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NONLINEARITIES AND THE BUSINESS CYCLE
IN SPANISH IMPORTS:
A SMOOTH TRANSITION REGRESSION APPROACH

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Abstract

Traditional specifications about imports have their foundations on the symmetry of the cycle, so that the linear framework has been the usual one in the empirical literature. However, the wide debate about the asymmetric character of the cycle has aroused much interest in nonlinear dynamics due to the cyclical state of the economy.

Economic theory maintains a linear long-run relationship linking imports, GDP and relative prices. In this paper we analyze whether short-run deviations from this equilibrium display any kind of nonlinear behavior related to the state of the cycle. Nonlinearities will be captured by a smooth transition regression (STR) in an error correction form. We consider two different types of switch between regimes: an endogenously determined transition where nonlinearities arise from idiosyncratic components specific to foreign trade and an exogenous one where GDP growth acts as an indicator of the cycle of the economy.

We provide empirical evidence, focused on Spanish imports of goods, supporting that short-run deviations of this variable from its linear equilibrium state display a nonlinear behavior, which is appropriately captured through an error correction STR model. As we demonstrate, this behavior is caused by the cyclical state of the economy, which defines two extreme regimes associated with a recession (or a stagnation) and a positive growth.

JEL classification: C32, E32

Key words: nonlinear behavior, smooth transition models, imports, business cycle

1. INTRODUCTION

Economic time series behavior has long assumed symmetry, so that the related model building procedure has essentially leant on the linear framework. The assumption of symmetry was not questioned in general until middle eighties, partly due to the influential article of Neftçi (1984), despite several authors have supported the existence of cyclical asymmetries for a long time (Mitchell, 1913; Hicks, 1950).

Since then, many empirical works have confirmed the asymmetry of the cycle. Plenty of economic papers stress asymmetry to lead to a nonlinear behavior in the observed variables; by way of example, we quote some articles on GDP (van Dijk & Franses, 1999; Cancelo & Mourelle, 2005a) or unemployment (Skalin & Teräsvirta, 2002; Cancelo, 2007).

Faced to this situation, we must resort to models able to capture the asymmetry of the cycle: this fact means phases of negative evolution of the variable generally deeper although shorter than those of positive behavior. The most usual specifications in the empirical literature are (Potter, 1999): the Markov Switching model, the Self-Excited Threshold AutoRegression and the Smooth Transition model. We focus on the latter. From a theoretical point of view, its flexibility allows an adequate description of a wide range of nonlinear evolutions; from an applied point of view, the smooth transition between regimes permits the use of standard nonlinear estimation techniques.

Imports have a main role in economic development; particularly, their weight over GDP has been growing for the last three decades and the tendency to import is high in Spain. The aim of this paper is to characterize cyclical asymmetries in Spanish imports of goods. This variable has hardly received attention from a nonlinear approach, as investigations have traditionally assumed a symmetric evolution; as an exception, we highlight two articles that consider a nonlinear approach to imports: Cancelo & Mourelle (2005b) and Escribano (1999).

There are two key issues in our empirical work: to investigate whether there is empirical evidence of nonlinear behavior related to cyclical asymmetries in Spanish imports of goods and, in the affirmative, to find out the underlying economic component in this nonlinear evolution. We consider that nonlinearities can either arise from idiosyncratic components specific to foreign trade or, given the clear relevance of foreign trade in economic activity, from the cyclical state of the economy.

The evolution of Spanish imports of goods is especially influenced by the economic activity level, which can be picked up by GDP, and by (domestic and import) prices. Both variables bring about the dynamics of imports and GDP might also be the cause of the asymmetry of the former; therefore, GDP plays a double role in this paper.

By means of the cointegration analysis we may evidence whether a linear long-run relation between imports and the variables determining their behavior exists. This investigation is centered on discussing to what extent short-run deviations of imports from the equilibrium location have a linear or a nonlinear dynamics. The latter will be explained through Error Correction-Smooth Transition Regression models.

The plan of the paper is as follows. Section 2 presents the foundations of smooth transition regressions and their building procedure. Section 3 contains the data analysis and reports the estimated model for Spanish imports of goods. In section 4 we develop a study to extract information about the dynamic behavior of imports in the short run. Finally, the main conclusions are outlined in section 5.

2. THE SMOOTH TRANSITION REGRESSION MODEL

2.1. Foundations

Smooth Transition (ST) models are members of the family of state-dependent models, which are a local linearization of the general nonlinear specification. In these formulations the

data-generating process is considered to be a linear process that switches between a certain number of regimes according to some rule; the regime is characterized as a continuous function of a predetermined variable, so that interactions between variables are permitted, as well as intermediate states between the extreme regimes.

This parameterization allows for capturing different types of behavior that a linear model cannot characterize in an appropriate way; moreover, once the state is given, the model is locally linear, involving an easy interpretation of the local dynamics. See Granger & Teräsvirta (1993), Teräsvirta (1998) and Sensier et al. (2002) for further details on STs.

The Smooth Transition Regression (STR) is the most general ST model: it contains an endogenous structure, as well as exogenous variables. Suppose $\{y_t\}$ a stationary, ergodic process, and, without loss of generality, only one exogenous variable x_t . The model is given by:

$$y_t = w_t' \pi + (w_t' \theta) F(s_t; \gamma, c) + u_t, \quad (1)$$

where $w_t = (1, y_{t-1}, \dots, y_{t-p_1}; x_t, x_{t-1}, \dots, x_{t-p_2})'$ is a vector of regressors, $\pi = (\pi_0, \pi_1, \dots, \pi_p)'$ and $\theta = (\theta_0, \theta_1, \dots, \theta_p)'$ are parameter vectors ($p = p_1 + p_2 + 1$), and u_t is an error process, $u_t \sim \text{Niid}(0, \sigma^2)$.

