The sustainability of monetary unions. Can the Euro survive?

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The Sustainability of Monetary Unions. Can the Euro Survive?

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November 21, 2012

Abstract

This paper aims to propose a new measure of exchange market pressure for countries operating in hard peg regimes, such as currency unions, currency boards or full dollarization. We use a general model of currency crisis to derive a sustainability index based upon the relationship between the shadow exchange rate and the output gap required to maintain the currency peg. We apply the new index to European Union countries in order to assess the sustainability of the Euro.

Keywords: shadow exchange rate, currency crisis, exchange market pressure

Jel classification: F3;F31;F41;G01
1. Introduction

The period of high turbulence in international financial markets that started in 1992 with the collapse of Exchange Rate Mechanism (ERM) in Europe has continued unabated over the years. The growing fears of a currency crisis in the European Monetary Union (EMU), have now revitalized the interest in the choices and consequences of exchange rate regimes. An influential view, known as the "two-corner" or "bipolar" hypothesis, states that only two extreme exchange rate regimes are crisis-proof: irrevocable fixed rates or hard pegs, such as currency unions, currency boards or full dollarization, and free floating. Intermediate forex exchange regimes, including soft pegs (such as conventional fixed pegs, crawling pegs, horizontal and crawling band) and managed floats, are inevitably exposed to speculative attacks and hence are not viable in a world of global capital markets (see, e.g., Eichengreen, 1994; Summers, 2000; Fischer, 2001, 2008).

The devaluation of CFA (Communauté financière d’Afrique) franc under a currency union in 1994, the speculative pressure on Hong Kong SAR’s currency board in 1998, the collapse of the Argentina currency board in 2002, on the one hand, and the pressure on the Canadian dollar in 1992, the Italian lira in 1995, the South African rand in 1998 and 2001, the global crisis of 2008, on the other hand, have seriously questioned the two extreme

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1For helpful comments and discussions, we thank Barbara Annicchiarico, Luisa Corrado, Giovanni Di Bartolomeo, Alessandro Piergallini, Pasquale Scaramozzino, Yothin Jinjarak and seminar participants at the II Workshop in International Economics on October 26-27, 2010, organized by the University of Rome Tor Vergata, Faculty of Economics, the XX International Tor Vergata Conference on Money, Banking and Finance on December 5-7, 2011, the XXIV Villa Mondragone International Economic Seminar on June 26-27, 2012, CeFiMS, SOAS, University of London on November 28, 2011, the University of Rome Tor Vergata on February 27, 2012, and the University of Teramo on March 28, 2012.
ends of the bipolar spectrum and prepared the ground for a more balanced approach that views speculative attacks and crises about as likely to occur under the corner solutions as they are under the intermediate regimes (see, e.g., Ghosh, Ostry, and Tsangarides, 2010).

In order to measure tensions on the foreign exchange market to assess the vulnerability of countries to crisis, economic theory has developed a variety of analytical tools proposed to act as an effective early warning signal. One of the warning devices that are mostly used in the literature is the index of Exchange Market Pressure, first formulated by Girton and Roper (1977) and further extended and improved by Weymark (1995) and Eichengreen, Rose, and Wiplosz (1996). The index is a weighted average of the changes in exchange rates, international reserves, and interest rates, and can be applied to measure tensions in pegged or floating exchange rate regimes.

The sustainability of hard peg regimes cannot, of course, be measured using Girton-Roper type indexes since crucial variables, such as international reserves, exchange rates, and interest rates are not observable at a country level.

We propose to evaluate the sustainability of currency unions employing a new index based on cost-benefit analysis. A hard peg regimes is viable when our indicator, based on the relationship between the shadow exchange rate and the output gap, shows the capability of the member countries to remain in the hard peg regime. This is possible as long as the difference between the costs of staying relative to the benefits does not exceed a critical value.

