IMK
Institut für Makroökonomie
und Konjunkturforschung
Macroeconomic Policy Institute

April 2012 90

Working Paper

Christian Schoder | Christian R. Proaño |
Willi Semmler

Are the current account imbalances between EMU countries sustainable?

Evidence from parametric and non-parametric tests

Are the current account imbalances between EMU countries sustainable? Evidence from parametric and non-parametric tests*

Christian Schoder† Christian R. Proaño Willi Semmler

The New School for Social Research
New York, USA

April 19, 2012

Abstract

Using parametric and non-parametric estimation techniques, we analyze the *sustainability* of the recently growing current account imbalances in the euro area and test whether the European Monetary Union has aggravated these imbalances. Two alternative criteria for the assessment of external debt sustainability are considered: One based on the Transversality Condition of inter-temporal optimization, and the other based on the stationarity properties of the stochastic process of the debt-GDP ratio. Econometric sustainability tests are performed using the pooled mean-group estimator and panel unit root tests, respectively. Variants of both test procedures with varying coefficients using penalized splines estimation are applied. We find empirical evidence suggesting that the introduction of the euro is associated with a regime shift from sustainability to unsustainability of external debt accumulation for the euro area.

Keywords: Debt sustainability, external debt, current account imbalances, EMU, penalized splines
JEL Classification: F32, F34, F42, C14

1 Introduction

As discussed e.g. by Berger and Nitsch (2010), a pronounced widening of the current account imbalances between countries of the European Monetary Union (EMU) has been observable since the introduction of the euro. Some countries like Italy, Portugal, Spain and Greece have been characterized by significant and persistent current account deficits – and subsequently by an ongoing increase in their net external debt level – over the last decade, while other countries like Germany and Belgium have recurrently recorded current account surpluses, accumulating thus net foreign assets during the same period.

*We would like to thank Duncan Foley, Lukas Steinberger, Fabian Lindner, Daniele Tavani and two anonymous referees for helpful comments as well as the Schwartz Center for Economic Policy Analysis for financial support. The usual caveats apply.

†Corresponding author: Adress: Department of Economics, The New School for Social Research, 6 East 16th Street, 11th Floor, New York, NY 10003, Email: schoc152@newschool.edu

Whether these asymmetric and unbalanced developments can be considered as sustainable from a long-run perspective is, however, still an open question. On the one hand, as it has been argued e.g. by Blanchard and Giavazzi (2002) and Blanchard (2007), these imbalances may be a reflection of the deeper capital market integration resulting from the monetary unification which may have allowed domestic agents an easier access to international funds. Standard growth theory predicts saving rates (investment rates) to be lower (higher) in low-income countries than in high-income countries. Thus, the emergence of persistent current account imbalances among EMU countries would naturally arise in the process of economic convergence. Following this line of argumentation, the persistent current account imbalances among EMU countries would be simply the result of the optimizing individual behavior of the economic agents under free-market conditions, and could, therefore, be considered as sustainable.

On the other hand, as stressed e.g. by Blanchard and Milesi-Ferretti (2010) and Jaumotte and Sodsriwiboon (2010), the significant rise of external borrowing in some EMU countries may be a reflection of bubble-driven booms caused by overly optimistic growth prospects and excessive private and public borrowing. In this case, the present current account imbalances in the EMU may not be consistent with the transversality condition (TC) of inter-temporal optimization and, therefore, considered as unsustainable. Further, Arghyrou and Chortareas (2008) among others have associated the persistence and widening of external imbalances in the euro area with the decrease of real exchange rate flexibility associated with the establishment of the EMU.[1] Under this perspective, the present current account imbalances would be the result of the euro area's inability to fully adjust to macroeconomic shocks through real exchange rate adjustments. Indeed, as the recent economic crisis has illustrated, highly persistent external imbalances may hinder economic recovery and pose a threat to the monetary union, and are therefore a serious policy issue, even if current account deficits were driven by economic convergence and consistent with the TC. Assessing the prospective sustainability of the current account imbalances in the EMU is thus crucial as changes in the policy setting may be required if the divergent accumulation of net external debt in the EMU proves unsustainable. The present paper studies this question by means of defining and empirically testing criteria for debt sustainability.

Our study is closely related to Durdu et al. (2010) who perform tests for external debt sustainability derived from a stochastic inter-temporal framework with a panel of 21 industrial and 30 emerging market countries. The focus of our study, however, is the euro area and the question whether the introduction of the common currency has aggravated imbalances and affected sustainability. Other related analysis address the question of debt sustainability, but not from a stochastic inter-temporal utility maximization perspective. Holmes et al. (2010) analyze the stationarity of current account imbalances and conclude that external deficits are sustainable for the core European countries and unsustainable for the peripheral European countries. However, stationarity of the current account is not a requirement of sustainability in a stochastic economy. Belke and Dreger (2011) find that EMU current account imbalances are primarily driven by competitiveness rather than economic convergence. Yet, they do not explicitly address the question of sustainability. In a recent study, Lane and Pels (2011) examine European current account imbalances and conclude that the widening of imbalances was driven by greater optimism about future growth without ex-

[1] Given the low labor mobility existing among the majority of European countries (cf. Bertola 2000), the real exchange rate channel is a central macroeconomic adjustment mechanism to external imbalances. The link between exchange rate flexibility and the speed of current account adjustments has been supported empirically by Ghosh et al. (2010) and, for the euro area, by Berger and Nitsch (2010) as well as contested by Chinn and Wei (2008).

plicitly analyzing sustainability issues. Arghyrou and Chortareas (2008) consider the dynamics of current account adjustment and the role of real exchange rates in current account determination in the EMU member countries. They find that for some countries meeting the nominal convergence criteria has come at the cost of growing current account imbalances.

If external imbalances are purely the consequence of optimizing individual behavior, then, in a stochastic general equilibrium setting, the transversality condition (TC) cannot be violated. Along the lines of Bohn's (1995, 1998) analyses of fiscal debt sustainability, we establish a simple testable sufficient condition for the validity of the TC: the response of the net exports to a one-unit change in external debt has to be positive. We call the development of a net external debt-GDP ratio over time *TC sustainable* if it is consistent with this condition. As shown by Bohn (2007), however, the transversality condition holds for any debt process which is integrated of finite order which makes this condition a very weak criteria for assessing debt sustainability. For that reason, we additionally consider an operational sustainability criterion which addresses the persistence of imbalances. We call an external debt-GDP process *operationally sustainable* if it is mean-reverting. This operational definition of sustainability has two advantages: First, mean reversion is not only a sufficient but, in a general equilibrium setting, also a necessary condition for operational sustainability. Second, the autoregressive parameter measures the persistence of the debt series and provides a measure of how fast the debt series returns to its mean.

Using parametric as well as non-parametric estimation techniques we test for TC sustainability and operational sustainability of external debt for ten European countries which joined the EMU right from the start from 1975:2 to 2011:2: Germany (DE), France (FR), Finland (FN), Belgium (BG), the Netherlands (NL), Austria (AT), Italy (IT), Spain (ES), Portugal (PT) and Greece (GR).[2] We also consider four European countries which maintained an independent monetary policy as a control group: United Kingdom (UK), Sweden (SD), Norway (NO) and Denmark (DK). To obtain robust results in the estimation of long-run relations for groups of countries and for sub-periods and highlight differences between countries with high and low external debt we use the pooled mean-group estimator proposed by Pesaran and Smith (1995) and Pesaran et al. (1999). Further, in order to assess the mean reverting property of the external debt-GDP ratio, we perform Augmented Dickey-Fuller unit root tests for each country. Robustness with respect to small sample bias and structural breaks is checked by the Elliot-Rothenberg-Stock (1996) unit root test and the Zivot-Andrews (1992) and Clemente-Montanes-Reyes (1998) unit root tests, respectively. Because of the low power of unit root tests and, in order to analyze the processes for sub-periods, we perform the Breitung and Das (2005) panel unit root test.