In equation (1), $F(s_t; \gamma, c)$ is the transition function, which is customarily bounded between 0 and 1; this makes the STR coefficients vary between π_j and $\pi_j + \theta_j$ ($j = 0, \dots, p$), respectively. The regime at each t is determined by the transition variable, s_t , and the associated value of $F(s_t)$. The state variable can be: a lagged endogenous variable ($s_t = y_{t-d}$ for certain integer $d > 0$, d transition lag), an exogenous variable ($s_t = x_{t-d}$) or just another variable.

The smooth transition regression is a regime-switching model that considers two distinct regimes (the basic version of STs), corresponding to $F=0$ and $F=1$. The transition from one regime to the other is smooth over time, so that there may be intermediate states between them; “smoothness” means that parameters in (1) gradually change with the state variable.

The STR model links two linear components through $F(s_t)$, so that connection features depend on the formulation for F , especially on whether it is odd or even. On this matter, we highlight two specifications. First, the logistic function, which has the form

$$F(s_t) = \frac{1}{1 + \exp[-\gamma(s_t - c)]} , \quad \gamma > 0 \quad (2)$$

and the resulting model is the Logistic STR or LSTR model. This function is the usual one in the empirical literature representing the odd case, which means that $F(-\infty) = 0$ and $F(\infty) = 1$. The slope parameter γ defines the smoothness of the transition from one regime to the other: the greater it is, the more rapid the change. The location parameter c indicates the threshold between the two regimes; here, $F(c) = 0.5$, so the regimes are associated with low and high values of s_t relative to c .

Second, the exponential function

$$F(s_t) = 1 - \exp[-\gamma(s_t - c)^2] , \quad \gamma > 0 \quad (3)$$

provides the Exponential STR (ESTR) model. This even function implies $F(\pm\infty) = 1$ and $F(c) = 0$ for some finite c , defining the outer and the inner extreme regime, respectively.

The selection of the transition function is a key point when investigating nonlinearities since, as it is noticed, LSTR and ESTR models describe quite different types of (regime-switching) behavior. In the logistic model the extreme regimes are associated with s_t values far above or below c , where dynamics may be different; the ESTR model suggests a rather similar dynamics in the extreme regimes, related to low and high s_t absolute values, while it can be different in the transition period.

The logistic transition seems to be the most adequate to capture cyclical asymmetries. However, Teräsvirta (1994) indicates that the ESTR model can have similar implications to those of the LSTR model in practice when the vast majority of the data lie to the right of the

location parameter. The choice between LSTR and ESTR will be based on the data, as economic theory hardly provides enough a priori information to distinguish between them.

These are the most common transition functions in empirical applications, although many others have been proposed in the literature, giving rise to a great variety of STR specifications. The family of ST models is a powerful tool for modeling nonlinear behavior.

For our purpose, we consider error correction models with STR structure in order to capture short-run and long-run effects in the data.

2.2. Modeling procedure

Traditionally, the STR modeling cycle has relied on developing the iterative methodology proposed by Teräsvirta (1994) for the univariate case. It involves three stages: search for specification, estimation and evaluation of the model. There exists a well-established STR modeling strategy in the literature (Granger & Teräsvirta, 1993; Teräsvirta, 1994, 1998).

The starting point consists of finding out the linear model that is characterising the behavior of the series under study. Once we obtain this specification, its adequation to the relation we are analysing is tested: if we reject the null hypothesis of the series being generated by a linear process against the alternative of a STR one, a preliminary specification of the nonlinear model is defined. This stage is centered on the selection of the appropriate transition lag and the form of the transition function. In the next step, we proceed to estimate the parameters of the STR specification by nonlinear least squares (NLS).

Despite what we have previously said, the most recent empirical works do not follow that procedure in such a strict manner. It is argued that it is possible to develop nonlinear formulations that improve the fit of the linear ones without having to do the previous test. This is done by means of an extensive search of STR models. A grid for (γ, c) through the potential values of d is defined; we select the combination (γ, c, d) that minimizes the sum of squared residuals. Lesser emphasis is laid on the early stages of the modeling procedure in

exchange for paying more attention to the evaluation of the finally proposed model (van Dijk et al., 2002; Sensier et al., 2002).

After estimating the STR model, it is necessary to evaluate its properties in order to verify if it satisfactorily explains the behaviour of the variable. Most part of the tests commonly used in dynamic models are valid in STR models. Besides, three evaluation tests especially derived for smooth transitions by Eitrheim & Teräsvirta (1996) are also presented. Particular attention is also paid to significant estimated coefficients and to the comparison between the residual variance of the nonlinear model and that of the linear regression.

Finally, a structural analysis of the STR model is developed. It is based on defining and understanding the theoretical paths imports would follow in response to different kinds of changes in GDP and in prices. As a result, the immediate effect of this change on imports (in sign and quantity) and how the variable returns to an equilibrium path can be appreciated.

In this paper, attention is centered on determining which kind of variable represents the source of nonlinearities in the evolution of Spanish imports. We focus on two cases: nonlinear behavior can have its foundations on the recent history of imports (regimes are endogenously determined) or on the cyclical state of the economy (exogenously determined regimes).

3. EMPIRICAL RESULTS

3.1. Data and preliminary issues

Imports of goods, GDP and relative prices are quarterly and seasonally unadjusted series (Source: Quarterly Spanish National Accounts base 1995, National Statistics Institute). The sample goes from 1987:Q1 to 2004:Q4 and we do the logarithmic transformation of the data.