The paper is organized as follows. Section 2 discusses the theoretical

\footnote{The literature on currency unions, dating back to Mundell (1961), is fully discussed in, e.g., De Grauwe (2009). A comprehensive treatment of hard peg regimes can be found in Alesina and Barro (2002), Beetsma and Giuliodori (2010).}
model. Section 3 illustrates the practical relevance of our index investigating the sustainability of the Euro. Section 4 concludes.

2. The model

Our indicator builds on a model of currency crises that combines the features of both first and second generation approaches into a simple model of contagion.

Opting out is a result of an optimizing behavior by the policy maker and occurs when a threshold gap between the shadow exchange rate and the entry parity is reached (see, for example, Masson, 1999a,b; Cavallari and Corsetti, 2000; and Berger and Wagner, 2005).

Consider a multi-country setting consisting of two peripheral economies (e.g., two EU countries or two emerging countries), an industrial (or leader) country (e.g., the United States or Germany) or a currency union (e.g., the EMU), and the rest of the word. Let the superscript $A$ and $B$ be used to distinguish the two external countries, and assume, for simplicity, that all structural parameters are the same in the two countries. Assume also that output is a function of the real wage and that nominal rigidities exist in the form of a one period wage contract. Measuring all variables in logs and letting the nominal exchange rate be defined as the price of the foreign industrial currency in terms of the local currency, we can write the aggregate supply equation for country $A$ as

$$y_t^A = a_1(\Delta s_t^A - E_{t-1}\Delta s_t^A),$$

setting, for simplicity, the worker’s target level of output and the inflation rate in the industrial country and in the rest of the world equal to zero,
where \( y_t^A \) is date \( t \) output in country \( A \), \( \Delta s_t^A \) is the change in exchange rate for country \( A \) at time \( t \), and \( E_{t-1} \Delta s_t^A \) is the expected exchange rate change at time \( t \) estimated at time \( t-1 \) for country \( A \).

Let international demand for the goods produced in country \( A \) depend on the real exchange rate, defined as a trade-weighted variable with weight \( \phi \) for country \( B \), \( \eta \) for the leader country, and \( \omega = 1 - \phi - \eta \) for the rest of the world. Assuming that the currencies of the two peripheral economies are pegged, at least initially, to the currency of the industrial country or currency union\(^3\), and that prices are fixed, for simplicity, the equations for aggregate demand \( (D_t^A) \) and the real exchange rate \( (\rho_t^A) \) in country \( A \) are:

\[
D_t^A = \bar{D} + \gamma \rho_t^A - u_t^A,
\]
\[
\rho_t^A = s_t^A - \phi s_t^B - \omega \bar{s},
\]

where \( \bar{D} \) summarizes the autonomous components of aggregate demand, \( \bar{s} \) is the world exchange rate, assumed fixed for simplicity, and \( u_t \) is an i.i.d. random shock with a density function \( g(u_t) \) described as

\[
\begin{align*}
g(-u_t) = g(u_t) \quad &\forall u_t \in (-\infty, +\infty) \\
g'(u_t) > 0 \quad &\forall u_t \in (-\infty, 0) \\
g'(u_t) < 0 \quad &\forall u_t \in (0, +\infty) \\
g'(0) = 0, \quad &g''(0) < 0
\end{align*}
\]

These properties are consistent with a wide class of bell-shaped and symmetric distribution functions including the normal.

Equilibrium in the goods market of country \( A \) requires:

\(^3\)This is typical of the EMU, where a country willing to join the common currency is required to maintain, for an agreed time span, limited deviation from its target rate against the Euro.
\[ y_t^A = D + \gamma (s_t^A - \phi s_t^B - \omega \bar{s}) - u_t^A. \]  

(1)

Let now the two countries enter in a currency union at a nominal parity \( \bar{s} \). In this case equation (1) can be rewritten as

\[ y_t^A = \gamma (s_t^A - \bar{s}^A) + y_t^{A,F} \]  
\[ y_t^{A,F} = D + \gamma (\bar{s}^A - \phi s_t^B - \omega \bar{s}) - u_t^A, \]  

(2)

where \( y_t^{A,F} \) is the output for country A required to stay in the new monetary system.

