DISCUSSION PAPER SERIES

IZA DP No. 9467

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October 2015

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

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Discussion Paper No. 9467
October 2015

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IZA Discussion Paper No. 9467
October 2015

ABSTRACT

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This paper investigates whether exchange rate pass-through (ERPT) into import prices is a nonlinear phenomenon for five heavily indebted Euro area countries, namely the so-called GIIPS group (Greece, Ireland, Italy, Portugal, and Spain). Using logistic smooth transition models, we explore the existence of nonlinearity with respect to sovereign bond yield spreads (versus the German bund) as an indicator of confidence crisis/macroeconomic instability. Our results provide strong evidence that the extent of ERPT is higher in periods of macroeconomic distress, i.e. when sovereign bond yield spreads exceed a given threshold. For almost all the GIIPS countries, we reveal that the increase in macroeconomic instability and the loss of confidence during the recent sovereign debt crisis has entailed higher sensitivity of import prices to exchange rate movements. For instance, the rate of pass-through in Greece is equal to 0.66% when the yield differential is below 2.13%, but beyond this threshold level, the sensitivity of import prices becomes higher and reaches full ERPT. Our findings raise the serious question of whether the exchange rate could be an effective tool to boost the trade balance and prevent deflationary threats when financial crisis hits.

JEL Classification: C22, E31, F31

Keywords: exchange rate pass-through, import prices, sovereign spreads, smooth transition models

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1. Introduction

The financial crisis of 2007-2008 had a serious impact on the Euro area government bond market and turned into a sovereign debt crisis at the beginning of 2010. Due to the general weakness of fiscal fundamentals in the so-called GIIPS countries, i.e. Greece, Italy, Ireland, Portugal and Spain, financial markets were highly affected by deeply felt concerns on the solvency of this group of countries. There was a change in the markets' assessment of sovereign debt risks. This caused yield spreads to German bonds to rebound to levels exceeding those observed in the early years of the third stage of the Economic and Monetary Union (EMU). As a matter of fact, the introduction of the single currency in 1999 eliminated normal market reactions towards highly indebted Euro area countries; there was a phase of pronounced government bond yield convergence, as the Euro was regarded as a safe haven (see Figure 1). Additionally, the improvement in the general macroeconomic environment brought about by the monetary union changed the general perception of risk towards EA economies with high debt ratios, significantly narrowing interest rate differentials.

In this paper, we test whether this change in macroeconomic conditions, caused by the crisis of confidence on sovereign debt, could influence the extent of exchange rate pass-through (ERPT). The exporter's decision on the extent to which exchange rate movements should be passed through into prices may depend on the perceptions of the importing country's macroeconomic stability. When the economy faces a financial or confidence crisis, foreign firms may decide to "pass through" a larger proportion of exchange rate changes in view of the increased likelihood of default from the importer. In this case, ERPT is higher, since exporters tend to set prices in their own currency (*producer-currency pricing* or *PCP* strategy). However, when macroeconomic conditions are considered good, exporting firms absorb currency fluctuations within markup by setting prices in the currency of the stable importing country (*local-currency pricing* or *LCP* setting). Consequently, ERPT is expected to be higher in times of confidence crisis than during periods of macroeconomic stability. Given that the European sovereign debt crisis gave rise to a deteriorating macroeconomic environment, we investigate whether pass-through rates were affected by this same crisis.

Several studies have underlined the role of macroeconomic environment in determining the degree to which currency changes are transmitted to domestic prices (Taylor, 2000; Choudhri and Hakura, 2006; Gagnon and Ihrig, 2004, to name but a few). A common drawback of most of this literature is that it assumes there is a linear connection between pass-through and macroeconomic factors (such as inflation environment or credibility levels of monetary policy), rather than testing it. However, as pointed out by Bussière (2013), there are several sources of nonlinearities in the ERPT mechanism, and the relationship between

macroeconomic variables and pass-through can potentially be nonlinear. In spite of its relevance for monetary policy, studies dealing with nonlinearities in the pass-through mechanism are still relatively scarce. Most of the few empirical works dealing with nonlinearities have used nonlinear threshold models where the transition across regimes is abrupt (see e.g. Correa and Minella, 2006; Ben Cheikh and Louhichi, 2014). Nevertheless, a threshold framework would be more appropriate at the microeconomic level where a single foreign firm is setting prices. In fact, an exporter can change pricing behaviour sharply with regard to macroeconomic conditions in the importing country. Meanwhile, at the aggregate level, firms form very diverse opinions about the macroeconomic environment in the importing country; hence, assuming an abrupt transition from one regime to the other is unrealistic. Therefore, the transition across regimes is rather gradual at the macro level, since there is some heterogeneity across firms in their attitude towards the state of the importer's macroeconomic environment. To overcome this shortcoming, a very recent empirical literature proposes to use another class of nonlinear regime-switching models, namely the smooth transition regression (STR) model where the transition between states is rather smooth.

To the best of our knowledge, there are very few empirical studies testing for nonlinearities in ERPT using a smooth nonlinear regression. Shintani et al. (2013) estimated ERPT to US domestic prices with respect to inflation regime. They found that periods of low ERPT tend to be associated with low inflation levels. In a similar vein, Ben Cheikh (2012) has investigated for the presence of a nonlinear mechanism in pass-through for the Euro area case. The author found strong evidence of nonlinearities with respect to inflation environment in 8 out of 12 Euro area countries, that is, when the inflation rate surpasses a given threshold, the transmission of exchange rate becomes higher in some European countries. For the case of Mexico, Nogueira Jr. and Leon-Ledesma (2011) examine the possibility of nonlinear pass-through with respect to macroeconomic instability. The authors conclude that under bad macroeconomic conditions, as in periods of financial or confidence crisis, ERPT to consumer prices will be higher than in periods of macroeconomic stability. As a measure of macroeconomic instability, Nogueira Jr. and Leon-Ledesma (2011) used the Mexican real interest rate differential with respect to the U.S. This indicator is used as a transition variable in their smooth transition model.

In this paper, our approach is close toNogueira Jr. and Leon-Ledesma (2011) when using a STR framework to estimate the nonlinear behaviour of ERPT with respect to macroeconomic instability. Nevertheless, our study introduces some novelties regarding the cited papers which are threefold. First, we focus on the five GIIPS countries, due to the recent context of the European sovereign debt crisis. Shedding light on how pass-through behaves

during such episodes is of key importance for the European monetary authorities. Second, we use the 10-year government yield spreads to German bonds as an indicator of macroeconomic instability. The perception that some Eurozone countries are reaching an unsustainable fiscal situation is reflected in the widening of sovereign bond yield differentials, synonymous with a worsening in macroeconomic fundamentals. Therefore, we suggest that foreign firms may tend to change their pricing behavior as a result of the deteriorating macroeconomic environment in the importing country, and the extent of ERPT will be affected accordingly. The main advantage of the STR models is that they capture this changing behaviour in a nonlinear fashion. To our knowledge, no other study has applied a nonlinear STR approach to measuring ERPT in this context. Finally, unlike previous works in this area, we analyze the so-called "first step pass-through", i.e. the transmission of exchange rate changes to import prices, instead of the pass-through to import prices. This issue is a key input for determining the path of external adjustment. As is well-known, in the case of currency depreciation, a higher degree of ERPT may help correct trade imbalances. However, if import prices respond sluggishly to changes in the exchange rate, an external adjustment of the economy via relative price changes would not happen. Thus, measuring the extent of ERPT to import prices in periods of crisis can help to assess the possibility of using the exchange rate as an instrument to improve the trade balance and, eventually, offset the slowdown in economic activity.