Before studying the behavior of Spanish imports of goods, a statistical processing of the information is required. The aim is to get a suitable form of the variable, what is done by investigating nonstationarity, cointegration relations and regressors' exogeneity.

In our empirical work, the search for unit roots in the data generating processes represents a previous and experimental stage to later analyse imports; in consequence, we use a traditional unit root test. Hylleberg et al. (1990) propose the HEGY test, which detects unit roots in the long run as well as in seasonal frequencies. The results point out the need for applying regular differences in imports, GDP and relative prices variables of the STR specification, adding dummy variables that reflect the seasonal component.

In the same manner, cointegration techniques are a tool for studying long-run behavior, not a main aim, so that we also employ standard methodology in this case. Johansen strategy (1995) reveals the existence of only one cointegration relation among imports, economic activity level and competitiveness of traded goods. These results are in line with those usually obtained in the empirical literature (Doménech & Taguas, 1997; Dutta & Ahmed, 1999).

Finally, the Wu-Hausman test (1973, 1978) indicates that GDP and relative prices verify the regressors' exogeneity assumption.

Detailed results of these three analysis are available from authors upon request.

3.2. Estimated model

Once the statistical processing is done, we determine the linear specification that would describe the evolution of imports, in an error correction form. This model building procedure is based on considering a maximum lag order (p) of the differenced variables, as well as the levels of the three variables at t-1, three seasonal dummies $D_{s,t}$ ($s = 1, 2, 3$) and a constant term. We regard 6 as the highest value for p.

We carry out an ordinary least squares estimation; first, all parameters are included, but then those nonsignificant at a 0.05 level are successively excluded. The resulting model is

$$\begin{aligned}
 \Delta y_t = & -2.47_{(1.73)} - 0.09D_{1t} - 0.03D_{2t} - 0.12D_{3t} - 0.35\Delta y_{t-2} - 0.30\Delta y_{t-3} - 0.22\Delta y_{t-5} + \\
 & + 1.39\Delta x_t + 1.80\Delta x_{t-1} + 3.07\Delta x_{t-2} + 2.61\Delta x_{t-3} + 1.40\Delta x_{t-4} + 1.05\Delta x_{t-5} - \\
 & - 0.45\Delta p_t + 0.28\Delta p_{t-1} + 0.26\Delta p_{t-2} + 0.30\Delta p_{t-3} + 0.58\Delta p_{t-4} - \\
 & - 0.34y_{t-1} + 0.66x_{t-1} - 0.40p_{t-1} + u_t
 \end{aligned} \tag{4}$$

In this expression, y_t stands for the imports variable, x_t for GDP and p_t for relative prices; $D_{s,t}$ ($s = 1, 2, 3$) denote seasonal dummy variables. Values under regression coefficients are standard errors of the estimates.

The long-run relation can be obtained from the estimation of the variable in levels in (4). The following expression captures the deviations from equilibrium (“ec” stands for the error correction term), where deterministic terms are neglected:

$$ec_t = y_t - 1.95 x_t + 1.16 p_t \quad (5)$$

This outcome confirms what economic theory maintains, as we notice a direct relation between economic activity level and imports, and the reverse between the latter and their relative prices level. Likewise, price elasticity is approximately one, whereas income elasticity moves around two. Our results are similar to those achieved in different empirical works related to foreign trade in Spain; see for instance Buisán & Gordo (1997) and Escribano (1996).

The final linear model is attained when reparameterizing formulation (4), so that the error correction term identifying the long-run relation appears in a explicit manner. The fitted specification, joint with the standard error of the estimated residuals (s) and the linear determination coefficient (R^2), is the following one:

$$\begin{aligned} \Delta y_t = & -2.47_{(0.49)} - 0.09_{(0.04)} D_{1t} - 0.03_{(0.02)} D_{2t} - 0.12_{(0.04)} D_{3t} - 0.35_{(0.10)} \Delta y_{t-2} - 0.30_{(0.11)} \Delta y_{t-3} - 0.22_{(0.11)} \Delta y_{t-5} + \\ & + 1.39_{(0.36)} \Delta x_t + 1.80_{(0.38)} \Delta x_{t-1} + 3.07_{(0.41)} \Delta x_{t-2} + 2.61_{(0.48)} \Delta x_{t-3} + 1.40_{(0.48)} \Delta x_{t-4} + 1.05_{(0.37)} \Delta x_{t-5} - \\ & - 0.45_{(0.15)} \Delta p_t + 0.28_{(0.15)} \Delta p_{t-1} + 0.26_{(0.14)} \Delta p_{t-2} + 0.30_{(0.14)} \Delta p_{t-3} + 0.58_{(0.14)} \Delta p_{t-4} - 0.34_{(0.06)} ec_{t-1} + u_t \end{aligned} \quad (6)$$

$$s = 0.0256, R^2 = 0.95$$

The first step in detecting nonlinearities in short-run deviations from equilibrium is to test a linear characterization of imports against a LSTR or an ESTR one. The discussion

concerning linearity tests goes beyond the scope of this paper; literature on the subject can be found in Teräsvirta (1994, 1998) or Escribano & Jordá (1999, 2001).

Linearity tests are based on a sequence of auxiliary regressions. As the transition lag, d , is unknown, two strategies have been proposed to deal with this problem. The first one consists of assuming that d is a known value: auxiliary regressions are estimated for all these potential values and we choose the one that minimizes the p-value of the linearity test (Teräsvirta, 1994). This is the so-called “conditional” approach.