Consistent with the second generation approach, let the policymaker in country A minimize the loss function:

\[ \mathcal{L}_t^A = (y_t^A - \bar{y}^A)^2 + \theta^A (s_t^A - s_{t-1}^A)^2 + \delta C^A, \]  

(3)

where \( \bar{y}^A \) is the policy maker’s output target, \( \theta^A \) is the inflation aversion coefficient, \( C^A \) is the cost of opting out of the pegged regime, and \( \delta \) is a dummy variable defined as

\[ \delta = 1 \text{ if } s_t^A - s_{t-1}^A \neq 0 \]
\[ \delta = 0 \text{ if } s_t^A - s_{t-1}^A = 0. \]

The policy maker’s incentive to exit and implement an independent, optimal (discretionary) monetary policy is measured by the difference in welfare losses arising from alternative policy regimes, that is

\[ \mathcal{L}_t^{A,F} - \mathcal{L}_t^{A,D} \geq 0, \]  

(4)

where \( \mathcal{L}_t^{A,F} \) is the loss incurred if country A decides to remain in the hard peg regime and \( \mathcal{L}_t^{A,D} \) the loss if country A decides to exit from the rigid
monetary regime. Following Cavallari and Corsetti (2000), we can express the optimal switching condition (4) in terms of the shadow exchange rate for country \( A \)

\[
s_t^A = \bar{s}^A - \frac{\gamma}{\gamma^2 + \theta^A} \left( y_t^{A,F} - \bar{g}^A \right),
\]

which shows a linear relationship between the shadow exchange rate \( s_t^A \) and the output gap \( y_t^{A,F} - \bar{g}^A \) required to stay within the hard peg regime.

Using (5), we can rewrite condition (4) as

\[
s_t^A - \bar{s}^A \geq \bar{C}^A,
\]

where \( \bar{C}^A \equiv \sqrt{\frac{C^A}{\gamma^2 + \theta^A}} \). This equation states that the policymaker will optimally choose to exit and devalue when the shadow exchange rate exceeds the entry parity by the critical value \( \bar{C}^A \). As shown in the next section, equation (5) can be used to assess the sustainability of hard peg regimes.

Setting \( s_t^A - \bar{s}^A = \bar{C}^A \) and solving for \( u_t^A \) using (5), the threshold value of the shock \( \bar{u}_t^A \) at which the government is indifferent between opting out and remaining in the hard peg arrangement is:

\[
\bar{u}_t^A = \frac{(\gamma^2 + \theta^A) \bar{C}^A}{\gamma} + \bar{D} + \gamma (\bar{s}^A - \phi s_t^B - \omega \bar{s}) - \bar{g}^A.
\]

If \( u_t^A \leq \bar{u}_t^A \) it is optimal for country \( A \) to stay in; on the contrary, if \( u_t^A > \bar{u}_t^A \) it is optimal to exit and implement an independent monetary policy, implying a devaluation of size \( s_t^A - \bar{s}^A \). Notice that a devaluation in country \( B \) reduces \( \bar{u}_t^A \), thus making the probability of country’s \( A \) exit to rise.

Letting \( \pi_t^A \) denote the probability, formed at time \( t \), of a devaluation in country \( A \) in period \( t + 1 \), we can write the condition satisfying the rational expectations equilibrium as:

\[
\pi_t^A = \Pr_t \left[ u_{t+1}^A > \bar{u}_{t+1}^A \right] = \Pr_t \left[ \left( s_{t+1}^A - \bar{s}_{t+1}^A \right) > \bar{C}^A \right].
\]
Figure 1: Crises zone with multiple equilibria

This condition can also be expressed as

$$\pi_t^A = 1 - G \left( \hat{\alpha}_{t+1} \left| s_{t+1}^A \right. = s_t^A + \xi^A \right) \equiv \Phi \left( \pi_t^A; f_t \right), \quad (7)$$

where $G(\cdot)$ is the cumulative distribution function of $g(\cdot)$, $\xi^A$ is the expected devaluation rate for country $A$ following the opting out decision, and $f_t$ summarizes the state of fundamentals at time $t$, i.e., the output gap required to stay in the monetary union. As both sides of equation (7) are increasing with $\pi_t^A$, multiple equilibria arise if the slope of $\Phi(\cdot)$ is greater than one at some fixed point and the fundamentals lie within a range defined by the two critical values $f_L$ and $f_H$, as shown in figure 1.