The remainder of the paper is organized as follows. Section 2 outlines several arguments that justify the existence of nonlinear ERPT with respect to macroeconomic environment. The empirical approach is provided in Section 3. Section 4 covers the main empirical results and Section 5 concludes.

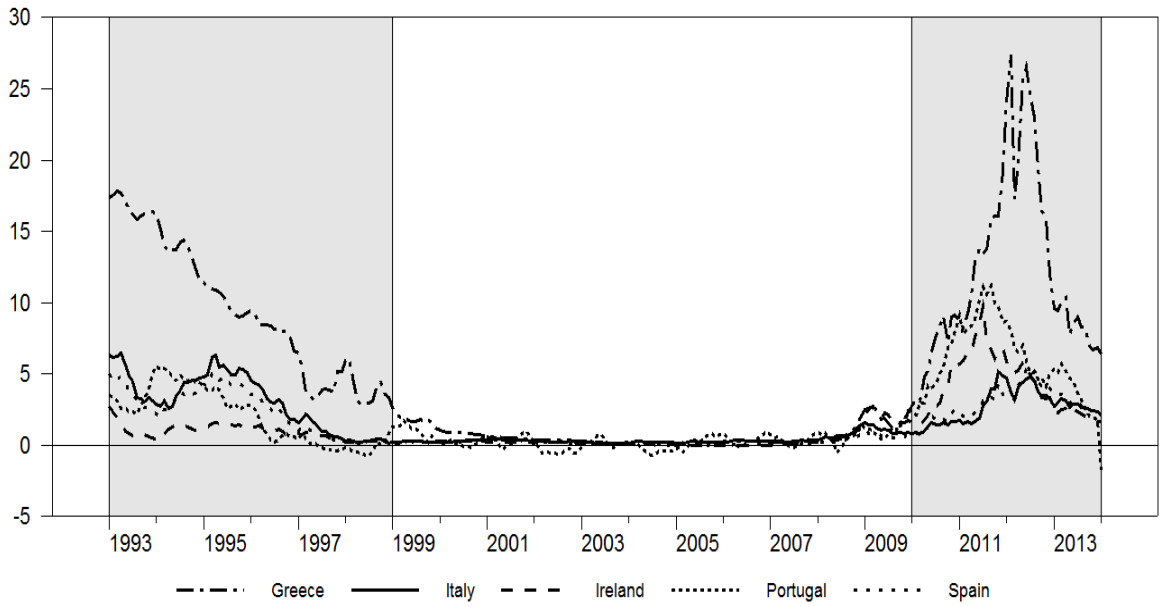
2. ERPT in times of crisis

In recent years, there has been a revival of interest in the role of macroeconomic factors as important determinants of the extent of pass-through. This strand of literature highlights the role of a stable macroeconomic environment and in particular the shift towards a credible monetary policy regime in explaining the observed decline in the degree of ERPT. One of the first to put forward this argument was Taylor (2000), who stipulates that countries with low relative inflation variability or stable monetary policies are more likely to have their currencies chosen for transaction invoicing, and hence are more likely to have low pass-through to domestic prices. In other words, a stable inflation environment in the importing country may lead exporters to adopt a *local-currency pricing* (*LCP*) strategy. Firms can absorb currency changes within markup, leading to a lesser extent of pass-through. By contrast, when the importing country experiences higher inflation levels, exporters may change their pricing decision by adopting a *producer-currency pricing* (*PCP*) strategy, by

transmitting exchange rate variations to the price in the importer currency. Thus, the degree of pass-through may depend on the importing country's general macroeconomic conditions.

Using a nonlinear STR framework, Nogueira Jr. and Leon-Ledesma (2011) argued that the exporter's decision on the extent to which exchange rate movements should be passed through into prices depends on the perception of the importing country's macroeconomic stability. When the economy faces a financial or a confidence crisis, foreign firms may decide to pass through a larger proportion of their cost changes in view of the increased likelihood of default from the importer. However, when macroeconomic conditions are good, prices will become more insulated from exchange rate changes, since foreign firms are willing to adopt the LCP strategy. The authors conclude that under bad economic conditions ERPT to import prices will be higher than in periods of macroeconomic stability, specifically in the case of Mexico. As a measure of macroeconomic instability, Nogueira Jr. and Leon-Ledesma (2011) used the real interest rate differential of Mexico with respect to the U.S., which corresponds to the transition variable in their smooth transition model.

Figure 1: Spreads of 10-year government benchmark bonds to German Bund



In the same way, the recent sovereign debt crisis experienced by some Euro area countries could influence the extent to which exchange rate changes are transmitted to prices. The start of the economic and financial crisis in the summer of 2007, which intensified in 2008 (in the aftermath of the collapse of Lehman Brothers), had a serious impact on the Euro area government bond market and marked the beginning of financial stress for the so-called

GIIPS countries, i.e. Greece, Ireland, Italy, Portugal, and Spain.[1] As shown in Figure 1, long-term government bond yields relative to the German bund started rising at the beginning of 2010, after ten years of stability at a very low level. Due to the unsatisfactory performance of the GIIPS countries group, the spreads were well above those of emerging market countries, such as Brazil.

Accordingly, we propose that exporting firms may have adopted a different strategy during the recent European sovereign debt crisis, due to the general weakness of macroeconomic fundamentals in the GIIPS group. With the perception of relatively high sovereign debt default risk in the fiscally distressed Euro area countries, firms have no incentive to absorb the single currency fluctuations within their margins. After a period of macroeconomic stability, where the interest rate spreads of 10-year government bonds against the German benchmark declined dramatically (see Figure 1), fiscal vulnerabilities and the risk of default - heightened since 2010 - widened the sovereign bond yield spreads to levels exceeding those observed in the monetary union's early years. As a result, with weaker fiscal fundamentals in the importing country, exporters may tend to modify their pricing strategy, shifting from importer's currency pricing (the *LCP* strategy) to exporter's currency invoicing (the *PCP* strategy), leading to higher rates of ERPT.[2] Therefore, we expect that for the GIIPS group the sensitivity of import prices will be higher during periods of macroeconomic instability or confidence crisis, such as the recent sovereign debt crisis. As an indicator of macroeconomic instability, we use the 10-year government bond yield spreads to the German bund.