The second strategy considers that the transition variable is the linear combination $\sum_{i=0,1}^p v_i s_{t-i}$, where $v' = (0 \dots 1 \dots 0)'$ is a selection vector with the only unit element corresponding to the unknown transition lag and s_t is the transition variable (Teräsvirta, 1998). This is the “unconditional” procedure.

The loss of degrees of freedom is particularly severe in our case, as there is a great number of cross products in the auxiliary regressions due to the presence of explanatory variables and seasonal dummies; the power is especially poor under the exponential alternative. In consequence, we use the conditional approach: we solve an auxiliary regression for each potential transition variable; the F-statistic determines the cases where a nonlinear evolution of Spanish imports of goods can not be rejected.

The transition variables we take into account in the auxiliary regressions are the seasonal differences (of the logarithm) of imports, GDP and relative prices, and the error correction term. The transition lag (d) varies from 1 to 4 in the case of imports growth and deviations from equilibrium, and from 0 to 4 for GDP and relative prices differences. The transition function is allowed to be either logistic or exponential.

Figures in table 1 indicate that we do not generally reject the hypothesis of a linear behavior of imports.

INSERT TABLE 1 HERE

As the tests show a low power, we take these empirical results with caution and do not consider them as conclusive, and we follow the aforementioned procedure of an extensive STR search. Based on this explanation, the role of linearity tests in our empirical research is more that of being a tool for the specification of the STR model than strictly use it to test a given theory.

The specification of the nonlinear model starts from the final linear regression: the latter determines which variables constitute the former. Furthermore, the estimated linear coefficients are used as starting values in the NLS estimation. The extensive search generates multiple STR specifications, although parameter convergence is not attained in some of them. Where it is reached, models are subject to further refinement. First, nonsignificant coefficients are excluded to conserve degrees of freedom; then, we simplify this first set of estimations through cross-parameter restrictions in order to increase efficiency. We take 1.6 as the limit t-value for these coefficients.

Finally, we carry out the selection of the model presenting the best properties among the candidates. The validation procedure is based on evaluation tests that will be shortly described; attention is also paid to the significance of the estimated coefficients and the characteristics of the transition function.

Given a linear equilibrium relation between our three variables, empirical evidence reveals that short-run deviations of Spanish imports of goods from this equilibrium show a nonlinear evolution. This behavior is described by means of a STR model with an exponential transition between regimes; the latter determines that the cyclical state of the economy

(captured by GDP annual growth) in term t produces nonlinear effects on imports growth three terms later.

Our proposed model, together with some diagnostic and evaluation statistics is reported in (7); figure 1 depicts the estimated transition function.

$$\begin{aligned}
\Delta y_t = & \underset{(1.16)}{-3.97} - \underset{(0.08)}{0.37} D_{1t} - \underset{(0.04)}{0.01} D_{2t} - \underset{(0.07)}{0.28} D_{3t} - \underset{(0.28)}{0.83} \Delta y_{t-2} - \underset{(0.07)}{0.22} \Delta y_{t-3} + \underset{(0.19)}{0.84} \Delta x_t + \underset{(0.94)}{4.21} \Delta x_{t-1} + \\
& + \underset{(0.90)}{4.39} \Delta x_{t-2} + \underset{(1.59)}{5.30} \Delta x_{t-3} + \underset{(1.16)}{3.66} \Delta x_{t-4} + \underset{(0.31)}{1.04} \Delta x_{t-5} - \underset{(0.36)}{0.95} \Delta p_t + \underset{(0.37)}{0.93} \Delta p_{t-1} + \underset{(0.44)}{1.10} \Delta p_{t-2} - \underset{(0.16)}{0.55} e_{t-1} \\
& + \left(\underset{(1.40)}{2.96} + \underset{(0.08)}{0.37} D_{1t} - \underset{(0.05)}{0.05} D_{2t} + \underset{(0.08)}{0.22} D_{3t} + \underset{(0.28)}{0.83} \Delta y_{t-2} - \underset{(0.07)}{0.22} \Delta y_{t-3} + \underset{(0.19)}{0.84} \Delta x_t - \underset{(1.10)}{3.18} \Delta x_{t-1} - \underset{(0.99)}{2.59} \Delta x_{t-2} - \right. \\
& \left. - \underset{(1.59)}{5.30} \Delta x_{t-3} - \underset{(1.16)}{3.66} \Delta x_{t-4} + \underset{(0.36)}{0.95} \Delta p_t - \underset{(0.37)}{0.93} \Delta p_{t-1} - \underset{(0.56)}{1.63} \Delta p_{t-2} + \underset{(0.22)}{0.55} \Delta p_{t-3} + \underset{(0.17)}{0.81} \Delta p_{t-4} + \underset{(0.19)}{0.41} e_{t-1} \right) \\
& \times \left[1 - \exp \left\{ - \underset{(0.30)}{0.74} \times 344827 \left(\Delta_4 x_{t-3} - \underset{(0.002)}{0.01} \right)^2 \right\} \right] + u_t
\end{aligned} \tag{7}$$

$$s = 0.0214, R^2 = 0.97, s^2/s_L^2 = 0.56, ARCH = 0.53(0.71), BCH = 0.06(0.81), AUTO = 2.32(0.06), NL = 2.19(0.06), PC = 0.45(0.91)$$

INSERT FIGURE 1 HERE

The diagnostic statistics employed are the following: the residual standard error (s); the determination coefficient (R^2); the variance ratio of the residuals from the nonlinear model and the linear specification (s^2/s_L^2). According to the latter, the ESTR model explains 44 percent of the residual variance of the linear regression.