Private agents’ expectations in different countries are, however, not in-
dependent. This implies that the expected probability of devaluation in country $A (\pi_t^A)$ also depends on the expected probability of exit (and hence of devaluation) in trade partner countries. Letting $\pi_t^B$ denote the subjective probability of exit in country $B$ formed at time $t$ for period $t + 1$, we can write the expected probability of exit and hence of devaluation in country $A (\pi_t^A)$ as:

$$\pi_t^A = \pi_t^B \Pr_t \left[ \left( (s_{t+1}^A - \bar{s}_{t+1}^A) \mid s_{t+1}^B = s_t^B + \xi^B \right) > \bar{C}^A \right]$$

$$+ (1 - \pi_t^B) \Pr_t \left[ \left( (s_{t+1}^A - \bar{s}_{t+1}^A) \mid s_{t+1}^B = s_t^B \right) > \bar{C}^A \right]$$

or

$$\pi_t^A = \pi_t^B \left[ 1 - G \left( \bar{s}_{t+1}^A \mid s_{t+1}^B = s_t^B + \xi^B \right) \right]$$

$$+ (1 - \pi_t^B) \left[ 1 - G \left( \bar{s}_{t+1}^A \mid s_{t+1}^B = s_t^B \right) \right] \equiv \Psi \left( \pi_t^A, \pi_t^B, f_t \right) , \quad (8)$$

where $\xi^B$ is the size of devaluation in country $B$ conditional on exit from the peg arrangement, and the critical realizations of the demand shock ($\bar{s}_{t+1}^A \mid s_{t+1}^B = s_t^B + \xi^B$) and ($\bar{s}_{t+1}^A \mid s_{t+1}^B = s_t^B$) are obtained from (6) setting $s_{t+1}^B = s_t^B + \xi^B$ and $s_{t+1}^B = s_t^B$.

Notice that the size of the loss in competitiveness coming from the devaluation in country $B$ is $\gamma \phi \xi^B$. Equation (8) now shows that private agents form their expectations of an exit for country $A$, by considering both the probability of a devaluation in country $B$ and the probability that $B$ will continue to remain in the hard peg regime next period. Hence, $\pi_t^A$ is a weighted average of the two conditional probabilities. The possibility of multiple equilibria arises when the slope of $\Psi (\cdot)$ is larger than one at some fixed point, and the point of intersection occurs within a ‘crisis zone’ determined by the tangency points of the function $\Psi (\cdot)$ with the 45° line from origin (see figure 1). When
the economy is in this critical zone, jumps across equilibria are determined by sunspots, as in the second generation models by Obstfeld (1996), Velasco (1996), Jeanne (1997). Thus, a sudden shift in market sentiment may trigger an attack against a country’s currency even if the fundamentals are in order.

In this model, contagion could happen when a country jumps from a no-run to a run equilibrium as a result of a crisis or perceived probability of crisis in another country. This emerges from equation (8), which shows the three channel for contagion of the shocks. Monsoonal effects can originate by changes in the world’s exchange rate $s$, or in world demand. Spillover effects can arise from changes in the nominal exchange rate of country $B$. Pure contagion effects follow from the possibility of self-fulfilling expectations of devaluation for country $A$, since both sides of (8) are increasing with $\pi_t^A$. The possibility of contagion is also related to changes in devaluation expectations for country $B$. This can easily be seen by computing the effect on $\pi_t^A$ of a change in $\pi_t^B$:

$$\frac{\partial \pi_t^A}{\partial \pi_t^B} = G\left(\pi_{t+1}^A \mid s_{t+1}^B = s_t^B\right) - G\left(\pi_{t+1}^A \mid s_{t+1}^B = s_t^B + \xi^B\right) > 0,$$

which implies that a rise in $\pi_t^B$ can push the devaluation probability in country $A$ high enough that a crisis can hardly be avoided. Fear of a crisis in one country can spread in the other country, making a crisis more likely to occur.