3. Empirical approach

3.1. Towards a nonlinear specification for the ERPT equation

In order to capture the nonlinear behaviour of ERPT with respect to macroeconomic instability, as a starting point, we use a standard pass-through regression traditionally tested throughout the literature (see e.g. Campa and Goldberg, 2005; Choudhri and Hakura, 2006):

$$\Delta p_t = \alpha + \sum_{j=1}^{N} \lambda_j \Delta p_{t-j} + \sum_{j=0}^{N} \psi_j \Delta y_{t-j} + \sum_{j=0}^{N} \delta_j \Delta w^*_{t-j} + \sum_{j=0}^{N} \beta_j \Delta e_{t-j} + \varepsilon_t, \qquad (1)$$

[1]These Eurozone members are called "peripheral" Euro area countries. Since the European sovereign debt crisis, the term "GIIPS"' has been used to refer to this group of countries as a label for heavily-indebted economies.

[2]As mentioned in the literature, the introduction of the Euro entailed a decline in the extent of pass-through for most Euro area members, since the process of monetary union entailed some convergence towards more stable macroeconomic conditions. Foreign firms choose the Euro as the currency of denomination of their exports (*LCP* strategy) and European prices have become more insulated from exchange rate variations (see e.g. Devereux et al., 2003, among others).

where Δp_t is the change in local currency import prices, Δe_t is the rate of depreciation of the nominal exchange rate, Δy_t is the output growth as a primary control variable used to capture changes in domestic demand conditions, and Δw_t^* is the changes in foreign producer cost, which is a second control variable representing exporter costs. From equation (1), long-run pass-through ($LR\ \ ERPT$) elasticity is given by following expression: $LR\ ERPT = \sum_{j=0}^{N} \beta_j / (1 - \sum_{j=1}^{N} \lambda_j)$.[3] The response of import prices to exchange rate changes is expected to be bounded between 0 and 1. The degree of pass-through tends to be complete, *i.e.* $LR\ ERPT \to 1$, when foreign firms follow *PCP* strategy and markups do not respond to fluctuations in the exchange rate. However, foreign producers may absorb currency changes or adopt *LCP* setting imports; consequently, import prices become insulated from exchange rate movements, leading to null pass-through, *i.e.* $LR\ ERPT = 0$.

As discussed above, it is expected that foreign firms' pricing behavior will be affected by the general macroeconomic stability in the importing country. In other words, the exporter's decision on the extent to which exchange rate movements should be passed through into prices depends on their view on the importer's macroeconomic conditions. We believe that under bad economic conditions, firms have no incentive to absorb exchange rate fluctuations into their margins, which thus leads to higher ERPT (the *PCP* strategy). However, countries with a stable macroeconomic environment are more likely to have their currencies chosen for transaction invoicing. As a result, prices will become less sensitive to exchange rate changes as foreign firms are willing to adopt the local pricing strategy (*LCP*).

Most of the few empirical works dealing with nonlinearities have used nonlinear threshold models, where the transition across regimes is abrupt (see e.g. Correa and Minella, 2006; Ben Cheikh and Louhichi, 2014). Nevertheless, a threshold framework would be more appropriate at the microeconomic level where a single foreign firm is setting prices. In fact, an exporter can change pricing behaviour sharply with respect to macroeconomic conditions in the importing country. At the aggregate level, firms vary considerably in how they view the macroeconomic environment; hence, assuming an abrupt transition from one regime to another is unrealistic. The transition across regimes is rather gradual since there is some heterogeneity across firms in their attitude towards the state of the importer's macroeconomic environment. To overcome this shortcoming, in our paper we propose using another class of

[3] It is possible to calculate short-run ERPT elasticity which is given by the coefficient β_0. However, the response of import prices to exchange rate changes may not be immediately apparent, especially when foreign firms take time to adjust their prices in the domestic currency. Thus, to account for the potential inertial behaviour of domestic-currency import prices, we focus on the long-run coefficient of ERPT.

nonlinear regime-switching models, namely the STR model, where the transition between states is rather smooth.

3.2. Smooth transition regression modelling

A nonlinear STR model has the following form:

$$y_t = \theta_1 x_t + \theta_2 x_t G(s_t; \gamma, c) + u_t, \quad (2)$$

where $u_t \sim \text{iid}(0, \sigma^2)$, θ_1 and θ_2 are the parameters of the linear and the nonlinear part, respectively. $G(s_t; \gamma, c)$ is the transition function bounded between 0 and 1, and depends upon the transition variable, s_t, the slope parameter, γ, and the threshold level for transition function, c. The parameter γ is also called the speed of transition which determines the smoothness of the switching from one regime to the other. A popular choice for the transition function is the logistic specification that is given by:

$$G(s_t; \gamma, c) = [1 + exp\{-\gamma(s_t - c)\}]^{-1} \quad (3)$$

Equations (2) and (3) jointly define the logistic STR (LSTR) model. In the latter, the nonlinear coefficients acquire different values depending on whether the transition variable is below or above the threshold c. Thus, the parameters $[\theta_1 + \theta_2 G(s_t; \gamma, c)]$ change monotonically as a function of s_t from θ_1 to $(\theta_1 + \theta_2)$. As $(s_t - c) \to -\infty$, then $G(s_t; \gamma, c) \to 0$ and the coefficient corresponds to θ_1; if $(s_t - c) \to +\infty$, then $G(s_t; \gamma, c) \to 1$ and the coefficient becomes $(\theta_1 + \theta_2)$; and if $s_t = c$, then $G(s_t; \gamma, c) = 1/2$ and coefficient will be equal to $(\theta_1 + \theta_2/2)$.

Another popular choice of the transition function which is often used in the literature is the exponential specification: $G(s_t; \gamma, c) = 1 - exp\{-\gamma(s_t - c)^2\}$. It is important to note that the dynamic behavior of the logistic form is different from the exponential specification. The latter is appropriate in situations in which the dynamic behavior is different for large and small values of s_t - what matter is the magnitude of shock, if they are large or small. In other words, the coefficient changes depending on whether s_t is near or far away from the threshold, regardless of whether the difference $(s_t - c)$ is positive or negative. In our paper, we capture the macroeconomic stability in a given country with respect to the 10-year government bond yield spreads to the German bund. A higher bond yield differential indicates an episode of macroeconomic instability in a given economy, while the tightening of bond yield spreads corresponds to a stable macroeconomic environment. As mentioned above, a logistic specification is relevant in describing asymmetric dynamic behavior between negative

or positive deviations of the transition variable s_t from the threshold level c.[4] Therefore, estimating a LSTR is more appropriate for our empirical exercise.