Regarding the evaluation statistics, we consider the statistic of no autoregressive conditional heteroskedasticity with four lags (ARCH); the Öcal & Osborn's (2000) test of business cycle heteroskedasticity (BCH); the Eitrheim & Teräsvirta's (1996) tests specially derived for smooth transition models. The latter include: i) the test of residual serial independence against a process of order 10 (AUTO); ii) the test of no remaining nonlinearity in the residuals, which has been computed for several values of the transition lag under the alternative but only the one minimizing the p-value of the tests is displayed (NL); iii) the test of parameter constancy that allows for monotonically changing parameters under the alternative (PC).

The estimated ESTR model in (7) shows how imports growth depends on its own recent history, as well as on GDP and relative prices dynamics; in the same manner, it reacts to deviations from the equilibrium state. The specification contains seasonal dummies, whose behavior can vary according to the transition function (i.e., with the state of the economy). Data suggest the application of cross-parameter and exclusion restrictions.

Even though the transition function is exponential, it has similar regime implications to the logistic specification in practice, as almost all the observations lie to the right of the location parameter. The variation range of this function is reasonably wide, allowing more flexibility in the dynamics of imports. As the nonlinear behavior is determined by the general cycle of the economy, we can define a lower extreme regime, covering from recession to moderate economic growth, and an upper extreme regime, in case of moderate growth to strong recoveries. The better adequacy of a (in practice) logistic transition function is now justified, as imports clearly display a different behavior depending on the economic regime.

The model presents no evidence of misspecification. There are neither signs of ARCH nor cyclical heteroskedasticity in the estimated residuals at a 0.05 significance level. Eitrheim & Teräsvirta (1996) validation tests do not detect serial dependence in the estimated residuals. They also evidence no need for a second transition function, as well as constancy in the parameters of the model.

In order to describe the behavior of the ESTR model more in depth, the previous evaluation tests are completed with the analysis of the estimated residuals. Figure 2 plots the residuals from nonlinear and linear models, together with their respective standard errors (s), 0.0162 and 0.0218.

INSERT FIGURE 2 HERE

The ESTR model globally lessens the highest (positive or negative) residuals of the linear specification in a considerable way. We can appreciate how the residuals of the nonlinear model are to a greater extent within the band that defines their standard error than those of the linear model. Here we count on the first signs of a better behavior of the nonlinear model, a fact the variance ratio had already pointed out.

These divergences between residuals are particularly striking in the most outstanding phases of the Spanish economy along the sample: the strong growth in late eighties (1988-1991), the later crisis (1992-1994) and the beginning of a slowdown period in 2001. Figure 3 depicts the differences, in absolute values, between the residuals of the linear formulation and those of the ESTR model. Positive deviations are the prevailing ones over time.

INSERT FIGURE 3 HERE

The evaluation of the selected ESTR model is satisfactory, so we may conclude that this specification explains in an appropriate way the evolution of Spanish imports of goods.

4. ANALYSING THE SHORT-RUN DYNAMICS OF SPANISH IMPORTS OF GOODS

The exam of the lag structure and the residuals of the ESTR model does not provide us with all the information about the dynamics of imports of goods. Thus, we complete the evaluation of the nonlinear model by analysing its dynamic properties, which will allow us to better characterize the variable. This study consists of comparing the path imports would keep, depending on whether its behaviour is described by the nonlinear model or the linear specification, after the effect of changes in GDP or in relative prices.

Two essential aspects have to be mentioned in this comparative analysis. On the one hand, we consider as starting values for GDP and relative prices their corresponding means in the

period under study. On the other hand, when examining the effect of a change in one of the regressors on imports, we assume that the values of the other regressor remain constant at a certain level. For each assumption of changes in GDP or in relative prices, figures 4 to 9 plot the simulated evolution of imports. Variables are expressed in annual terms, using percentages.

Starting with the variable of economic activity, the point of departure is a stationary equilibrium state where a 3.2 percent GDP annual rate of growth and a constant level in relative prices lead to a rate of growth of imports equal to a 6.2 percent.

INSERT FIGURE 4 HERE

INSERT FIGURE 5 HERE

The first case we pose is depicted in figure 4: the economic activity level steadily rises at a 3.2 percent rate until it starts to rise at a lower pace, a 0.4 percent. Faced with this slowdown, imports following the two estimated models show an outstanding and sharp fall in their growth. A remarkable fact is the overreaction that characterises the subsequent periods to the change. In the long run, imports grow at an annual 0.8 percent, a very low rate compared to that of the starting point.

The recovery and return to an equilibrium growth after the initial overreaction takes place, in principle, more rapidly in the linear specification. Nonetheless, this result must be interpreted with caution, as the readjustment process in the case of the ESTR model is dominated by the seasonal behavior; seasonality difficult to detect that imports reach their long-run growth almost at the same time in both models.

The ESTR model (7) reveals two important questions regarding seasonal dummy variables: their significant coefficients, as well as their interaction with the estimated transition function, dependent on GDP annual rate of growth. Therefore, any variation in the state of the economy affects the seasonality of imports of goods.

In this exercise, when GDP varies from a 3.2 percent to a 0.4 percent growth rate, the transition function changes from 0.59 to 0.20, respectively; the coefficients of the seasonal dummies are rather different in one case and the other. The evolution plotted in figure 4 reflects the key role the transition function plays.