We find that, on average over all EMU countries and the entire period analyzed, the external debt accumulation has been consistent with the TC but not with the stronger condition of mean reversion. The same holds for the non-EMU countries considered. By splitting the sample, we find that current account adjustment mechanisms seem to have avoided unsustainable debt accumulation especially in the period prior to the implementation of the convergence criteria in 1997. Yet, in the period thereafter, the coefficient estimates do not allow us to confirm the validity of the TC nor can we reject the hypothesis of non-stationarity of the debt-GDP ratio. This indicates that the introduction of the euro may have impeded some of the forces adjusting the current accounts. For the group of non-EMU countries, the point estimates are consistent with the validity of the TC in both periods. Overall, our results do not confirm Blanchard and Giavazzi's (2002) suggestion

[2] All of them introduced the euro in 1999, apart from Greece which followed in 2001. We exclude Ireland and Luxembourg from our sample due to lack of data.

that the growing imbalances in the euro area are optimal. Further, the unit root tests indicate a considerable increase in the persistence of current account imbalances since the commencement of the EMU.

Furthermore, we fit the data to a generalized additive model using a penalized spline estimator to investigate whether changes in the real exchange rate flexibility may have affected both the response of the net exports to changes in the external debt-GDP ratio, as well as the the persistence of the external debt-GDP series. The results of this non-parametric estimation approach are consistent with the view that the abandonment of the exchange rate mechanism came at a higher cost for the southern countries than for the northern. We find slight but robust positive (negative) relationships between the sustainability measures considered and exchange rate flexibility for the southern (northern) countries.

The remainder of the paper proceeds as follows: In section 2, we motivate and derive the two alternative criteria to assess the sustainability of external debt processes: the TC sustainability criterion and the operational sustainability criterion. In section 3, we discuss in detail the various parametric and non-parametric estimation techniques we used in this study as well as our estimation results both for individual countries as well as for alternative country sub-groups and sub-samples. Section 4 concludes the paper.

2 Defining external debt sustainability

2.1 A theory-based criterion

In order to obtain a theory-based criterion for external debt sustainability, we adapt Bohn's (1995, 1998) analysis of fiscal debt in closed economies for a two-country environment more suitable for our question of interest. Accordingly, we assume two symmetric open economies – a *home country* and a *foreign country* – each populated by an infinitely lived representative agent. Although considering only two countries, we suppose complete international asset markets. Following the notational convention of Obstfeld and Rogoff (1996, pp. 340-3), the state of the world in period t and the history of realized states up to t are represented by s_t and h_t, respectively, with $h_t \in H_t$, $s_t \in S(h_{t-1})$ and h_0 denoting the initial history. We suppose a discrete probability distribution of the states.

Each period, the representative agent of the home country receives Y_t units of a good which can be used for consumption or trading in risky assets with the agent of the foreign country, and we assume that the infinite stream of this income has a finite present value.[3] The representative agent in the domestic economy chooses an optimal consumption path through all t and all $h_t \in H_t$ to maximize expected utility,

$$V_t = \sum_{\tau=0}^{\infty} \beta^{\tau} \sum_{h_{t+\tau}} \pi(h_{t+\tau}) U\big(C(h_{t+\tau})\big) \tag{1}$$

$$s.t. \quad A_t(h_t) + Y_t(h_t) = C_t(h_t) + \sum_{s_{t+1}} Q(s_{t+1} \mid h_t) A(s_{t+1} \mid h_t), \tag{2}$$

[3]The existence of such a finite present value can be ensured by assuming the income generating process to follow a geometric random walk, $\Delta \ln Y_{t+1} = \mu + \sigma \varepsilon_{t+1}$, with μ and σ being known constants and ε_{t+1} identically and independently distributed with mean zero and unit variance. As shown by Pesaran et al. (2007), a finite present value continues to exist in the case of unknown parameters of the income generating process if they are subject to opportune structural breaks.

where $U(\cdot)$ is strictly increasing and concave, $\beta > 0$, $\pi(h_t)$ is the probability of the event h_t to occur and $Q(s_{t+n} \mid h_t)$ is the period t world-market price of an Arrow-Debreu security, $A(s_{t+n})$, that yields one unit of the consumption good in state s_{t+n} at $t+n$ and zero units otherwise. Equation (2) is the budget constraint in time t with realized history h_t which constrains current consumption and the purchase of contingent claims for the next period by the value of current assets and output. The optimization problem of the representative agent in the foreign country is equivalent.

Obviously, if both economies considered move along an optimal consumption path an initial stock of external debt from one country cannot be rolled over infinitely at the expense of the other one, i.e. Ponzi-Schemes are ruled out. This condition is given by

$$\lim_{N\to\infty} \sum_{h_{t+N}} Q(s_{t+N} \mid h_t) B(h_{t+N} \mid h_t) = 0 \tag{3}$$

where $B(h_t) = -A(h_t)$.[4]

The first-order condition of the optimization problem described by (1) and (2) implies $Q(s_{t+N} \mid h_t) = \pi(h_{t+N} \mid h_t) u_{t,n}$ with $u_{t,n}$ being the stochastic discount factor, which substituted into (3) implies after applying the expectations operator and noting that $\sum_{h_{t+N}} \pi(h_{t+N} \mid h_t) = 1$ that the NPC can be rewritten as the *transversality condition* (TC),

$$\lim_{N\to\infty} E_t[u_{t,N} B(h_{t+N} \mid h_t)] = 0 \tag{4}$$

By recalling that $B(h_t) = -A(h_t)$ and applying the expectations operator, we can derive the *inter-temporal budget constraint* (IBC) for the stochastic open economy from (2) and (3) as

$$B_t = \sum_{n \geq t} E_t[u_{t,n} X(h_{t+N} \mid h_t)], \tag{5}$$

where $X(h_t) \equiv Y(h_t) - C(h_t)$ denotes net exports.[5]

Further, by using $\sum_{s_{t+1}} Q(s_{t+1} \mid h_t)\big(1 + R(s_{t+1} \mid h_t)\big) = 1$ resulting from the Euler equations, where $R(s_{t+1} \mid h_t)$ is the return of an asset in state s_{t+1}, dividing by Y_t and dropping the state and history indices for notational convenience, the budget identity given by (2) can be rewritten as

$$b_{t+1} = \frac{1 + R_{t+1}}{1 + \gamma_{t+1}} (b_t - x_t) \tag{6}$$

where γ_t is the growth rate of output from $t-1$ to t and x_t and b_t are net exports and external debt, respectively, both normalized by GDP.

[4] The intuition why the *No-Ponzi-Game* condition follows from inter-temporal optimization is straightforward. Suppose the left hand side in (3) exceeds zero for the home country. Then the foreign investor cannot be on an optimal path as a slight expansion of consumption through time and state by selling contingent claims to the home country could improve his or her expected utility. The equivalent holds in the reverse case.