Besides, as discussed in Teräsvirta (1994, 1998), the modelling strategy of STR models consists of three stages: specification, estimation, and evaluation. The first stage consists of testing for nonlinearity and choosing the appropriate threshold variable s_t and the most suitable form of the transition function, *i.e*. logistic or exponential specification. In the second stage, the parameters of the STR model are estimated using the nonlinear least squares (NLS) estimation technique, which provides estimators that are consistent and asymptotically normal. Finding good starting values is crucial in this procedure. Thus, STR literature suggests constructing a grid search for estimating γ and c. The values for the grid search were γ set between 0 and 100 for increments of 1, whereas c was estimated for all the ranked values of the transition variable, s_t. For each value of γ and c the residual sum of squares is computed. The values that correspond to the minimum of that sum are taken as starting values in the NLS procedure. This procedure increases the precision of the estimates and ensures faster convergence of the NLS algorithm.[5] In the final evaluation stage, the quality of the estimated STR model should be checked against misspecification as in the case of linear models. Several misspecification tests are used in the STR literature, such as the LM test of no error autocorrelation, the LM-type test of no ARCH, and the Jarque-Bera normality test. Additionally, Eitrheim and Teräsvirta (1996) suggest two additional LM-type misspecification tests, namely an LM test of no remaining nonlinearity and an LM-type test of parameter constancy.

3.3. Model specification and data

In order to capture the nonlinear behavior of the ERPT mechanism with respect to macroeconomic instability, we extend the linear pass-through regression (1) by the following nonlinear specification:

$$\Delta p_t = \alpha + \sum_{j=1}^{N} \lambda_j \Delta p_{t-j} + \sum_{j=0}^{N} \psi_j \Delta y_{t-j} + \sum_{j=0}^{N} \delta_j \Delta w^*_{t-j} + \sum_{j=0}^{N} \beta_j \Delta e_{t-j} + \left(\sum_{j=0}^{N} \phi_j \Delta e_{t-j} \right) G(s_t; \gamma, c) + \varepsilon_t, \quad (4)$$

[4]For instance, van Dijk et al. (2002) mentioned that when modeling the business cycle, LSTR can describe processes whose dynamic properties are different in expansions from what they are in recessions. For example, if the transition variable s_t is a business cycle indicator (such as output growth), and if $c \simeq 0$, the model distinguishes between periods of positive and negative growth, that is, between expansion and contractions.

[5]It should also be noted that when constructing the grid, γ is not a scale-free. The transition parameter γ is therefore standardized by dividing it by the sample standard deviation of the transition variable, s_t.

The transition variables used as a measure of macroeconomic instability are the 10-year government bond yield spreads (versus Germany), $s_t = bys_{t-j}$. According to equation (4), the *LR ERPT* is given by the following long-run time-varying coefficients:

$$LR\ ERPT = \left[\sum_{j=0}^{N} \beta_j + \sum_{j=0}^{N} \phi_j\, G(s_t;\gamma,c)\right] \Big/ \left[1 - \sum_{j=1}^{N} \lambda_j\right] \tag{5}$$

Due to the features of LSTR models, the long-run ERPT coefficient is expected to acquire different values depending on whether the transition variable, *i.e.* government bond yield spreads, is below or above the threshold. If the measure of macroeconomic instability is below the threshold, *i.e.* $(s_t - c) \to -\infty$, then the importing country experiences a stable macroeconomic environment and pass-through elasticity is equal to: $LR\ ERPT = \sum_{j=0}^{N} \beta_j / \left(1 - \sum_{j=1}^{N} \lambda_j\right)$. If the measure of macroeconomic instability is above the threshold value, *i.e.* $(s_t - c) \to +\infty$, then the economy is facing a confidence crisis and pass-through coefficient becomes: $LR\ ERPT = \left(\sum_{j=0}^{N} \beta_j + \sum_{j=0}^{N} \phi_j\right) / \left(1 - \sum_{j=1}^{N} \lambda_j\right)$.

The LSTR pass-through equation (4) is estimated for the five highly indebted Euro area countries, *i.e.* Greece, Italy, Ireland, Portugal and Spain, also called the GIIPS group. We use monthly data spanning the period 1993:01 to 2012:12 in order to cover the changing behaviour in pass-through dynamics during the European sovereign debt crisis. All the data we use are taken from the OECD's Main Economic Indicators database, except for the exchange rate series, which are obtained from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). The 10-year government bond yield spreads are from European Central Bank (ECB) statistics. For our dependent variable, *i.e.* the change in local currency import prices, we use the price of non-commodity imports of goods and services. This represents the import prices of core goods by excluding primary raw commodities, because of their marked volatility. Output growth is constructed using the rate of growth of the Industrial Production Index. The nominal exchange rate is defined as domestic currency units per unit of foreign currencies, which implies that an increase represents a depreciation for the home country. Finally, to capture changes in foreign costs, we follow Bailliu and Fujii (2004) by constructing an exporter partners' cost proxy. In logarithms, this latter is measured as follows: $w_t^* \equiv q_t + ulc_t - e_t$, where q_t is the unit labor cost (ULC) based real effective exchange rate, ulc_t is the ULC in the domestic country and e_t the nominal effective exchange rate.[6] To determine the lag length of the variables entering equation (4), we follow van Dijk et

[6]Individual series in level are non-stationary according to the efficient unit-root test suggested by Elliott *et al.* (1996), and the Kwiatkovski-Phillips-Schmidt-Shin (KPSS, 1992) test, extended by Carrion-i-Silvestre and Sanso (2006). We also tested for the presence of a cointegrating relationship between variables (in levels) entering the pass-through equation using the well-known cointegration tests of Johansen (1988, 1991), and we

al. (2002) by adopting a general-to-specific approach to select the final specification. We start with a model with a maximum lag length of $N = 4$, and then sequentially drop the lagged variables for which the t-statistic of the corresponding parameter is less than 1.0 in absolute value.[7]

3. Empirical Results

In this section we investigate whether ERPT responds nonlinearly to the macroeconomic instability in the GIIPS countries empirically. We assume that foreign firm markup responds nonlinearly to the importing country's general macroeconomic conditions. When the economy faces a financial or a confidence crisis, foreign firms may decide to pass through a larger proportion of currency changes in view of the increased likelihood of default from the importer. However, in periods of good macroeconomic conditions, foreign firms prefer local currency price-setting, leading to lower ERPT rates due to improved macroeconomic management.

Therefore, in our empirical analysis we must look for a suitable proxy for macroeconomic instability/confidence crisis. In their LSTR model, Nogueira Jr. and Leon-Ledesma (2011) used the real interest rate differential of Mexico with respect to the U.S. as a measure of macroeconomic instability, which is the transition variable in their nonlinear smooth transition model.[8] The use of the real interest rate spread as a proxy of macroeconomic instability, and particularly as a leading indicator of confidence crises, has been advocated by Kaminsky et al. (1998) among others. In our study, we propose an alternative indicator of macroeconomic instability due to the recent context of the European sovereign debt crisis. Hence, we use the sovereign yield spreads to German bonds as an indicator of macroeconomic instability. We expect that this variable will provide a proxy of the risks perceived by foreign firms with respect to the economy under consideration. The widening of sovereign bond yield differentials would indicate the increasing of macroeconomic instability and the loss of confidence in a given economy. In such a case, exporters are willing to shift from the *LCP* strategy to set prices in their own currencies (*PCP* strategy), leading to a higher extent of ERPT.

