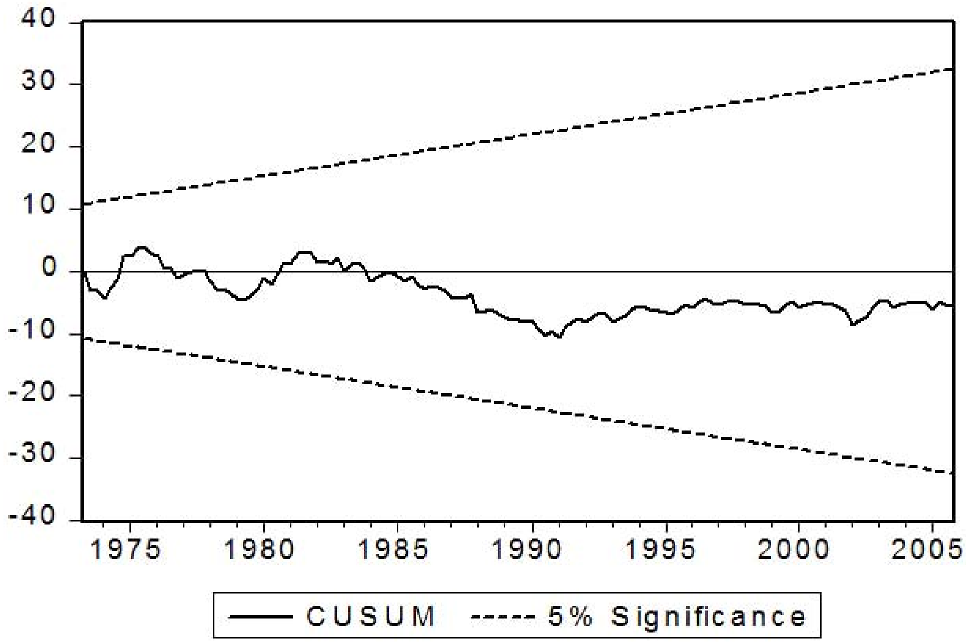
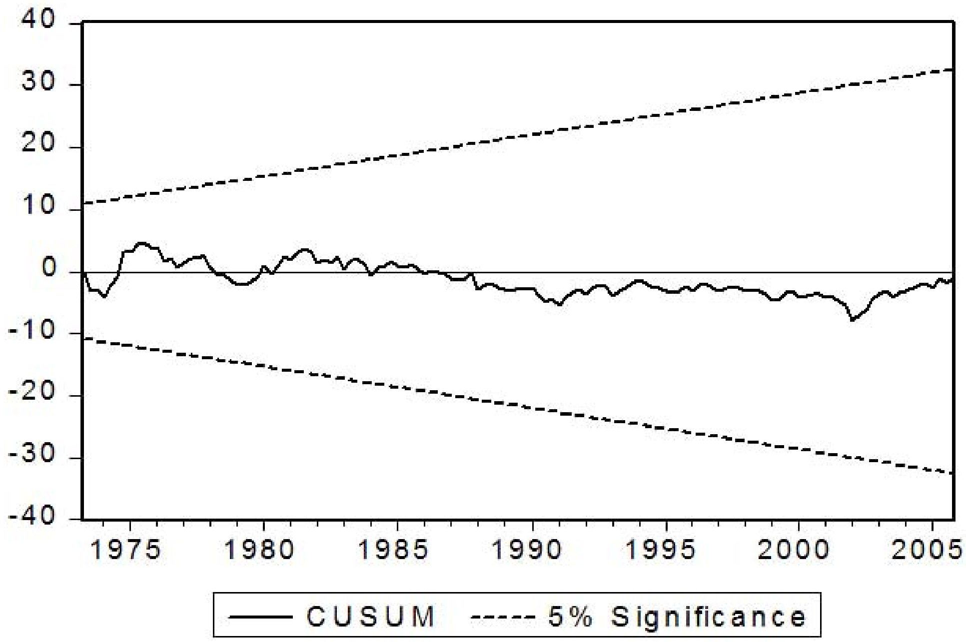


Figure 3.3: Stability tests; CUSUM test

(a) OLS vector



(b) FIML vector



The models satisfy the sign restriction as suggested by the theory of import demand (see Section 1). Also, in **Table 3.3**, the estimated coefficient of the error-correction term has the right sign[35] and shows a significant rate of adjustment (-0.234 % and -0.206 % each quarter in both methods of estimation, that is, the case of OLS-vector and FIML-vector respectively). The magnitude of this coefficient indicates that deviations from the long run function due to random shocks represent a significant determinant of the short-run dynamic behaviour.