[5] Note that, we have not imposed any restriction on the discount factor, $u_{t,n}$. As argued by Bohn (1995), setting up the TC and the IBC within a general stochastic framework allows us to derive and rationalize an econometric test outlined by Bohn (1998) which has the following advantages over tests derived from deterministic economies (cf. Hamilton and Flavin 1986; Wilcox 1989; Trehan and Walsh 1991): First, the test can be applied to countries whose long-term interest rate for external debt falls short of the growth rate of GDP – a phenomenon inconsistent with *dynamic efficiency* for deterministic economies but not for stochastic economies. Second, traditional tests of debt sustainability need to make an assumption about the discount rate which usually has been approximated by (the average of) a safe long-term interest rate. As shown by Bohn (1998), however, this may not be a theoretically sound practice as there is no straight forward relationship between $u_{t,n}$ and an observed interest rate.

Following Bohn (1998) and the subsequent empirical literature on fiscal debt sustainability, we suppose a linear relationship between a country's net exports and its stock of external debt of the form

$$x_t = \varrho b_t + \mu_t \tag{7}$$

where ϱ is a parameter and μ_t a stochastic process.[6] Substituting (7) into (6) and iterating forward, we get

$$b_{t+n} = (1-\varrho)^n \prod_{k=1}^{n} \frac{1+R_{t+k}}{1+\gamma_{t+k}} b_t - \sum_{l=1}^{n} (1-\varrho)^{n-l} \prod_{k=1}^{n} \frac{1+R_{t+k}}{1+\gamma_{t+k}} \mu_{t+l-1} \tag{8}$$

Using the straightforward relationships $b_t = \frac{B_t}{Y_t}$ and $Y_{t+n} = \prod_{k=1}^{n}(1+\gamma_{t+k})Y_t$ as well as the result of the Euler equations which apply to all financial claims that $E_t[u_{t,n} \prod_{k=1}^{n}(1+R_{t+k})] = 1$, substituting (8) into the TC in (4) and re-arranging yields

$$\lim_{N\to\infty} (1-\varrho)^N b_t - \sum_{l=1}^{N} (1-\varrho)^{N-l} E_t \left[u_{t,l-1} \prod_{k=1}^{l-1} (1+\gamma_{t+k}) \mu_{t+l-1} \right] = 0 \tag{9}$$

where we drop the history index for notational convenience. The assumption of a finite present value of all future income, $\lim_{N\to\infty} Y_t \sum_{l=1}^{N} E_t[u_{t,l} \prod_{k=1}^{l}(1+\gamma_{t+k})]$, requires that each summand of it converges to zero. This implies for (9) that the second term equals zero in the limit leading to

$$\lim_{N\to\infty} (1-\varrho)^N b_t = 0 \tag{10}$$

A sufficient condition for a positive initial stock of debt to converge to zero in present value terms is thus that $\varrho > 0$.[7] Because an external debt process which is consistent with (10) fulfills the transversality condition, it shall be referred to as *TC sustainable* in the following.

A home country's debt policy may violate TC sustainability in two ways: the left hand side of (3) can go either beyond zero or below zero. Yet, only in case of a violation of the former type a country's accumulation of external debt is traditionally perceived as unsustainable. As becomes clear in the general equilibrium setting, however, asset accumulation consistent with a violation of the latter type is also unsustainable in the sense that, as a compensation, there need to be at least one country running a Ponzi-Game against the surplus country.

[6] As shown by Bohn (1998) and Canzoneri et al. (2001), non-linear response functions as well as those with time-variant response coefficients may be consistent with the TC. A non-linear response function $f(b_t)$ implies TC sustainability if $f(b_t) \geq \varrho(b_t - b^*)\ \forall\ b_t \geq b^*$ where b^* is a finite constant. A time-variant ϱ_t implies TC sustainability if $\varrho_t \geq 0\ \forall\ t$ and $\varrho_t > 0$ holds infinitely often. However, as pointed out by Bohn (2005), these generalizations of (7) entail severe problems of ergodicity as the historical realization of the random variables x_t and b_t may not allow for identification of a non-linear response function or one involving a time-variant coefficient. For this reason, we suppose a linear response function with a constant parameter in the baseline specification. In the econometric analysis, however, we slightly relax this assumption by allowing for a structural break in the response coefficient in order to examine the hypothesis that the introduction of the euro reduced ϱ. We also consider a response function with a time-variant ϱ_t.

[7] A formal proof of the proposition that a positive ϱ is a sufficient condition for the TC and IBC to hold is provided in the unpublished appendix of Bohn (1998).

2.2 An operational criterion

Even though the Bohn-type condition ($\varrho > 0$) for external debt TC sustainability was derived from an inter-temporal optimization problem of a rational forward-looking representative agent, it has two important shortcomings for the present analysis: On the one hand, as shown by Bohn (2007), because any debt process which is integrated of finite order is consistent with the TC, the validity of the TC is a very weak sustainability criterion, as a broad range of debt processes are consistent with it. Hence, a positive reaction coefficient, ϱ, implies the validity of the TC, even if debt-GDP process is unbounded.[8] On the other hand, the Bohn-type TC sustainability criterion can only assess a violation of a domestic country's TC by which it runs a Ponzi-Game against the rest of the world but not by which some foreign country runs a Ponzi-Game against the domestic country. Thus, the case of a country accumulating net external *assets* to an extent inconsistent with the TC is not addressed by this criterion. However, since in a closed economic area accounting implies that one countries's assets are other countries' liabilities, a criterion able to assess the sustainability of growing imbalances should also take into account such cases of excessive asset accumulation.

Hence, an *operational* criterion for the assessment of external debt sustainability should be designed to also include the following two cases: first, when a country's external debt-GDP ratio rises without bounds and, second, when a decreasing external debt-GDP ratio in one country, i.e. rising net assets relative to GDP, is necessarily associated with an unbounded expansion of the debt-GDP ratio in another country. Since the conditions under which an unbounded expansion of assets relative to GDP in one country implies an unbounded expansion of liabilities relative to GDP in another are not obvious, let us consider a stylized open economic area consisting of countries trading with each other and with the rest of the world. We assume the interest rate on international assets to be zero. Let b_t^i denote the external debt-GDP ratio of any country i in period t with external debt being the cumulated negative net exports. $x_t \sim I(k)$ stands for the process x_t to be integrated of order k. Then, the following holds:

Proposition 1. *Let A and B denote two random countries of an open economic area and let $\mathfrak{C}$ denote the set of all countries of this area different from A and B. Suppose that the growth rate of GDP is equal across all countries of the economic area and that each country's share of exports to the rest of the world is constant and equal to its share of imports from the rest of the wold. Suppose further that $b_t^i \sim I(0)$ for all countries $i \in \mathfrak{C}$. Then, $b_t^A \sim I(0)$ if and only if $b_t^B \sim I(0)$.*

Proof. Let X_t^i denote the net exports of country $i \in \{A, B\} \cup \mathfrak{C}$ in period t. Let Y_t^i denote GDP and γ_t its growth rate which is assumed to be equal across all countries of the *open* economic area. Then we can define the net external debt-GDP ratio for country i, b_t^i, as

$$b_t^i \equiv \frac{-\sum_{\tau=0}^{t} X_\tau^i}{\prod_{\tau=1}^{t}(1+\gamma_\tau) Y_0^i} \tag{11}$$

where Y_0^i is the initial GDP. Note that part of this net external debt is matched by net external assets of the rest of the world, i.e. countries outside the economic area considered.[9]

[8] For this reason, Bohn (2007) suggests to impose stronger conditions for a debt accumulation process to be sustainable, such as boundedness of the debt-GDP ratio. In particular, Bohn (2007) suggests to interpret the size of the response coefficient, ϱ. Assuming a constant save interest rate, R, and a constant GDP growth rate, γ, $\varrho > R - \gamma$ implies the debt-GDP process to be stationary. If $0 < \varrho \leq R - \gamma$ the debt-GDP process is unbounded. In our study, however, we do not interpret our coefficients along these lines as the assumption of constant interest and growth rates seems inappropriate to us for empirical analysis.