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report that variables are not cointegrated. Results are available upon request. Consequently, log differences of the variables are used in the estimation of the nonlinear pass-through equation given in equation (4).

[7] Given the monthly nature of our data, it is possible to start with a maximum lag length superior to $N = 4$. Doing so, we find that in most of cases variables are not significant beyond four lags.

[8] To obtain the real interest rate differential, Nogueira Jr. and Leon-Ledesma (2011) used data on money market interest rates for Mexico and for the United States. CPI inflation was used to obtain the real interest rates from the nominal interest rates collected.

Using the LSTR model, we assume the exporter's markup depends nonlinearly on the importing country's sovereign bond yield differential, that is, when the economy faces a confidence crisis, ERPT increases. The transition variables used as a measure of macroeconomic instability in the nonlinear framework is the 10-year government bond yield spreads to the German bund (bys_{t-j}). The data is obtained from the ECB statistics. When the transition variable, $s_t = bys_{t-j}$, exceeds an estimated threshold, this can be interpreted as a period of confidence crisis/macroeconomic instability. The choice of the adequate lagged bond yield spread, bys_{t-j}, as a transition variable by means of linearity tests is reported in Table 1. The linearity tests are conducted for each lagged bond yield spread (bys_{t-j}) with $j = 1, 2, 3, 4$. According to the linearity tests, there is strong evidence of presence of nonlinearities in the five peripheral Euro area countries. The LSTR model is found to be the best specification to capture the nonlinearity with respect to the sovereign bond yield differential.

Table 1: Linearity tests against STR model with $s_t = bys_{t-j}$

Country	Transition Variable	H_0	H_{04}	H_{03}	H_{02}	Specification
Greece	bys_{t-1}	0.025	0.282	0.055	0.017	LSTR
	bys_{t-2}	0.080	0.267	0.416	0.032	Linear
	bys_{t-3}	0.047	0.148	0.380	0.037	LSTR
	bys_{t-4}	0.669	0.897	0.674	0.038	Linear
Ireland	bys_{t-1}	0.183	0.056	0.991	0.519	Linear
	bys_{t-2}	0.009	0.016	0.155	0.281	LSTR
	bys_{t-3}	0.035	0.054	0.351	0.102	LSTR
	bys_{t-4}	0.933	0.986	0.100	0.823	Linear
Italy	bys_{t-1}	0.000	0.000	0.017	0.248	LSTR
	bys_{t-2}	0.017	0.009	0.249	0.322	LSTR
	bys_{t-3}	0.453	0.811	0.078	0.534	Linear
	bys_{t-4}	0.006	0.004	0.260	0.171	LSTR
Portugal	bys_{t-1}	0.040	0.025	0.679	0.388	LSTR
	bys_{t-2}	0.473	0.510	0.537	0.295	Linear
	bys_{t-3}	0.978	0.837	0.867	0.884	Linear
	bys_{t-4}	0.011	0.023	0.543	0.023	LSTR
Spain	bys_{t-1}	0.003	0.119	0.038	0.006	LSTR
	bys_{t-2}	0.003	0.233	0.094	0.000	LSTR
	bys_{t-3}	0.039	0.030	0.412	0.169	LSTR
	bys_{t-4}	0.339	0.292	0.322	0.649	Linear

Note: The numbers are p-values of F versions of the LM linearity tests. The third column shows the test of linearity against the alternative of STR nonlinearity. From the forth column to the sixth, we report the p-values of the sequential test for choosing the adequate transition function. The decision rule is the following: if the H_{03} test yields the strongest rejection of the null hypothesis, we choose the exponential STR specification. Otherwise, we select the logistic STR model. The last column gives the selected model.

Estimation results from the LSTR pass-through equation are summarized in Table 2.[9] In addition to the estimated threshold values and the speed of transition, we report LR ERPT coefficients for the two extremes, *i.e*. under good macroeconomic conditions, $G(s_t;\gamma,c)=0$, and in a bad macroeconomic environment, $G(s_t;\gamma,c)=1$, as defined in (5). Moreover, we compute the sum of the squared residuals ratio (SSR_{ratio}) between the LSTR model and the linear specification which suggests a better fit for the nonlinear model. We also check the quality of the estimated LSTR models by conducting several misspecification tests. In most cases, the selected LSTR models pass the main diagnostic tests, *i.e.* no error autocorrelation, no conditional heteroscedasticity, parameter constancy and non remaining nonlinearity.

Table 2: Estimated ERPT elasticities for different macroeconomic regimes

	Greece	**Ireland**	**Italy**	**Portugal**	**Spain**
Transition variable (s_t)	bys_{t-1}	bys_{t-2}	bys_{t-2}	bys_{t-4}	bys_{t-2}
Threshold (c)	2.130	2.107	1.581	1.136	1.129
	(0.000)	(0.063)	(0.000)	(0.025)	(0.001)
Speed of transition (γ)	32.119	4.982	12.502	8.583	3.097
	(0.337)	(0.156)	(0.106)	(0.073)	(0.324)
Stable Regime: $G(s_t;\gamma,c)=0$					
LR ERPT	0.660	0.749	0.702	0.775	0.559
	(0.012)	(0.000)	(0.000)	(0.000)	(0.007)
Instable Regime: $G(s_t;\gamma,c)=1$					
LR ERPT	1.063	0.193	0.881	1.004	0.933
	(0.001)	(0.730)	(0.000)	(0.000)	(0.002)
R^2	0.679	0.739	0.713	0.700	0.737
SSR_{ratio}	0.632	0.552	0.694	0.670	0.672
AIC	-7.374	-5.660	-5.886	-7.291	-9.019
pJB	0.246	0.409	0.171	0.419	0.361
$pLM_{AR(6)}$	0.613	0.728	0.810	0.833	0.724
$pLM_{ARCH(6)}$	0.673	0.889	0.883	0.697	0.503
pLM_C	0.248	0.678	0.764	0.394	0.517
pLM_{RNC}	0.390	0.291	0.271	0.368	0.447

Note: Table reports elasticities of exchange rate pass-through into import prices from LSTR equation (4). Numbers in parentheses are p-values of estimates. R^2 denotes the coefficient of determination, SSR_{ratio} is the ratio of sum of squared residuals between LSTR model and the linear specification, and AIC is the Akaike Information Criterion. The following rows correspond to the misspecification tests: pJB is the p-values of the Jarque-Bera normality test, $pLM_{AR(6)}$ is the p-values of the LM test of no error autocorrelation up to sixth order, $pLM_{ARCH(6)}$ is the p-values of the LM test of no ARCH effects up to sixth order, $pLM_C$is the p-values of the LM test of parameter constancy and pLM_{RNC} is the p-values of the LM test of no remaining nonlinearity.

According to Table 2, the threshold values of bond spreads are strongly significant, and vary across the GIIPS countries, ranging from 1.3% in Spain to 2.13% in Greece.

[9]Full results of NLS estimates of our LSTR models are presented in Table 3 in Appendix B.