In the short-run, the size and timing of the coefficients have important implications for policy analysis. In **Table 3.3**, all coefficients have the right sign; the coefficient of the rate of change in current GDP (ΔY) is large and shows that a change in GDP of one percent has an immediate response in the current quarter of 2.375 percent on import demand. Lagged rates of change in GDP (ΔYt-1) have a milder effect. We found no *a priori* reason to select such a time lag except that it is the smaller one, this is the time lag with the nearest effect on current values. Note, however, that it is significant and its coefficient has similar values in both OLS vector and FIML vector methods. However, a change in the exchange rate has a small (- 0.15) and immediate effect on the demand for imports. These overall results are very similar in both methodologies, that is OLS vector and FIML vector, and also they are in line with previous works for Argentina (Aggarwal 1984, and Cline 1989). Moreover, this finding is consistent with the long-run model. As indicated in the footnote to **Table 3.3**, the lagged endogenous variable, imports, is included to correct for autocorrelation and there is no theoretical indication that the coefficients should satisfy any specific sign or lag pattern. Clearly the results in the two methods are not identical. Consequently, if the model was to be used for forecasting one would have to choose for one among the two. Our intention here, however, is not forecasting but simply to highlight that the income elasticity of demand for imports remains remarkably high after correcting for autocorrelation. That autocorrelation has thus been corrected is shown by the Lagrange Multiplier (LM) test for up to fourth-order serial correlation.

---

[35] This coefficient reflects the impact of previous period deviations from the equilibrium condition on import variations (ΔM) and for the purpose of dynamic stability and cointegration, it must be negative.

2.4. Non-linear Adjustment

In the previous analysis, the adjustment of the demand for imports to its long-run relationship has been restricted to be linear. More recently, however, there is increasing interest in analysing cointegration subject to non-linear dynamic adjustment, e.g. Terasvirta & Eliasson (2001), Saikkonen (2004) and Escribano (2004). This non-linear adjustment could be assumed to be smooth rather than discrete in the presence of heterogeneous agents (see Anderson, 1997 for an empirical application of agent heterogeneity and smooth transition in the bond market). Kapetanios et al. (2006) proposed a test to detect non-linear adjustment within a co-integrating framework.[36] In what follows, we shall concentrate on the particular case where the adjustment to the long-run relationship follows a Smooth Transition Autoregressive (STAR) process.

As previously noted, the linear ECM model might suffer a misspecification problem as shown by the RESET test in **Table 3.3**. In the light of this result we proceed to the detection of a possible non-linear adjustment mechanism in the demand for imports in Argentina. In addition to the RESET test we apply the t_{NLEG} statistic developed by Kapetanios et al. (2006) which is the non-linear analogue to the Engle and Granger statistic for linear cointegration. We obtain a value of -3.65 which is significant at the 5 percent level (critical value is -3.30). According to this result deviations from the co-integrating relationship (u_t) would follow the following process

(5) $\Delta u_t = -[1-\exp(-\theta u^2_{t-1})]u_{t-1} + \varepsilon_t$

This adjustment is symmetric and faster the larger the deviation in previous period (u_{t-1}). Please note that in contrast with the classical linear ECM where the adjustment coefficient is constant, in the nonlinear case the coefficient of adjustment is time varying and depends on previous period deviations. A major feature of this nonlinear ECM is that the speed of adjustment fluctuates between the following range:

---

[36] The major advantage of this methodology over some others can be summarised as follows. Very recently, a number of studies (see e.g. Gallagher & Taylor 2001, and Hansen & Seo 2002) have used linear cointegration tests to confirm the existence of cointegration and then non-linearity is allowed to enter at the estimation stage. However, the methodology we shall apply here uses a test that is designed to have power against the alternative non-linear dynamic adjustment in the very first stage. In brief, the null hypothesis of no cointegration against the alternative of a globally stationary exponential smooth transition auto-regressive (ESTAR) cointegration is tested by examining the significance of the speed of adjustment parameter which at the same time controls the degree of non-linearity.