3. Empirical investigation

To illustrate the practical relevance of our sustainability index we focus on the currently debated issue of the Euro sustainability. The European Monetary

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4 A taxonomic classification of the main channels for contagion is found in Masson (1999a, b).
Union (EMU) is a hard peg regime where member countries have adopted a single currency and monetary policy is conducted by a common central bank.

The index is shown to include: the nominal fixed parity ($\bar{s}$), the elasticity of aggregate demand to the real exchange rate ($\gamma$), the output gap ($y_f - \bar{y}$), and the inflation aversion coefficient ($\theta$). We need estimates of $\gamma$ and of $y_f - \bar{y}$, and to set values for $\bar{s}$ and $\theta$.

The empirical analysis is conducted for Germany, France, Portugal, Italy, Ireland, Greece and Spain.

Using quarterly data over the period 1980-2010, the estimates for $\gamma$ were obtained by the following long-run or cointegration equation:

$$x_{i,t} - m_{i,t} = \alpha + \gamma \epsilon_{i,t} + \epsilon_{i,t},$$  \hspace{1cm} (9)

where $x_{i,t}$ and $m_{i,t}$ are the (logs of) exports and imports of country $i$, $x_{i,t} - m_{i,t}$ is a measure of trade balance for country $i$, $\epsilon_{i,t} = -\rho_{i,t}$ is country’s $i$ real effective exchange rate, so that an increase in $\epsilon_{i,t}$ refers to a real appreciation and a decrease to a real depreciation, and $\epsilon_{i}$ is an i.i.d. error term.

The advantages of using equation (9) as a model specification for our empirical investigation are that the definition of the trade balance is unit-free and insensitive to nominal-real distinction, and it is a close substitute for testing the Marshall-Lerner condition\footnote{See, for example, Bahamani-Oskooee (1991). As the Marshall-Lerner or elasticities condition refers to a long-run analysis, the $\gamma$ coefficient must be negative and statistically significant.}. Estimates of $\gamma$ for each selected country implied by equation (9) are shown in the second column of Table 1 below. These were obtained using a Vector Error Correction Model (VECM) estimation.

The VECM estimations are shown in the Appendix A (Table 3). Appendix A also reports the Augmented Dickey-Fuller and the Johansen Cointe-
Estimates of potential output ($\bar{y}^i$) and output gaps ($\bar{y}_i^{i,F} - \bar{y}^i$) for individual countries were obtained using the Hodrick-Prescott filter\(^6\). The inflation aversion coefficients ($\theta^i$) were fixed taking logs from a scale of tens $[1, 10, 20, ..., 100]$, where 100 and 1 denote the maximum and the minimum inflation aversion value, respectively, taking into consideration the anti-inflation reputation for each country as proxied by their past recorded inflation\(^7\). Values for $\theta^i$ are shown in the third column of Table 1. The nominal fixed parities ($\bar{y}^i$) were given by Euro official fixed conversion rates for each country\(^8\).

<table>
<thead>
<tr>
<th>Country</th>
<th>$\gamma$</th>
<th>$\theta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>-3.468</td>
<td>$\log(100) = 4.6$</td>
</tr>
<tr>
<td>France</td>
<td>-5.384</td>
<td>$\log(50) = 3.9$</td>
</tr>
<tr>
<td>Portugal</td>
<td>-0.449</td>
<td>$\log(40) = 3.7$</td>
</tr>
<tr>
<td>Italy</td>
<td>-1.220</td>
<td>$\log(40) = 3.7$</td>
</tr>
<tr>
<td>Ireland</td>
<td>-0.384</td>
<td>$\log(40) = 3.7$</td>
</tr>
<tr>
<td>Greece</td>
<td>-4.973</td>
<td>$\log(10) = 2.3$</td>
</tr>
<tr>
<td>Spain</td>
<td>-2.874</td>
<td>$\log(40) = 3.7$</td>
</tr>
</tbody>
</table>

Data sources: see Appendix C

The results of our index for each country are shown in figures 3-9 of

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\(^6\) Analogous results were obtained using estimates of ($\bar{y}_i^{i,F} - \bar{y}^i$) from the IMF.