Regarding speed of transition γ, our results indicate relatively moderate values, proof of a smooth transition between good and bad macroeconomic regimes.[10] Concerning long-run ERPT, we note that for the highly indebted Euro area countries, except for Ireland, we find significant nonlinear response of import price inflation to exchange rate movements with respect to macroeconomic instability. Most of the GIIPS group shows a significant positive relationship between the widening of bond yield spreads and the extent of pass-through, with strong evidence of complete ERPT in some cases. For example, when the Portuguese bond yield spread (versus Germany) exceeds 1.13%, the rate of pass-through increases from 0.77% (when $G = 0$) to about 1% (when $G = 1$). Similarly, for Greece, the extent of ERPT differs strongly in periods of confidence crisis. The degree of pass-through is equal to 0.66% when the Greek yield differential is below 2.13%, but beyond this threshold level, the sensitivity of import prices becomes higher and reaches full ERPT.

Thereafter, we plot the estimated logistic transition functions and the ERPT as a function of the transition variable $s_t = bys_{t-j}$ (see Figure 3 in Appendix A). It is clear that the transition between both extreme regimes, *i.e.* $G = 0$ and $G = 1$, is smooth in most cases. In addition, plots reveal the regime dependence of ERPT on macroeconomic conditions. The positive connection between the degree of ERPT and macroeconomic instability is quite clear for all GIIPS countries. Our results suggest that macroeconomic instability significantly affects ERPT. Under bad economic conditions, firms have noincentive to absorb exchange rate movements into their margins, which thus leads to higher ERPT, whereas in periods of macroeconomic stability ERPT is expected to decline. This is in line with Nogueira Jr. and Leon-Ledesma (2011) who found that the sensibility of CPI inflation is higher when the Mexican economy faces a financial or confidence crisis. To gain furtherinsight into the role of crisis in determining the degree of pass-through, plots of long-run ERPT estimates over time and yield spreads are displayed together in Figure 2 with the estimated threshold level superimposed.[11] The displayed plots reveal that, since the start of the sovereign debt crisis in the beginning of 2010, the transmission of the single currency movements increased, after ten years of stability at very low levels. The loss of confidence in GIIPS markets has made for higher ERPT rates. This effect might result from foreign firms recognizing that these countries are themselves fundamentally in dire economic straits. Indeed, the Euro area sovereign debt crisis pushes exporters to follow the *PCP* strategy, due to the general weakness of macroeconomic fundamentals in the GIIPS group.

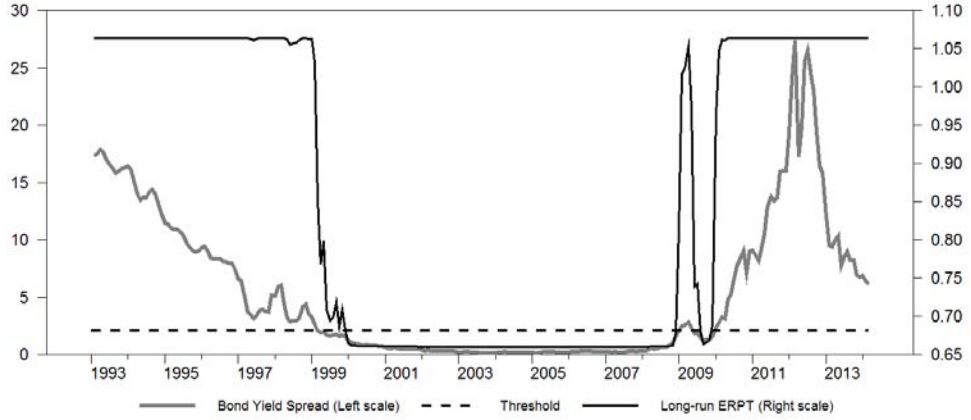
[10]According to van Dijk et al. (2002) estimates of γ may appear to be insignificant. This should not be interpreted as evidence of weak nonlinearity.

[11] Plots for Ireland are not displayed since ERPT is not significant when $G(s_t; \gamma, c) = 1$.

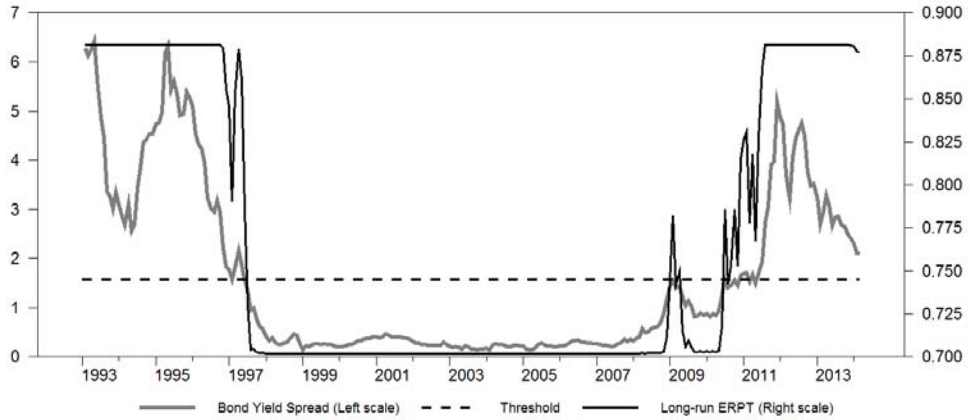
Moreover, a significant result is that the 10-year yield spreads versus Germany was very low during the first ten years of the third stage of the EMU. During this period, there was a low rate of ERPT across the GIIPS Eurozone countries. However, during the pre-EA era, the yield differentials were more pronounced, with a higher degree of exchange rate transmission. It is plausible that the credibility gained from the adoption of the single currency was responsible for the tightening of bond yield spreads and to some extent the decline in rates of ERPT. This conclusion reinforces the argument that the introduction of a set of policies that boost market confidence in the economy can indeed lead to lower ERPT. The adoption of sounder policies may be an effective tool for reducing ERPT. Of course, we do not suggest that the gain in terms of lower ERPT rates is entirely due to better macroeconomic management or the only source of nonlinearity, but it is an important finding for Euro area countries with historically poor macroeconomic policies.

Furthermore, in the context of sovereign debt crisis more attention must be paid to the potential effect of the euro fluctuations on domestic prices. As a matter of fact, our results would ultimately have important implications for the appropriate stance of monetary policy during this episode. On one hand, as the degree of pass-through becomes higher in time of crisis, ECB may use the exchange rate as an instrument for correcting external imbalances in the heavily-indebted Eurozone economies. A depreciation in the European currency, in the case of higher ERPT, would entail expenditure switching from imports to domestic goods, leading to improving in trade balance. This may contribute to offset the activity contraction in time of crisis. On the other hand, some Euro area countries have recently been concerned with deflationary risks. The European monetary authority should take into this nonlinear behaviour of ERPT in period of macroeconomic instability, and how it affects inflation dynamics, in order to prevent a damaging deflation spiral.