The second exercise is based on a variation in GDP growth from an annual 3.2 percent to a 6 percent. This evolution leads to a high growth in imports in the short run in both models; the magnitude of these growths is greater than the one that determines the long-run behavior (that is, existence of overreaction). Initial growths last a longer period of time until they reach the equilibrium, which is given by a 11.7 percent rate, in the ESTR model; their irregular evolution is depicted in figure 5. Now, the value of the estimated transition function goes from 0.59 to 1, what causes an important change in the coefficients of the seasonal dummies.

Below, we detail the simulation analysis with the relative import prices variable. The starting point is a stationary state where a constant GDP level and a growth of an annual -4 percent in relative prices determine a 4.6 percent rate of growth for imports.

INSERT FIGURE 6 HERE

INSERT FIGURE 7 HERE

In the first exercise we assume a fall in their rate of growth, an annual -7.2 percent at present. Imports react to this decrease in the rate with an increase in their growth level: the result is that the nonlinear model defines a similar path to that described by the linear specification (see figure 6). After the change, both models display a growth in imports slightly higher than the one defining the starting stationary state. The mentioned growth remains almost stuck in the new value a (relatively) short period of time until it starts a gradual rise towards the new stationary state (long-run variation, 8.4 percent).

In the second case, relative prices grow at a higher rate than the initial one: the current rate is a -0.8 percent. Paths described by both models are shown in figure 7, where their similarity

is appreciated, as well as their symmetry with those presented in the previous analysis. The evolution of imports turns unfavorable in this situation, although their growth is scarcely affected: it decreases in a short magnitude at the initial moments to subsequently start a gradual fall towards the long-run location, where imports grow at only a 0.9 percent rate.

It is worth mentioning that we have carried out some other tests with different equilibrium growth values: the results we obtain are similar to those presented here.

A fact stands out in these two exams: a positive effect of relative prices as well as a negative one generate, according to both models, symmetric responses in imports. So as to prove whether the short-run response of imports to variations in competitiveness is the same or not depending on the state of the cycle, we carry out an additional analysis. The simulations already done had their basis on an economy in stagnation, with a null GDP growth; let's assume, under the same hypothesis on prices, a stationary state given by a 3 percent GDP annual rate of growth. The transition function passes from 0.37, corresponding to the exams plotted in figures 6 and 7, to 0.84 in the simulations illustrated in figures 8 and 9.

INSERT FIGURE 8 HERE

INSERT FIGURE 9 HERE

Under the two assumptions on prices, paths defined by ESTR and linear models are again symmetric. Nevertheless, in this new context the path the ESTR specification determines proves to be more abrupt than in the previous case; the influence a different seasonal behavior of imports can be exerting must be taken into account. Equilibrium growths of imports are greater in this stage of outstanding economic growth.

From these results we conclude that, in the short run, the reaction of Spanish imports of goods to alterations in their competitiveness is affected by the phase of the economy at each t.

Along the simulation tests we prove the different character of the response, in the short run, of imports of goods to changes in GDP and in relative prices according to the (nonlinear or linear) specification the variable follows. In this horizon, the behavior of both models almost exclusively differs when changes in GDP occur; with regard to prices, the evolution is similar. Likewise, we confirm that nonlinear and linear models lead to the same long-run state for imports.

5. CONCLUSIONS

The cointegration analysis pointed out the linear long-run relation among Spanish imports of goods, economic activity level and relative import prices. The results we have just presented in detail reveal that short-run deviations of imports from this equilibrium evidence a nonlinear behavior that is adequately captured by a smooth transition regression model. Nonlinearities are associated to the asymmetric effects of economic activity on imports (GDP annual rate of growth comes out as the transition variable); the cyclical state of the economy defines two extreme regimes assimilable to recession/stagnation and positive evolution.

An aspect to take into account is the role the long-run relation is playing; we have checked that deviations of imports from the equilibrium path is one of the determinants of the current behavior of our variable. Nonlinearities affect the response of imports to deviations, as imports re-adjust in a different manner depending on the phase driving the economy.

The cointegration relation between the three variables makes the evolution of imports converge, with nonlinear and linear specifications, to the same long-run growth. In spite of this fact, the study of the theoretical paths of imports reflecting changes in GDP or in relative prices allows us to appreciate the different behavior ESTR and linear models display in the short run. According to both specifications, imports path in the short run undergoes overreactions in view of GDP modifications, as well as relevant but less acute reactions to

changes in relative prices. Faced with alterations in the explanatory variables, the different intensity in the response nonlinear and linear models show explains the different behavior they describe. In particular, the ESTR specification generally determines more abrupt reactions of imports than those associated to the linear model.

Furthermore, the simulation research reveals two striking matters. On the one side, the general cycle of the economy determines the response of imports to variations in the competitiveness of traded goods; on the other side, the cyclical state of the economy also affects the seasonal behavior of imports, so the former has influence on the responses of the latter to changes in the explanatory variables.

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Table 1.- Linearity tests against the STR alternative (p-values)

d	Transition variables							
	$\Delta_4 y_t$		$\Delta_4 x_t$		$\Delta_4 p_t$		ec_t	
	LSTR	ESTR	LSTR	ESTR	LSTR	ESTR	LSTR	ESTR
0	-	-	0.3083	0.2669	0.6430	0.7348	-	-
1	0.4635	0.9678	0.6501	0.2646	0.0816	0.0856	0.7544	0.7648
2	0.4563	0.3327	0.4824	0.8109	0.3850	0.5796	0.5163	0.5032
3	0.0982	0.2215	0.3861	0.0740	0.5995	0.2523	0.2355	0.7109
4	0.0563	0.2914	0.1020	0.7466	0.6066	0.1094	0.5361	0.6748