[9] In an open economy, the symmetry between unbounded asset and debt accumulation normalized by GDP is thus

Let $1-\lambda^i$ be the fraction of a country i's exports to the rest of the world which we assume to be equal to the fraction of its imports from the rest of the world. We assume λ^i to be constant and define

$$\hat{b}_t^i \equiv \frac{-\sum_{\tau=0}^{t} \lambda^i X_\tau^i}{\prod_{\tau=1}^{t}(1+\gamma_\tau) Y_0^i} \tag{12}$$

as the relation between the part of a country i's net external debt which is matched by the net external assets of countries within the economic area considered and its GDP.

Accounting implies for any period t that $\lambda^A X_t^A + \lambda^B X_t^B + \sum_{j\in\mathfrak{C}} \lambda^j X_t^j = 0$. Hence, summing up this equation over all periods $\tau = 0, \ldots, t$, dividing by $\prod_{\tau=1}^{t}(1+\gamma_\tau)$ and using (12) yields

$$\hat{b}_t^A Y_0^A + \hat{b}_t^B Y_0^B + \sum_{j\in\mathfrak{C}} \hat{b}_t^j Y_0^j = 0 \tag{13}$$

Note that $\hat{b}_t^i \sim I(k)$ with $i \in \{A, B\} \cup \mathfrak{C}$ and $k \in \mathbb{N}^+$ if and only if $\hat{b}_t^i Y_0^i \sim I(k)$ since Y_0^i is a constant. Similarly, $\hat{b}_t^i \sim I(k)$ with $i \in \{A, B\} \cup \mathfrak{C}$ and $k \in \mathbb{N}^+$ if and only if $b_t^i \sim I(k)$ since λ^i is a constant.

Suppose $b_t^i \sim I(0)\ \forall\ i \in \mathfrak{C}$. Then, (13) implies that $b_t^A \sim I(0)$ if and only if $b_t^B \sim I(0)$.

□

In the long-run, a sustainable net external debt-GDP ratio should be thus mean-reverting. Hence, we consider an external debt-GDP process as *operationally sustainable* if it can be categorized as a covariance-stationary process.[10] In the following we assume the debt-GDP process, b_t, to follow an AR(1) process of the form

$$b_t = \bar{b} + \rho b_{t-1} + \eta_t \tag{14}$$

where $\bar{b}$ is a country-specific external debt-GDP ratio which is perceived as a long-run equilibrium position of that particular economy. η_t is a disturbance term. Operational sustainability holds if $\rho < 1$, i.e the debt-GDP ratio is mean reverting. This parameter measures the persistence of the debt series and tells us how long it takes the debt series to return to $\bar{b}$.

Even though boundedness of b_t is not a requirement for debt accumulation to be consistent with inter-temporal optimization, our operational criteria of debt sustainability has high economic significance from a policy perspective as suggested by the following observations: First, even if an unbounded debt-GDP process is consistent with the TC, the prediction that lenders will maintain the flow of credit is implausible from a policy perspective. As there are market imperfections such as limits to export capacities, bounds on sustainable debt-GDP ratios which go beyond the requirements imposed by the TC may be of economic interest (Bohn 2007). Especially in the context of prevalent nominal rigidities arising in a fixed exchange rate regime with low transnational

established if the growth rates of GDP are equal across countries and each country's shares of outside exports and outside imports are equal and constant. These conditions are met by the EMU only to some extent. Yet, making these conditions transparent allows us to qualify our empirical results in the context of deviations. Slight discrepancies may still be sufficient, as the conditions are only sufficient and not necessary. As we will argue in the empirical section, in the context of the EMU, only the assumption of synchronized GDP growth requires some caution when interpreting the results.

[10] Note that the property of mean-reversion is weaker than covariance stationarity as the former does not require time-invariant auto-covariances. Yet, unit root testing procedures test against the hypothesis of covariance stationarity which is the reason why we impose the stronger restriction on an operationally sustainable debt-GDP process.

labor mobility and sub-optimal financial market regulation, the negative effects of adverse shocks on systemic risk and contagion are more severe with persistent current account imbalances implying non-stationary debt-GDP series. Also the incentive of deficit countries to leave and, therefore, weaken the currency union is stronger if the economic recovery is undermined by low price competitiveness and high foreign saving which are associated with current account imbalances. Second, financial markets do not seem to be very sensitive towards the level of external debt-GDP ratios which were often inherited from times before the liberalization of international capital flows. They respond primarily to changes of those ratios. Third, in the equivalent case of sovereign debt, the Maastricht criteria require a debt-GDP ratio of below 60%, a level which enjoys high political and economic attention but is obviously a much stronger restriction on a debt-GDP process to be sustainable than the TC.

Whereas the violation of the TC contradicts the argument by Blanchard and Giavazzi (2002) that the observed imbalances are purely the consequence of convergence, the presence of structural breaks in the mean may impede the detection of stationarity of b_t. Even though we will employ econometric techniques that are robust to structural breaks to some extent, failure to reject the non-stationarity hypothesis for the euro era may still be due to a gradual adjustment of the means to a new long-run equilibrium as suggested by Blanchard and Giavazzi (2002). However, as argued above, excessive accumulation of net external assets (liabilities) of the northern (southern) EMU countries may still be problematic in the context of a currency union even if part of it is caused by adjusting to a new equilibrium.

3 Empirical analysis

3.1 Data description

For all countries considered, we used quarterly data on net exports, net foreign liabilities, GDP, domestic demand and both the real effective exchange rate index based on consumer prices and unit labor costs.[11] The data cover the period from 1975:2 to 2011:2. Quarterly data on net exports, GDP and relative domestic demand were obtained from the OECD Economic Outlook 90 database, exchange rate data from Eurostat. The series on net foreign liabilities were taken from the updated and extended version of the External Wealth of Nations Mark II database developed by Lane and Milesi-Ferretti (2007) who provide a comprehensive dataset on net external debt which draws from different sources, in particular from national statistics about a country's *international investment position*. Since these data is available only at an annual frequency from 1970 to 2007, we employed the Chow and Lin (1971) procedure outlined in Appendix B to interpolate and extrapolate, respectively, the annual series by using variations in the quarterly series of the accumulated current account in order to compute a quarterly series.[12]

Figure 1 presents the net exports-output ratio, x_t, and the external debt-output ratio b_t for all countries investigated. On the first sight, the observed imbalances seem to be consistent with the predictions of growth theory: high-income countries tend to realize persistent trade surpluses while low-income countries tend to run deficits. In particular, Germany, France and Belgium managed to accumulate positive stocks of net assets while the reverse picture holds for Italy, Spain, Portugal and

[11] The weights for computing the real effective exchange rate are determined according to the volume traded bilaterally with 12 trading partners.

[12] Since the constructed debt series comprises end-of-period values, we define its first lag as B_t. All *R* and *STATA* scripts can be obtained from the authors upon request.

Greece. These southern countries started to accumulate large amounts of external debt in the mid-1990s. For the non-EMU countries, we observe that, while the UK experienced a deterioration of its net debt position since the mid 1980s, Sweden and Denmark managed to reduce their net external debt considerably. Norway accumulated a large amount of external assets due to a upwards shift in the trade balance around 2000. Whether the growing imbalances can be considered as sustainable will be discussed in the next section.