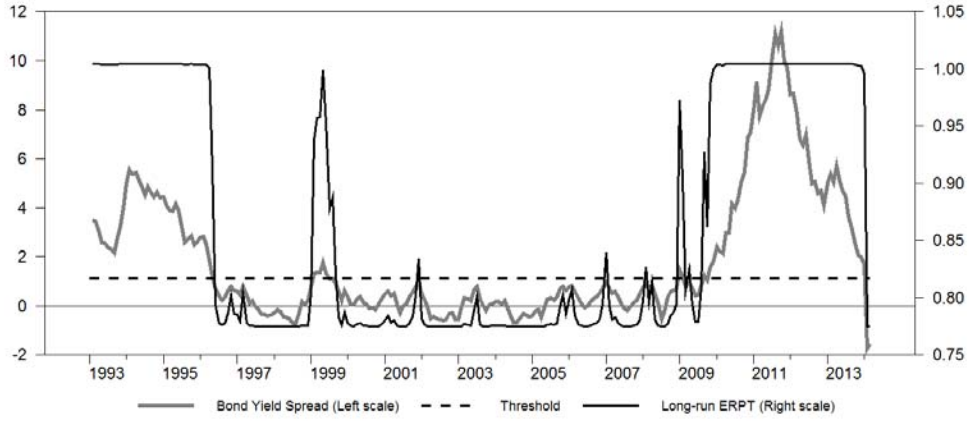
Figure 2: Time-varying long-run ERPT and bond yield spread



Greece

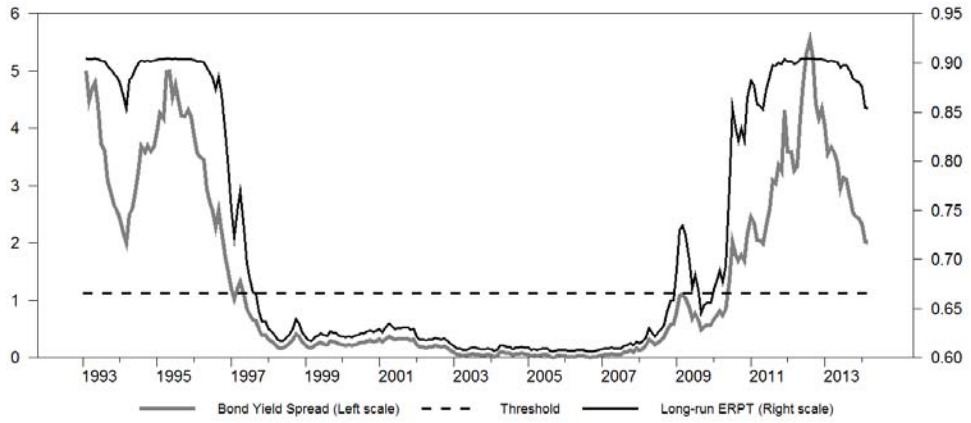


Italy



Portugal

Figure 2: *Continued*



Spain

Note: Time-varying long-run ERPT and past bond yield spread, 1993-2012. Results are from LSTR model (4) with $s_t = bys_{t-j}$.

5. Summary and concluding remarks

This paper examines the presence of a nonlinear mechanism in the extent of pass-through for five heavily indebted Euro area countries. As the European sovereign debt crisis gave rise to a deteriorating macroeconomic environment, we investigate whether pass-through rates were affected in a nonlinear way. Using logistic smooth transition models, we explore the existence of nonlinearity with respect to sovereign bond yield spreads (versus German) as an indicator of confidence crisis/macroeconomic instability. Using monthly data spanning 1993 to 2012, we find that, for highly indebted Eurozone economies, *i.e*. the GIIPS group except Ireland, the extent of ERPT is higher in periods of macroeconomic distress. For example, when the Portuguese bond yield spread (versus Germany) exceeds 1.13%, the rate of pass-through increases from 0.77% to reach full ERPT. Our results reveal that the increase in macroeconomic instability and the loss of confidence entail higher sensitivity of import prices to exchange rate movements in the GIIPS countries. The perception of relatively high sovereign debt default risk in the fiscally distressed Euro area countries may lead exporting firms to change pricing behaviour, shifting from the *LCP* to *PCP* strategy, leading to a higher degree of ERPT. Our findings offer serious guidance regarding the appropriate stance of monetary policy in time of crisis. As the degree of pass-through becomes higher during episodes of macroeconomic instability, the European monetary authority could use the exchange rate changes as an effective tool to boost trade balance and prevent falling into deflationary spiral.

References

Bailliu, J., and Fujii, E. (2004). Exchange Rate Pass-Through and the Inflation Environment in Industrialized Countries: An Empirical Investigation. Working Paper No. 2004-21, Bank of Canada.

Ben Cheikh, N. (2012). Non-linearities in exchange rate pass-through: Evidence from smooth transition models. *Economics Bulletin*, Vol 32 (3):2530–2545.

Ben Cheikh, N. and Louhichi, W. (2014) Revisiting the role of inflation environment in exchange rate pass-through: A panel threshold approach. *Economic Modelling*, http://dx.doi.org/10.1016/j.econmod.2014.11.004

Bussière, M. (2013). Exchange Rate Pass-Through to Trade Prices: The Role of Nonlinearities and Asymmetries. *Oxford Bulletin of Economics and Statistics*, Vol. 75 (5): 731-758.

Campa, J., and Goldberg, L. (2005). Exchange Rate Pass-Through into Import Prices. *The Review of Economics and Statistics*, 87 (4): 679–690.

Carrion-i Silvestre, J., and Sanso, A. (2006). A Guide to the Computation of Stationarity Tests. *Empirical Economics*, 31: 433-448.

Choudhri, E., and Hakura, D. (2006). Exchange Rate Pass Through to Domestic Prices: Does the Inflationary Environment Matter? *Journal of International Money and Finance*, 25: 614–639.

Correa, A., and Minella, A. (2006). Nonlinear mechanisms of exchange rate pass-through: a Phillips curve model with threshold for Brazil. Working Paper No. 122, Central Bank of Brazil.

Devereux, M., Engel, C., and Tille, C. (2003). Exchange Rate Pass-Through and the Welfare Effects of the Euro. *International Economic Review*, 44:223–242.

Eitrheim, O., and Teräsvirta, T. (1996). Testing the adequacy of smooth transition autoregressive models. *Journal of Econometrics*, Vol. 74: 59–76.

Elliott, G., Rothenberg, T., and Stock, J. (1996). Efficient Tests for an Autoregressive Unit Root. *Econometrica*, Vol. 64 (4): 813-836.

Gagnon, J., and Ihrig, J. (2004). Monetary Policy and Exchange Rate Pass-Through. *International Journal of Finance and Economics*, 9 (4):315–38.

Johansen, S. (1988). Statistical analysis of cointegrating vectors. *Journal of Economic Dynamics and Control*, 12: 231-254.

Johansen, S. (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. *Econometrica*, Vol. 59 (6): 1551-1580.

Goldberg, P., and Knetter, M. (1997). Goods Prices and Exchange Rates: What Have We Learned? *Journal of Economic Literature*, 35: 1243–72.