\(^7\) Results do not change if the above scale is multiplied by a factor $k > 0$. In order to rank countries according to their anti-inflation reputation, we used the annual percentage change in CPI over the period 1976-2010.

\(^8\) The conversion rates are: 1.95583 for Deutsche mark; 6.55957 for French franc; 200.482 for Portuguese escudo; 1936.27 for the Italian lira; 0.787564 for Irish pound; 340.750 for Greek drachma; 166.386 for Spanish peseta.
Appendix B. The results for all countries are described in figure 2 which shows, for the post 2008-09 global financial crisis, a clear tendency toward parity (the 0-line) for Germany, Italy, France, Spain, and Ireland, although with different speed of convergence\textsuperscript{9}. Germany is the fastest and shows an implicit appreciation, and therefore a gain of competitiveness against the other countries in 2011. Spain and Ireland are the slowest to converge, with an implied depreciation and a loss of competitiveness relative to Germany over the same period; France and Italy, who also suffer a relatively smaller loss of competitiveness relative to Germany, show a faster turn back. By contrast, Greece and Portugal display a clear tendency to linger in the upper limit of the bound, thus showing a severe loss of competitiveness against Germany.

It should also be noticed that a possible exit from the EMU of both Greece and Portugal might have unpredictable consequences for the future of the Euro, as it could fuel expectations of further countries’ exit, arising from the marked increase in the participation cost to the Monetary Union triggered by the inevitable sharp devaluations of the Greek and Portuguese currencies. This would lead to a crisis similar to the collapse of the Exchange Rate Mechanism occurred in 1992. At that time exchange rate pressure was marked due to the inflation differentials across countries and unilateral gains in competitiveness for Germany.

\textsuperscript{9}The figure was built using the transformation of the computed indicators of market pressure in standard indexes with mean 0 and standard deviation 1, and applying the ±2 standard deviation bounds as critical thresholds to identify crisis episodes in the foreign exchange market. This implies the assumption of normality in the statistical distribution of the market pressure index conforming to the literature (see, e.g., Eichengreen, Rose and Wyploz, 1995, 1996; Sachs, Tornell and Velasco, 1996; Kamisky, Lisonzo and Reinhart, 1998; Kaminsky and Reinhart, 1999).
Figure 2: Standardized Sustainability Indexes
The current scenario, in spite of financial turmoils, might however leave room for hope that there will not be a complete breakdown. A way out of the crisis should thus be possible, since fundamentals do not show so far deviations of parity of such entity as to put in danger the common currency\textsuperscript{10}. It is clear though, that self-fulfilling attacks might still take place if the political will to sustain the common currency is perceived to weaken. Our indicator can thus also be used as an early warning device, since it allows a continuous monitoring of the costs and benefits of staying in a currency union for each country.

4. Conclusions

We have proposed a new measure of vulnerability to crisis for countries operating in hard peg regimes (such as currency unions, currency boards or full dollarization), where traditional indexes of exchange market pressure are not applicable. We have used a simple model of currency crisis, including the main channels for contagion, to derive a sustainability index that builds on cost benefit analysis. The model implies that a hard peg regimes is viable when our indicator, based on the relationship between the shadow exchange rate and the output gap, shows the capability of the member countries to remain in the hard peg regime. This is possible as long as the difference between the costs of staying relative to the benefits does not exceed a critical value. This makes our indicator a powerful alternative to existing early warning devices, since it allows a continuous monitoring of the costs and benefits of remaining in a hard peg regime for each country.