3.2 TC sustainability tests

3.2.1 Parametric estimation results

As discussed in the previous section, an external debt-GDP process is TC sustainable if the parameter ϱ in the linear relation between x_t and b_t given in (7) is positive. Similarly, Bohn (2007) showed for fiscal as well as for external deficits that an error-correction relationship between the surplus-to-GDP process and the debt-GDP process with a long-term coefficient $\varrho > 0$ and $\varrho \in (0, 1+r]$ implies that the TC holds.[13]

Given the low number of observations available for each country, we follow a panel estimation approach which pools heterogeneous groups but allows for flexibility in the specification of the short-run dynamics. Including an index for country i and lags of order p and q for $b_{i,t}$ with parameters $\theta_{i,k}$ for $k = 0, \ldots, p$ and for $x_{i,t}$ with parameters $\psi_{i,k}$ for $k = 1, \ldots, q$, respectively, we thus reformulate (7) through the following error correction specification

$$x_{i,t} = \alpha_i + \sum_{k=0}^{p} \theta_{i,k} b_{i,t-k} + \sum_{k=1}^{q} \psi_{i,k} x_{i,t-k} + \varepsilon_{i,t}, \tag{15}$$

where $\alpha_i + \sum_{k=1}^{p} \theta_{i,k} b_{i,t-k} + \sum_{k=1}^{q} \psi_{i,k} x_{i,t-k} + \varepsilon_{i,t} = \mu_{i,t}$. $\varepsilon_{i,t}$ is an i.i.d disturbance term with mean zero. Some manipulation yields

$$\Delta x_{i,t} = \alpha_i + \phi_i (x_{i,t-1} - \varrho_i b_{i,t}) + \sum_{k=0}^{p-1} \theta^s_{i,k} \Delta b_{i,t-k} + \sum_{k=1}^{q-1} \psi^s_{i,k} \Delta x_{i,t-k} + \varepsilon_{i,t} \tag{16}$$

where $\theta^s_{i,k} = -\sum_{j=k+1}^{p} \theta_{i,j}$ and $\psi^s_{i,k} = -\sum_{j=k+1}^{q} \psi_{i,j}$. The parameter $\varrho_i = -\phi_i^{-1} \sum_{k=0}^{p} \theta_{i,k}$ is the long-run relationship between x_t and b_t where $\phi_i = -(1 - \sum_{k=1}^{q} \psi_{i,k})$ measures the speed of adjustment of x_t after a change in b_t.

Since we are interested in the average response of x_t to a change in b_t, two alternative estimation techniques seem appropriate: the *mean-group* (MG) estimator and the *pooled mean-group* (PMG) estimator suggested by Pesaran and Smith (1995) and Pesaran et al. (1999), respectively. The former estimates independent ECMs for each group and computes the mean of the group-specific coefficients and statistics. However, the MG estimator is inefficient if the error-correction coefficients such as ϱ_i are the same across countries. In such a case, the PMG estimator, which restricts $\varrho_i = \varrho \; \forall \; i$ but allows short-run parameters including the error correction parameter to vary across countries, is preferable. Since Hausman tests indicated superiority of the PMG estimator in most of the

[13] If both processes are non-stationary but a linear combination (μ_t) of the two is stationary, a co-integration relationship exists and the OLS estimate for ϱ is super-consistent.

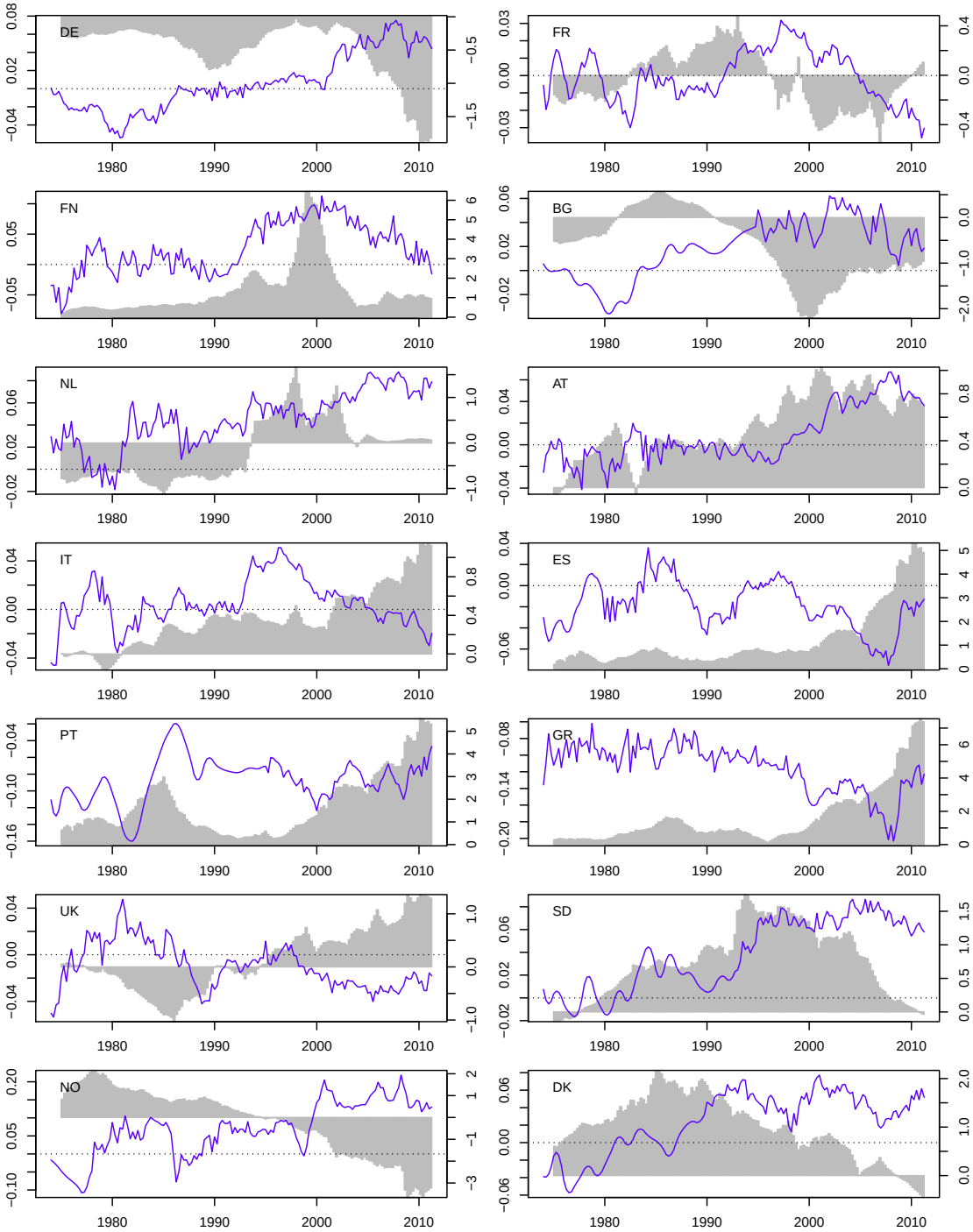

Figure 1: The net external debt-GDP ratio (bars, right axis) and the net exports-GDP ratio (solid line, left axis) from 1974:1 to 2011:2. Sources: OECD, Lane and Milesi-Ferretti (2007) and own calculations

estimations, we primarily report these results.[14] As a robustness check, we estimated (16) extended

[14] As a general rule, the lag order has been selected according to the BIC with a maximum lag length of 4 in each

by including the log of domestic demand in country i over total domestic demand in the OECD and the real effective exchange rate based on unit labor costs as additional covariates as theory predicts these variables to affect the trade balance (cf. Arghyrou and Chortareas 2008). Yet, since the results are qualitatively the same as the estimates of the baseline model, we report only the results derived from the more parsimonious specification.