Figure 1.- Estimated transition function

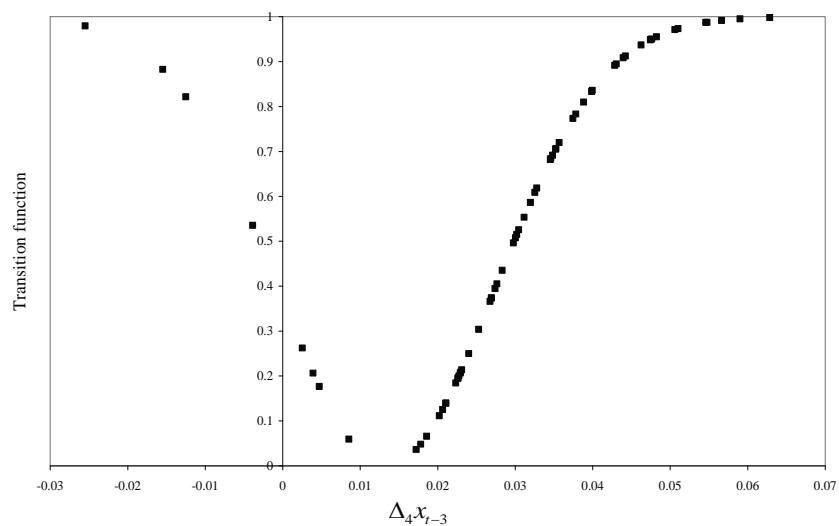


Figure 2.- Estimated residuals from ESTR and linear models

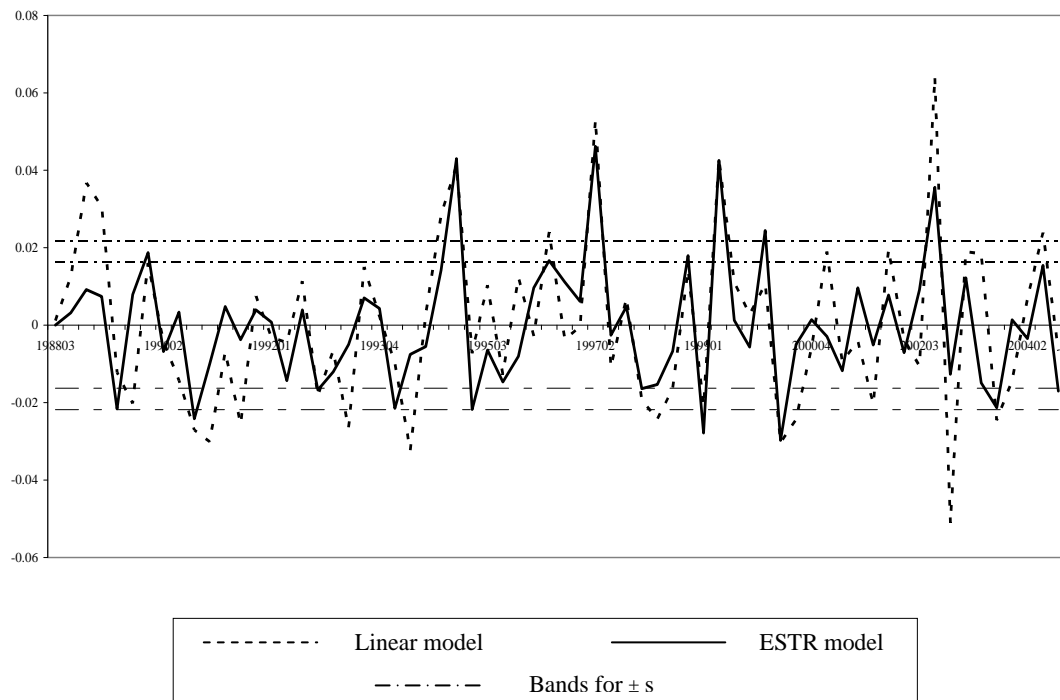


Figure 3.- Differences between the absolute values of the estimated residuals from ESTR and linear models

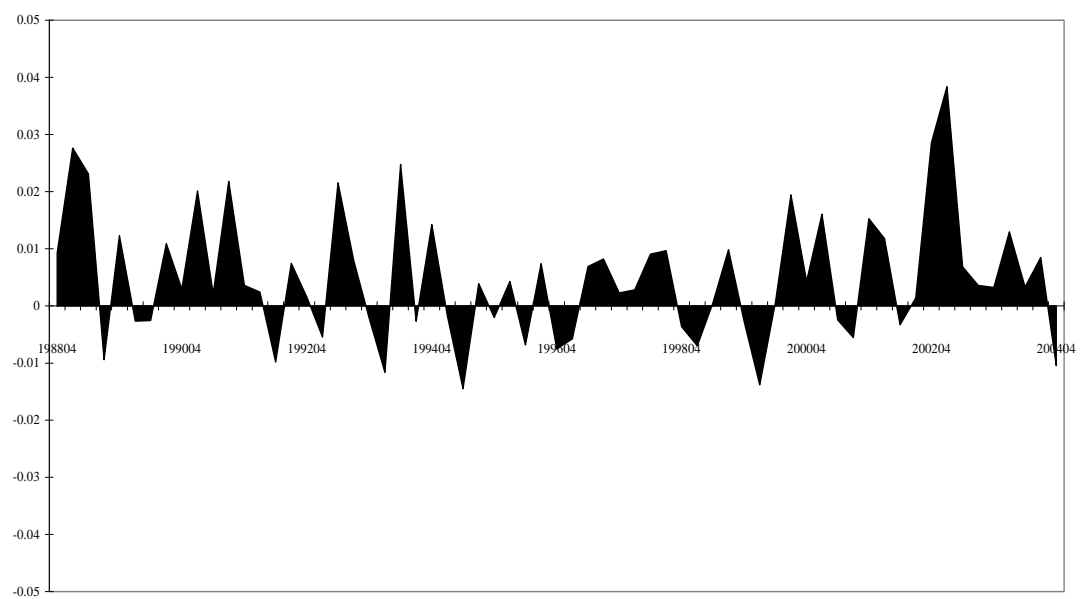


Figure 4.- Changes in GDP growth: effect on imports
Decrease in the annual rate of growth: from 3.2% to 0.4%