\textsuperscript{10}A complementary analysis assessing market-based sovereign risk of European countries can be found in Aizenman, Hutchison and Jinjarak (2011).
We have applied the new index to European Union countries in order to assess the sustainability of the Euro. The index shows that tensions do exist, particularly for Greece and Portugal. However, they are not so far of such entity as to necessarily cause a breakdown of the common currency, although self-fulfilling attacks, starting in countries with weaker fundamentals, might well occur if the markets are in doubt about the political will to sustain the common currency. In such an uncertain scenario, the model also predicts that the survival of the Euro might be seriously threatened through spillover and contagion effects.

References


Appendix A

Augmented Dikey-Fuller (ADF) Unit Root Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>$x_{i,t} - m_{i,t}$</th>
<th>$\mathcal{E}_{i,t}$</th>
<th>$D[x_{i,t} - m_{i,t}]$</th>
<th>$D[\mathcal{E}_{i,t}]$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country</strong></td>
<td><strong>ADF</strong></td>
<td><strong>CV$^a$</strong></td>
<td><strong>ADF</strong></td>
<td><strong>CV</strong></td>
</tr>
<tr>
<td>Germany</td>
<td>-2.25</td>
<td>-3.46$^b$</td>
<td>-1.48</td>
<td>-2.89$^a$</td>
</tr>
<tr>
<td>France</td>
<td>-0.75</td>
<td>-2.89$^a$</td>
<td>-0.1</td>
<td>-1.94$^c$</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.22</td>
<td>-1.94$^c$</td>
<td>1.14</td>
<td>-1.94$^c$</td>
</tr>
<tr>
<td>Italy</td>
<td>-1.69</td>
<td>-1.94$^c$</td>
<td>-0.11</td>
<td>-1.94$^c$</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.16</td>
<td>-1.94$^c$</td>
<td>-2.31</td>
<td>-2.89$^a$</td>
</tr>
<tr>
<td>Greece</td>
<td>-1.24</td>
<td>-3.46$^b$</td>
<td>1.95</td>
<td>-1.94$^c$</td>
</tr>
<tr>
<td>Spain</td>
<td>-0.72</td>
<td>-1.94$^c$</td>
<td>0.37</td>
<td>-1.94$^c$</td>
</tr>
</tbody>
</table>

CV: Critical values for ADF tests at 5% level of significance.

$^a$ includes a constant; $^b$ includes a constant and linear trend; $^c$ neither.
Table 2 shows ADF test statistics for \( x_{i,t} - m_{i,t} \) and \( E_{i,t} \) both in levels and first differences. The sample cover quarterly data over the period 1985Q1-2010Q2. Lag lengths have been set equal to 5.

For both variables, ADF is less than its critical value only when we use first differences. This means that the hypotheses that \( x_{i,t} - m_{i,t} \) and \( E_{i,t} \) have a unit root, cannot be rejected. On the other hand, we can reject the hypotheses that first differences of \( x_{i,t} - m_{i,t} \) and \( E_{i,t} \) have a unit root.
Johansen Cointegration Test (JCT) and Vector Error Correction (VEC) Estimate