Table 1: Pooled mean group estimation of the long-run response of the net exports-to-GDP ratio to a change in the net external debt-to-GDP ratio for various subsamples

	(a)	(b)	(c)		(d)	
	EMU countries	Non-EMU countries	EMU countries		non-EMU countries	
	1975:2-2011:2	1975:2-2011:2	1975:2-1996:4	1997:1-2011:2	1975:2-1996:4	1997:1-2011:2
$\hat{\varrho}$	0.025***	0.053**	0.090***	-0.030***	0.043***	0.011
	(0.006)	(0.023)	(0.016)	(0.004)	(0.008)	(0.009)
$\bar{\phi}$	-0.040***	-0.025***	-0.083***	-0.086*	-0.091***	-0.130***
	(0.015)	(0.007)	(0.030)	(0.049)	(0.021)	(0.020)
# of obs.	1440	576	860	580	344	232
	(e)		(f)		(g)	
	North	South	North		South	
	1975:2-2011:2		1975:2-1996:4	1997:1-2011:2	1975:2-1996:4	1997:1-2011:2
$\hat{\varrho}$	0.076***	0.008	0.037***	-0.029***	0.110***	-0.060***
	(0.019)	(0.010)	(0.010)	(0.004)	(0.020)	(0.022)
$\bar{\phi}$	-0.036*	-0.030***	-0.115***	-0.116	-0.120*	-0.030
	(0.019)	(0.011)	(0.035)	(0.074)	(0.065)	(0.028)
# of obs.	864	576	516	348	344	232

Notes: $\hat{\varrho}$ and $\bar{\phi}$ denote the long-run coefficient and the average error-correction coefficient, respectively. Standard errors are in parenthesis. *, **, and *** denote the significance level at 10%, 5%, and 1%, respectively.

Column (a) in Table 1 reports the results for an estimation of (16) including all EMU countries over the entire period considered. Note that the speed of adjustment coefficients in Table 1 always exhibit the correct negative sign and are almost always significant at the 90% confidence level. This implies that there seems to exist a co-integrated relationship between x_t and b_t. More specifically, we find a significant common long-run response coefficient, ϱ of 0.02 and an average speed of adjustment coefficient of 0.04 in absolute terms. The latter implies an average half-life of roughly 15 quarters.[15] Our results are different from but not inconsistent with Durdu et al. (2010) who analyze a large panel of industrialized and emerging market economies and find evidence for TC sustainability for both groups of countries. Using annual data, they find a long-run response coefficient of 0.05 and a speed of adjustment coefficient of 0.22 for the panel of 21 industrialized countries. Column (b) reports the estimation results for our control group of non-EMU countries which indicate debt sustainability.

An interesting question we are able to discuss is whether the introduction of the euro convergence criteria in 1997 is associated with a change in the long-run responsiveness of net exports to a change in the stock of external debt.[16] To check the robustness of our results, we also considered 1994 (implementation of Stage Two of the monetary integration process) and 1999 (implementation of

variable. If the iterative MLE procedure ran into identification issues, the maximum lag length was decreased as long as the problem persisted. We refer to the results of the MG estimator only when they differ qualitatively from the results of the PMG estimator and the Hausman test rejects the null of homogeneity of the long-run coefficient.

[15] The half-life is computed as $\frac{ln(0.5)}{ln(1-|\sigma|)}$.

[16] This break-point has been chosen as the implementation of the euro convergence criteria reduced the flexibility

Stage Three) as alternative break-points. Since the results results obtained from these sub-samples are very similar to the results based on the 1997-break-point, we only refer to them when they differ substantially from the latter.

The parameter estimates for the two sub-periods are reported in column (c). As these two parameter estimates show, the average long-run response coefficient decreased considerably from 0.09 to -0.03. This is a striking finding and suggests that the current setting of the currency union may have impeded the adjustment of trade accounts in the analyzed EMU countries. It is consistent with the view that the recent imbalances overshot a sustainable level due to excessive investment and consumption booms facilitated by economic and financial integration. As reported in column (d) for the non-EMU countries, the response coefficient decreased and turned insignificant with a p-value of 0.23, yet, still displaying a positive sign.[17] This suggests that the process of European economic integration in general has contributed to rising imbalances to an extent, however, which may still be considered TC sustainable.

Column (e) compares the average adjustment in northern and southern countries.[18] As indicated in Figure 1 the latter group tends to have a more pronounced expansion of debt over time than the latter. Over the whole period the average long-run response coefficient is 0.08 in the North which is significantly different form zero at the 1% level. In the South, the point estimate is positive but insignificant with a p-value of 0.42. This finding is consistent with Holmes et al. (2010) who conclude that current account imbalances are TC sustainable in the European core but not in the European periphery. Columns (f) and (g) report the estimates for North and South before and after the introduction of the EMU. The speed of adjustment decreased only in the South but turned just insignificant at the 10% level in both economic regions. The responsiveness of net exports to changes in debt dropped enormously in both. Before the EMU, ϱ was significantly positive in both regions and notably smaller in the North than in the South (0.04 and 0.11) and negative thereafter (-0.03 and -0.06).[19]

Assuming a constant response coefficient, we do not find evidence for the current account imbalances since the implementation of a common European currency to be consistent with the TC. This sheds doubt on the hypothesis by Blanchard and Giavazzi (2002) that the external imbalances in the euro area are purely the result of goods and financial markets integration and economic convergence. Our findings suggest that a considerable extent of the observed imbalances may be due to non-rational economic behavior such as bubble-driven investment and consumption booms, overly optimistic growth prospects and excessive government borrowing in deficit countries. This result is consistent with the findings of recent empirical studies: Belke and Dreger (2011) find that imbalances are mainly driven by divergent developments in competitiveness across EMU countries rather than by factors related to economic convergence such as income perspectives and population growth. Lane and Pels (2011) find that overly optimistic growth forecasts contributed to exces-

of the exchange rate system enormously by requiring member countries to contain inflation to below 1.5%-points above the average of the best three best performers and to join the exchange-rate mechanism under the European Monetary System.

[17] If Norway is excluded which can be argued to be special case due to its enormous endowment with natural resources, then the response coefficient turns significant for the then preferred MP estimator.

[18] The North includes Germany, France, Finland, Belgium, the Netherlands and Austria; the South includes Italy, Spain, Portugal and Greece.

[19] Due to identification issues for higher lag lengths, 3 was chosen as the maximum lag length for estimating the model for the South for the first sub-period. For the North, this result is not robust to the choice of the estimator nor to the selection of the break-point. The MG estimate for the response coefficient is positive but insignificant. For the period 1994:1-2011:2, the PMG estimate is positive and significant.

sive borrowing of southern European countries besides the convergence mechanism put forward by Blanchard and Giavazzi (2002).