Kaminsky, G., Lizondo, S., and Reinhart, C. (1998). Leading Indicators of Currency Crises. Staff Papers, International Monetary Fund, Vol. 45 (1):1–48.

Nogueira Jr., R. P., and Leon-Ledesma, M. (2011). Does exchange rate pass-through respond to measures of macroecomicinstabiltity? *Journal of Applied Economics*, XIV, No. 1: 167–180.

Omri, A., Nguyen, D.K., and Rault, C. (2014). Causal interactions between CO2 emissions, foreign direct investment, and economic growth: evidence from dynamic simultaneous equation models. *Economic Modelling*. 42, 382-389.

Shintani, M., Terada-Hagiwara, A., and Tomoyoshi, Y. (2013). Exchange Rate Pass-Through and Inflation: A Nonlinear Time Series Analysis. *Journal of International Money and Finance*, Vol. 32: 512–527.

Taylor, J. (2000). Low Inflation, Pass-Through and the Pricing Power of Firms. *European Economic Review*, 44: 1389–1408.

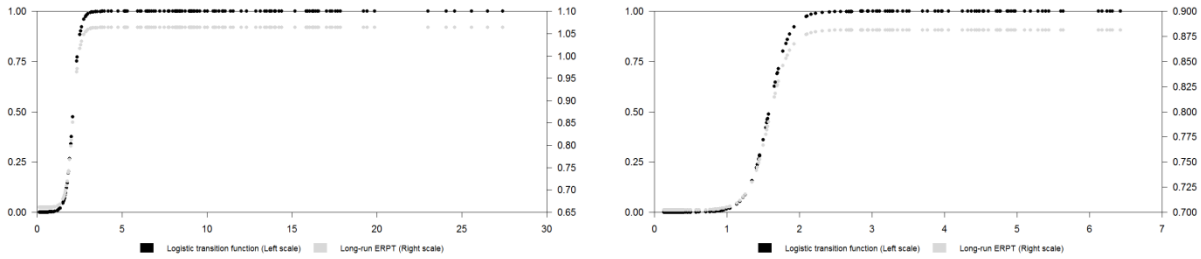
Teräsvirta, T. (1994). Specification, estimation and evaluation of smooth transition autoregressive models. *Journal of the American Statistical Association*, 89: 208–218.

Teräsvirta, T. (1998). Modelling Economic Relationship with Smooth Transition Regressions. In D. Giles, and A. Ullah (Eds.), Handbook of Applied Economic Statistics. New York: Marcel Dekker.

van Dijk, D., Teräsvirta, T., and Franses, P. (2002). Smooth Transition Autoregressive Models: A Survey of Recent Developments. *Econometric Reviews*, 21: 1–47.

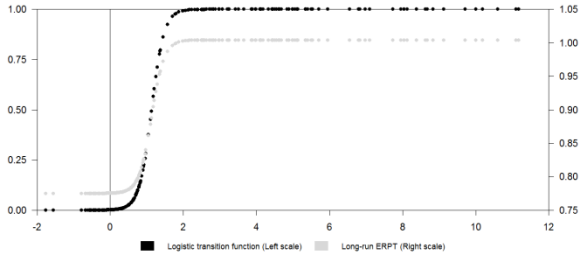
Appendix A. Plots from LSTR pass-through equation

Figure 3: Logistic functions and long-run ERPT as a function of yield spread

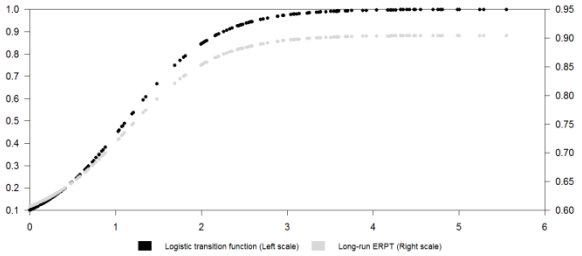


Greece

Italy



Portugal



Spain

Note: Estimated transition functions and long-run ERPT as a function of past bond yield spread. Results are from LSTR model (4) with $s_t = bys_{t-j}$

Appendix B. Full Results from LSTR pass-through model

Table 3: Estimation results from LSTR pass-through equation

	Greece	**Ireland**	**Italy**	**Portugal**	**Spain**
Transition variable (s_t)	bys_{t-1}	bys_{t-2}	bys_{t-2}	bys_{t-4}	bys_{t-2}
Threshold (c)	2.130	2.211	1.581	1.136	1.129
	(5.215)	(1.868)	(11.029)	(2.300)	(3.278)
Speed of transition (γ)	32.119	4.982	12.502	8.583	3.097
	(0.478)	(1.426)	(1.625)	(1.825)	(0.990)
Linear Part: $G(s_t;\gamma,c)=0$					
Constant	0.003	0.010	0.008	0.006	-0.020
	(1.174)	(2.706)	(2.348)	(3.894)	(-3.082)
Δp_{t-1}		-0.428	0.111	0.074	-0.736
		(-5.216)	(1.381)	(1.541)	(-7.545)
Δp_{t-2}	0.174	0.112		0.090	0.308
	(1.424)	(1.247)		(1.160)	(1.607)
Δp_{t-3}					
Δp_{t-4}		0.190	-0.095		0.045
		(1.494)	(-2.885)		(2.198)
Δe_t	0.328	0.351	0.462	0.151	0.335
	(2.676)	(2.655)	(5.458)	(3.612)	(2.875)
Δe_{t-1}		0.332		0.150	0.279
		(2.421)		(3.395)	(1.428)
Δe_{t-2}	0.218				
	(1.645)				
Δe_{t-3}		0.160	0.228		0.157
		(1.563)	(3.551)		(1.073)
Δe_{t-4}				0.347	
				(5.493)	
Δw_t^*	0.104	0.226	0.247	0.356	0.302
	(1.339)	(2.421)	(2.869)	(3.533)	(1.582)
Δw_{t-1}^*	0.261	0.118			0.378
	(1.715)	(1.130)			(1.933)
Δw_{t-2}^*			0.114	0.212	
			(1.302)	(2.321)	
Δw_{t-3}^*					
Δw_{t-4}^*					0.032
					(3.475)

Δy_t		0.044	0.093	0.011	0.024
		(1.695)	(2.173)	(1.784)	(1.322)
Δy_{t-1}	0.101				0.026
	(1.541)				(1.423)
Δy_{t-2}		0.034			
		(1.298)			
Δy_{t-3}					
Δy_{t-4}					
Nonlinear Part: $G(s_t; \gamma, c) = 1$					
Δe_t	0.199	-0.686	0.177	0.192	0.347
	(1.734)	(-1.075)	(2.997)	(2.665)	(1.584)
Δe_{t-1}		0.031			
		(1.183)			
Δe_{t-2}		0.030			0.170
		(1.319)			(1.094)
Δe_{t-3}	0.134				
	(2.389)				
Δe_{t-4}					

Key: Table reports estimates of LSTR pass-through equation (4). Numbers in parentheses are *t*-students.