<table>
<thead>
<tr>
<th>Country</th>
<th>Sample</th>
<th>Lags</th>
<th>NH</th>
<th>CT</th>
<th>CV</th>
<th>VEC Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>1985Q1-2010Q3</td>
<td>1-5</td>
<td>None</td>
<td>13.08</td>
<td>25.87</td>
<td>$x_{i,t} - m_{i,t} = -3.468 \bar{E}_{i,t} + 0.007 t + 16.9$</td>
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<tr>
<td>France</td>
<td>1985Q1-2010Q3</td>
<td>1-6</td>
<td>None*</td>
<td>15.69</td>
<td>15.49</td>
<td>$x_{i,t} - m_{i,t} = -5.384 \bar{E}_{i,t} + 24.8$</td>
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<tr>
<td>Portugal</td>
<td>1985Q1-2010Q3</td>
<td>1-4</td>
<td>None*</td>
<td>21.73</td>
<td>20.26</td>
<td>$x_{i,t} - m_{i,t} = -0.449 \bar{E}_{i,t} + 1.6$</td>
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<td>Italy</td>
<td>1985Q1-2010Q2</td>
<td>1-4</td>
<td>None*</td>
<td>17.07</td>
<td>15.49</td>
<td>$x_{i,t} - m_{i,t} = -1.22 \bar{E}_{i,t} + 5.7$</td>
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<tr>
<td>Ireland</td>
<td>1985Q1-2010Q1</td>
<td>1-4</td>
<td>None*</td>
<td>17.18</td>
<td>15.5</td>
<td>$x_{i,t} - m_{i,t} = -0.384 \bar{E}_{i,t} + 2.2$</td>
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<td>Greece</td>
<td>1985Q1-2010Q3</td>
<td>1-8</td>
<td>None*</td>
<td>20.25</td>
<td>19.39</td>
<td>$x_{i,t} - m_{i,t} = -4.973 \bar{E}_{i,t} + 0.0124 t + 20.5$</td>
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<tr>
<td>Spain</td>
<td>1985Q1-2010Q3</td>
<td>1-4</td>
<td>None*</td>
<td>18.25</td>
<td>15.5</td>
<td>$x_{i,t} - m_{i,t} = -2.874 \bar{E}_{i,t} + 12.8$</td>
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<td>At most 1</td>
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</tbody>
</table>

CV: Critical values for JCT tests at 5% level of significance

CT: Johansen Cointegration Tests: Trace statistic; * Max-Eigenvalue statistic

NH: Null Hypothesis: no cointegration equations, at most 1 cointegration equation

* Null Hypothesis rejected

( ) represents standard error in VEC estimate for $\bar{E}_{i,t}$ coefficient

[ ] represents T-statistic in VEC estimate for $\bar{E}_{i,t}$ coefficient

The last column of Table 3 shows the Vector Error Correction estimates displaying the long run equilibrium relationship between $x_{i,t} - m_{i,t}$ and $\bar{E}_{i,t}$.
Standard errors and T-statistics are shown in brackets.

Table 3 shows that we can not reject the hypothesis that both $x_{i,t} - m_{i,t}$ and $\varepsilon_{i,t}$ are cointegrated for each country.

**Appendix B**

The following figures show our index for each selected country. Maximum and Minimum denote the threshold levels (fixed at $\pm 2$ standard deviation) to identify crises episodes. Parity denotes the Euro official fixed conversion rate for each country.

![Figure 3: Germany](image-url)
Figure 4: France

Figure 5: Italy
Figure 6: Spain

Figure 7: Ireland
Figure 8: Portugal

Figure 9: Greece

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Appendix C - Data Sources

Variable’s name: $y_t$

- Source: International Monetary Fund: World Economic Outlook (Edition September 2011)
- Frequency: annual
- Period: 1999 -2011
- Description: Real GDP expressed in billions of national currency units; the base year is country-specific.

Variable’s name: $\xi_t$

- Source: International Monetary Fund: International Financial Statistics (Edition September 2011)
- Frequency: Quarterly
- Period: 1980Q1 - 2010Q3
- Description: Real effective exchange rate based on relative consumer price index

Variable’s name: $x_t$

- Source: International Monetary Fund: International Financial Statistics (Edition September 2011)
- Frequency: Quarterly
- Period: 1980Q1 - 2010Q3
• Description: Goods exports: F.O.B. (Units: US Dollars) (Scale: Millions)

Variable’s name: $m_t$

• Source: International Monetary Fund: International Financial Statistics (Edition September 2011)

• Frequency: Quarterly

• Period: 1980Q1 - 2010Q3

• Description: Goods imports: F.O.B. (Units: US Dollars) (Scale: Millions)

Variable’s name: $CPI$


• Frequency: Annual

• Period: 1976 - 2010

• Description: Consumer Price Index