3.2.2 Non-parametric estimation results

Structural breaks such as the introduction of the convergence criteria may cause the response of net exports to a change in the external debt-GDP ratio to vary over time. Non-parametric estimation techniques allow us to estimate state-dependent response coefficients. For this task, we use a simplified version of the model in (15) which relates the net exports-GDP ratio to the first lag of the external debt-GDP ratio. Specifying this as a generalized additive model with an identity link, we get

$$x_{i,t} = \alpha_i + f(z)b_{i,t} + \gamma_i \tilde{y}_{i,t-1} + \delta_i e_{i,t-1} + \varepsilon_{i,t} \tag{17}$$

where $f(\cdot)$ is a smooth function of the covariate z. As control variables we include in the regression $\tilde{y}_{i,t}$ and $e_{i,t}$ which denote the log of domestic demand as a share of total demand in the OECD and the real effective exchange rate based on unit labor costs, respectively.[20]

As smooth functions we use plate regression splines which have the advantage of determining the knot locations, which are the points where the parts of the spline base connect to form a twice differentiable smooth function, endogenously (cf. Wood 2006). To estimate the form of $f(\cdot)$ we use penalized least squares. The intuition behind this estimator is the following: given the trade-off between explaining a high share of the variance in the data and the smoothness of $f(\cdot)$, a function $f(\cdot)$ which is optimal for a given smoothness parameter reflecting the weights of this trade-off is chosen. The smoothness parameter is determined endogenously by minimizing the Generalized Cross Validation criteria (cf. Hastie and Tibshirani 1990).

In particular, we are interested in the relationship between the speed of adjustment of external imbalances and real exchange rate flexibility. Hence, we use a smoothing function $f(\cdot)$ in the volatility of the real effective exchange rate, $v_{i,t}$, which we take as a proxy for the flexibility of the real exchange rate regime.[21] The real effective exchange rates and the volatility measures used are plotted in Figure 2 for the countries considered. The real exchange rate volatility decreased enormously for the North and the South after the introduction of the Maastricht criteria in 1997, at around the same time when the current account imbalances in the EMU countries started to rise. This suggests that an important adjustment mechanism may have been impeded by the introduction of the euro. For the control group of non-EMU countries, the exchange rate flexibility did not decrease.

If the introduction of the euro aggravated the current account imbalances through impeding the real exchange rate mechanism, then one would expect an upward sloping function $\varrho(v_{i,t}) \equiv f(v_{i,t})$. Since the appropriate measure of exchange rate flexibility is not obvious, we emphasize only the results which are robust to the choice of the flexibility measure.[22] Figure 3 plots the function $\varrho(v_{i,t})$ for pooled estimations of the Northern, Southern and non-EMU countries using the flexibility

[20] These variables are commonly used in the empirical literature on the determinants of current accounts. See, among others, Arghyrou and Chortareas (2008).

[21] The volatility measure is computed by employing an HP-filter ($\lambda = 1600$) on the 8-quarter, one-sided rolling standard deviation of the real effective exchange rate based on the CPI. The robustness of our econometric results to the choice of the volatility measure has been checked as discussed below.

[22] We considered HP-filtered 5 to 10 quarter, one-sided rolling variances, standard deviations and average absolute deviations of the real effective exchange rate based on the CPI.

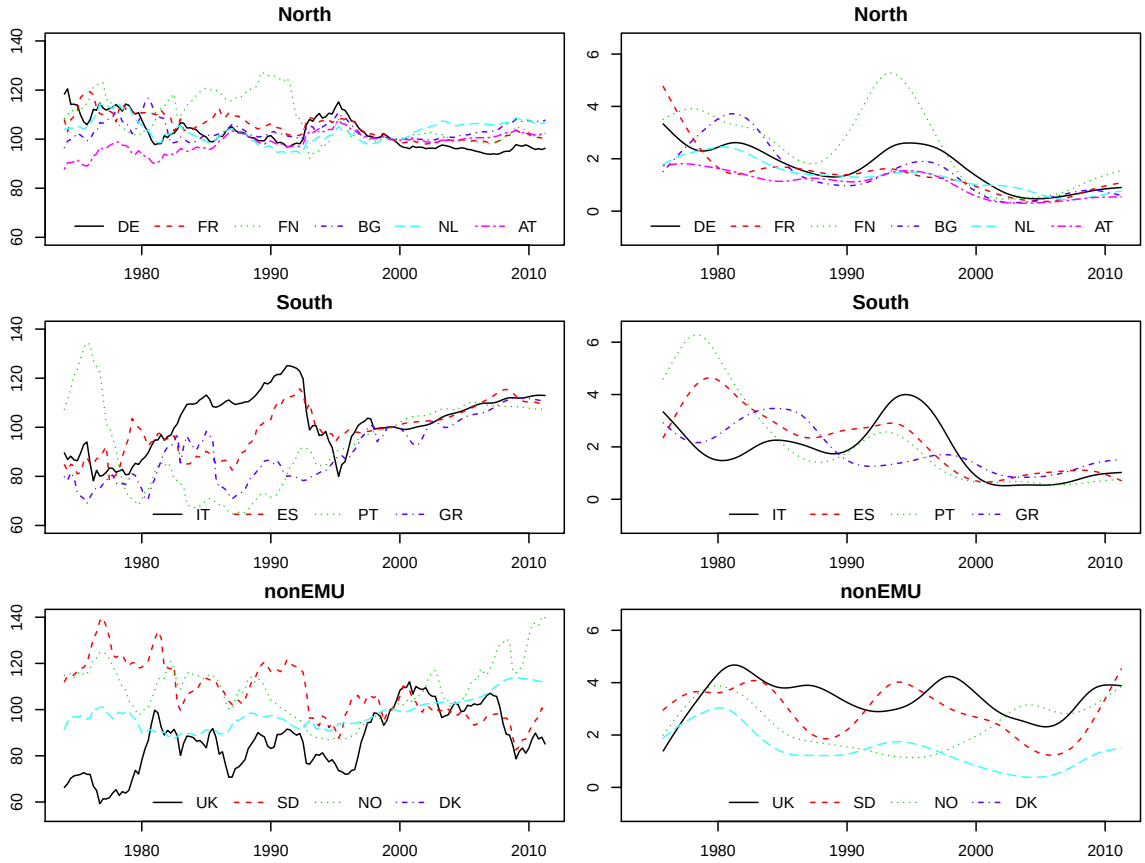

Figure 2: The real effective exchange rate index based on the CPI (left column) and its volatility (right column) for Northern, Southern and non-EMU European countries from 1974:1 to 2011:2

measures plotted in Figure 2.[23] The following findings are noteworthy and fairly robust. A negative relationship between the response of the net exports to the external debt-GDP ratio seems to have prevailed in the North countries over the analyzed sample. The response coefficient seems thus to have decreased, on average, with increasing exchange rate flexibility resulting from the introduction of the euro. Thus, the exchange rate mechanism does not seem to have been important for trade adjustment in these countries. We find the opposite for the South: Apart from very low levels of exchange rate flexibility, the response coefficient, on average, exhibits an increasing trend.[24] Especially, periods of large exchange rate adjustments seem to be associated with significant external adjustments. Hence, the exchange rate mechanism seems to be more important for Southern than for Northern countries.[25] For the control group of non-EMU countries no unambiguous relationship

[23] We applied a *within* transformation of the data in order to eliminate fixed country effects.

[24] Note that the inverse relationship between the TC sustainability and the flexibility measures at low levels of volatility is primarily due to the recessions in the Southern countries in the early 2000s which reduced their trade deficits considerably as can be observed in Figure 1.

[25] The identified differences between northern and southern EMU countries in the relationship between exchange rate flexibility and the response coefficient are consistent with Arghyrou and Chortareas (2008) who analyze how real exchange rates affect current account adjustment for the EMU and conclude that the nominal convergence criteria came at the cost of increasing current account imbalances.