(6) $\text{Lim}\ u_{t-1\rightarrow\infty}\ -[1-\exp(-\theta u^2_{t-1})] = -1$

$\text{Lim}\ ut-1\rightarrow-\infty\ -[1-\exp(-\theta u2t-1)] = -1$

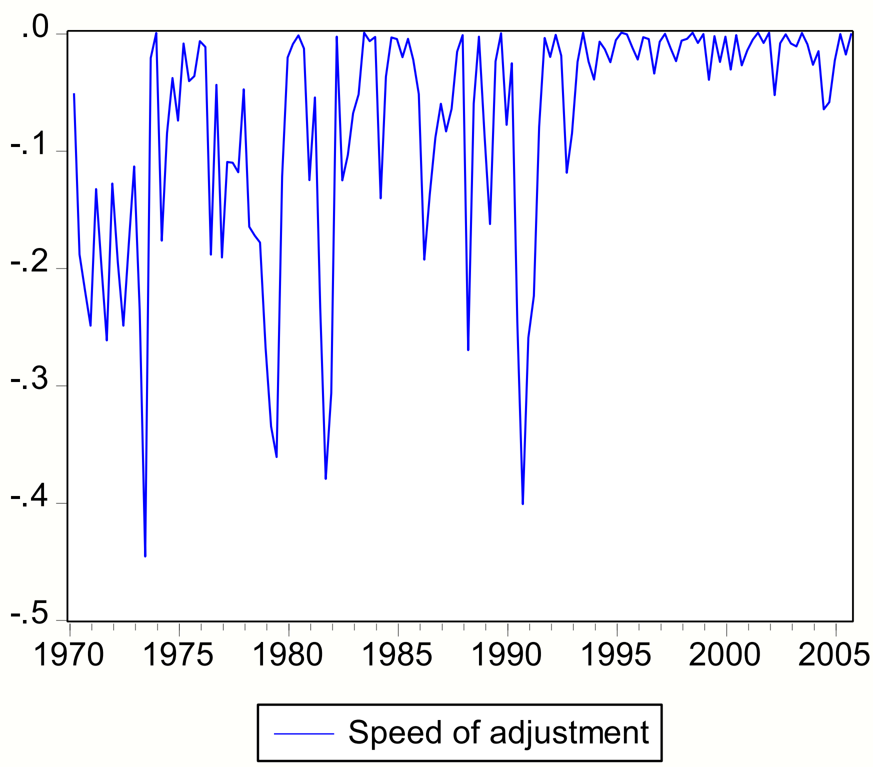
If $u_{t-1} = 0$, $[1-\exp(-\theta u^2_{t-1})] = 0$

The next step is to provide an estimate of the STAR form. In doing so, we apply Non-linear Least Squares to the following equation

(7) $\Delta u_t = -[1-\exp(-(\theta/\sigma_u)u^2_{t-1})]u_{t-1} + \Sigma\varphi\Delta u_{t-i} + \varepsilon_t$

The estimated θ value is 0.39 with a p-value of 0.01. **Figure 3.4** plots the time-varying adjustment coefficient $-[1-\exp(-\theta u^2_{t-1})]$. As can be seen, the adjustment varies from zero to -0.44. These results imply: (a) that the demand for imports in Argentina with respect to real income and exchange rate is a stable one, and (b) that its deviations adjust in a non-linear way.

Figure 3.4: Speed of adjustment coefficient in a Smooth Autoregressive (STAR) Process.



In order to compare the linear and nonlinear adjustments we compute the Generalized Impulse Response Function (GIRF). The GIRF introduced by Koop, Pesaran & Potter (1996) successfully confronts the challenges that arise in defining impulse responses for nonlinear models. Applying their methodology, our estimated half-lives for shocks of size 20%, 40% and 60% are seven, six, and five quarters, respectively. This contrasts with the linear (irrespective of shock size) half-life of three quarters. Our results suggest that the speed of adjustment in the ECM model is slower once the functional form of the residuals is free from misspecification.

3. Economic Interpretation of results

The economic interpretation of these results is quite straightforward. According to the OLS residual-based approach (eq. 3), in the long run the volume of imports grows 3.52 times faster than GDP and this does not change dramatically with changes in the exchange rate since its elasticity is rather low: 0.36. The Full Information Maximum Likelihood approach FIML (eq. 4) presents similar results: 3.29 and 0.56, respectively. In addition, the Error Correction Model (**Table 3.3**) presents again similar results for both short-run adjustment equations. During the 1970-2004 period, several and remarkably different fiscal, monetary and trade policies were adopted. Trade policies in particular, ranged from protectionism to an all-out liberalization in the nineteen nineties. Also Argentina moved from being one of the market economies with one of the highest degrees of government involvement in infrastructure to far reaching privatizations. In addition, the exchange rate experienced large fluctuations in the 1970-1990 period, a remarkable stability in 1990-2001 followed by a large currency depreciation in 2002. Therefore, such high income elasticity seems to be a structurally stable value independent of all these changes through time.[37]

The econometric results are robust and do not indicate a cointegration problem. Such high income elasticity value, however, cannot be sustained forever in a growing economy like Argentina. This calls for further research in the non-linear adjustment mechanism detected.

---

[37] Figure 3.2 and Figure 3.3 show recursive residuals and CUSUM stability tests to confirm these findings.

4. Conclusions

In this chapter new estimates for aggregate import demand in Argentina have been presented. Given the non-stationary nature of the series under study and to avoid the problem of spurious regression results, we apply the cointegration technique to quarterly data ranging from 1970:1 – 2005:4. We have found a statistically significant long-run relationship between the level of imports, real income and the exchange rate. Then, this stationary relationship has been used to estimate short-run adjustment in import demand with an error-correction model, including first differenced variables in the dynamic model.

Of particular interest is that our estimates of the income and price elasticities do not show significant changes over the period under study. Our empirical evidence has also shown that income effects play a dominant role in determining import demand with a very high elasticity, both in the long and the short-run. An implication is that Argentina may be facing an external constraint to growth if trade imbalances emerge as a result of economic expansion. At the same time, the estimated real exchange rates elasticities are very low in both the long-run and the short-run. The implication here is that conventional balance of payments adjustment (e.g. Krueger 1983) may not be effective. Finally, our non-linear analysis suggests that the demand for imports in Argentina with respect to real income and exchange rate is stable and its deviations adjust in a non-linear way.