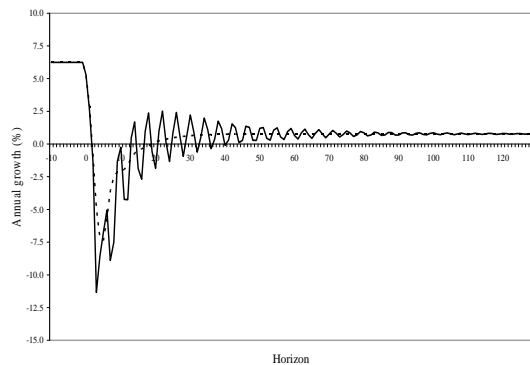


Figure 5.- Changes in GDP growth: effect on imports
Increase in the annual rate of growth: from 3.2% to 6%

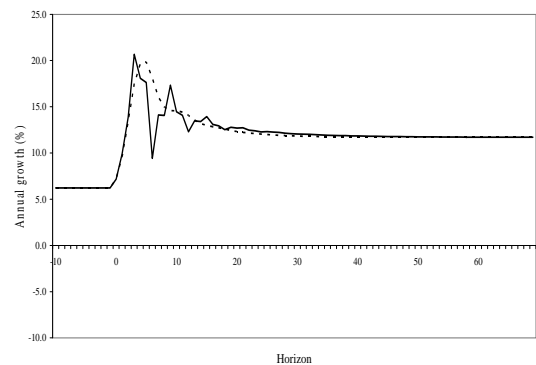


Figure 6.- Changes in relative import prices growth
(constant GDP): effects on imports
Decrease in the annual rate of growth: from -4% to -7.2%

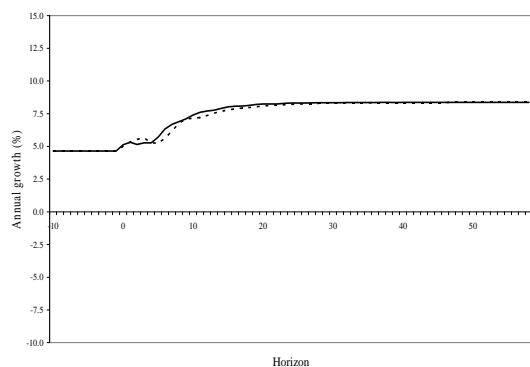


Figure 7.- Changes in relative import prices growth
(constant GDP): effects on imports
Increase in the annual rate of growth: from -4% to -0.8%

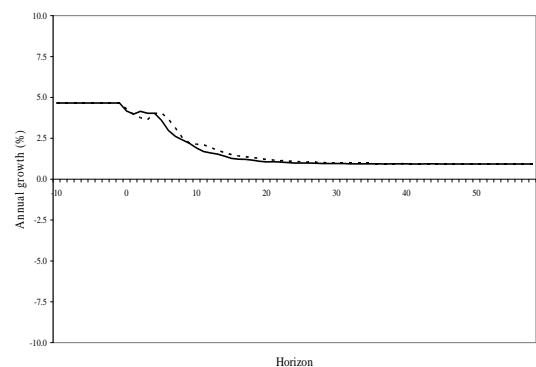


Figure 8.- Changes in relative import prices growth
(3% GDP equilibrium growth): effects on imports
Decrease in the annual rate of growth: from -4% to -7.2%

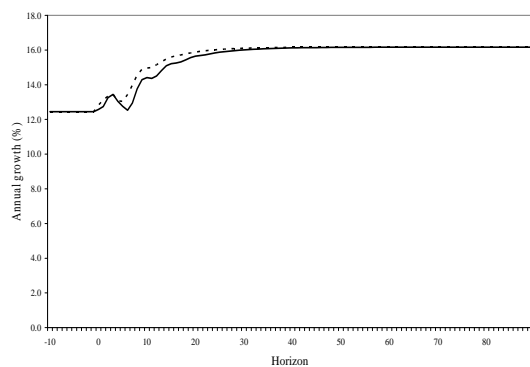
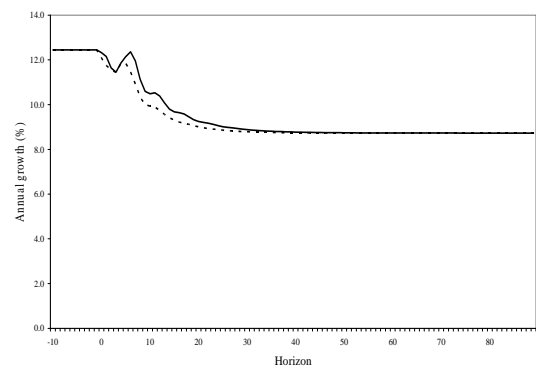


Figure 9.- Changes in relative import prices growth
(3% GDP equilibrium growth): effects on imports
Increase in the annual rate of growth: from -4% to -0.8%



————— ESTR model

- - - - - Linear model