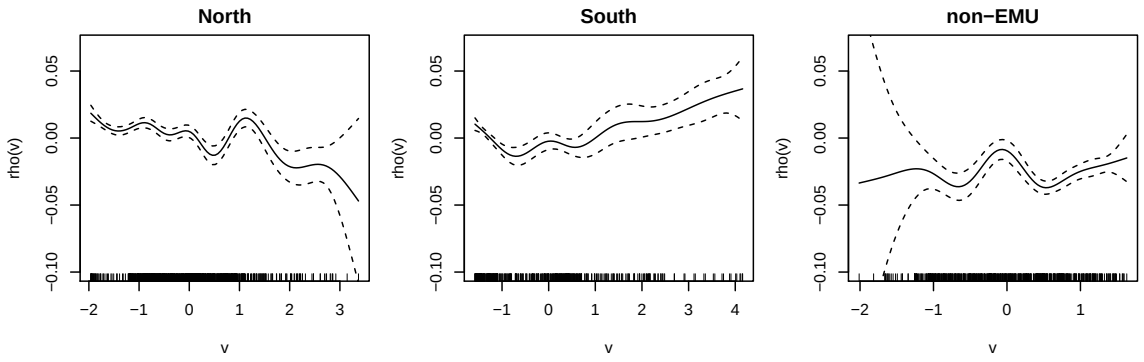

Figure 3: The relationship between the response of the net exports-GDP ratio to a one-unit change in the debt-GDP ratio and real exchange rate flexibility from 1975:2 to 2011:2 and the 95%-confidence interval

between TC sustainability and exchange rate flexibility can be observed.[26]

3.3 Operational sustainability tests

In this section, we analyze if the external debt accumulation in the euro area countries has been consistent with operational sustainability, i.e. if their external debt-GDP ratio featured a significant mean-reverting behavior. The econometric challenge is to test the unit root hypothesis for a finite sample at the presence of shifts in the drift term caused, for instance, by the adjustment to new equilibria in the course of economic integration. We attempt to address this issues with appropriate unit root tests. Obviously, it remains to be seen if the debt-GDP ratios of the countries with extreme surpluses and deficits, respectively, stabilize at new levels in the future. Nevertheless, analyzing the mean-reverting behavior of the currently available data yields some interesting insights.

3.3.1 Parametric estimation results

Country specific unit root tests

Since the external debt-GDP series are stationary after first-differentiating for all countries considered, we restrict the set of admissible processes violating sustainability to I(1) processes. In case of a unit root, there are no forces driving the debt-GDP ratio back to a long-run mean. We test the hypothesis of a unit-root against the hypothesis of stationarity by estimating an augmented version of (14),

$$\Delta b_{i,t} = \bar{b}_i + (\rho - 1) b_{i,t-1} + \sum_{k=1}^{p_i} \theta_i \Delta b_{i,t-k} + \varepsilon_{i,t}. \tag{18}$$

[26] Note that the non-parametric estimation results do not allow the conclusion of debt sustainability for any of the subsamples considered since the requirement for TC sustainability in case of assuming a time-variant ϱ_t, $\varrho_t \geq 0 \; \forall \; t$, is not met in none of the groups. However, this does not imply that the TC has been violated since we tested sufficient but not necessary conditions for debt sustainability. Moreover, time-variant estimators are more sensitive to miss-specification and omitted variables than OLS estimators. Therefore, these results have to be interpreted with caution. Here, we are merely interested in the trend of the response coefficient along different values of exchange rate flexibility.

The lagged values of the dependent variable have been included in order to avoid serial correlation in the residuals. The Augmented Dickey-Fuller (ADF) test infers the significance of ρ being different from unity in (18). Since the ADF test has low power in small samples we also apply the Elliot-Rothenberg-Stock (ERS) test. It utilizes an auxiliary regression to remove the constant and the deterministic trend from the time series which a simple ADF is then applied on. The lag length of the augmented term has been set equal to the respective lag length of the ADF tests above. Since the power of unit roots tests is notoriously weak at the presence of structural breaks, we additionally perform the Zivot-Andrews (ZA) test which allows for a single endogenously determined break point. Recursive regressions including dummies for changes in the intercept and/or trend are run moving from the beginning to the end of the sample to locate the structural break. Then, the Perron (1989) test procedure is applied.[27]

Table 2 reports the estimates for ρ_i as well as the ADF test statistic, τ_{ADF}, and the ERS test statistic, τ_{ERS}, for all countries and different time periods. The lag order p_i has been selected automatically according to the AIC up to a maximum of 5. The table also reports the results of the ZA test. Using the whole sample period, the autoregressive parameters are fairly close to 1. Averaging over the total period and ignoring structural breaks mostly yields coefficients which do not allow us to reject the unit-root hypothesis at the conventional 10% significance level. For any of the analyzed EMU and non-EMU countries, except Finland, we do not find evidence strong enough to reject the unsustainability hypothesis according to the ADF and ERS tests. Yet, the ZA test suggests stationarity for Finland, the Netherlands, Austria and Italy. Interestingly, there exists some evidence against the null of unsustainability for three southern countries (Spain, Portugal and Greece) for the period before the implementation of the convergence criteria, whereas thereafter such evidence only exists for Finland and Austria. Also note that, from the first to the second period, the statistics of both tests decreased for the North without Germany and increased for the South plus Germany. Note that the endogenously estimated break points lie close by the late 1990s which is consistent with the hypothesis that the commencement of the EMU implied a considerable structural break in the development of EMU trade imbalances.

Rather than considering only the significance levels of the parameters one may interpret the point estimates of ρ_i. For all southern countries, the estimated persistence of $b_{i,t}$ increased from the first to the second period. Also for Germany – which accumulated a large amount of net foreign assets over the last decade – the debt series's persistence increased substantially during the EMU. In the other EMU countries, ρ_i decreased. In the non-EMU countries, ρ_i did not change considerably from one period to the other.[28]

Panel unit root tests

Next we perform unit root tests for panels of countries. This is an especially useful exercise because of three reasons: First, the power of unit root tests is notoriously weak when applied to small samples. Pooling countries raises the power of unit root tests and we might be able to reject the null for a group of countries. Second, it allows us to analyze the persistence of the debt series

[27] To check the robustness of our results, we also ran the Clemente et al. (1998) innovational outlier test which is an extension of the unit root test proposed by Perron and Vogelsang (1992) by allowing for up to two endogenously determined gradual shifts in the mean. To some extent it takes into account the gradual shifts of $\bar{b}_i$ in (18) which were triggered by the European integration process. Since the findings confirm the ZA test results we do not report them here.

[28] The result that the persistence of $b_{i,t}$ decreases from the first to the second period for the northern countries without Germany and increases for the southern countries plus Germany is robust to the choice of the breakpoint.

Table 2: Unit root tests of the external debt-to-GDP ratio

	1975:2-2011:2			1975:2-1996:4			1997:1-2011:2			ZA	
	$\hat{\rho}_i$	τ_{ADF}	τ_{ERS}	$\hat{\rho}_i$	τ_{ADF}	τ_{ERS}	$\hat{\rho}_i$	τ_{ADF}	τ_{ERS}	t-statistic	break
EMU											
DE	0.994	-0.59	-0.53	0.979	-1.39	-1.33	0.998	-0.13	-0.66	-3.1	2000:1
FR	0.970	-1.69	-1.50	0.969	-1.38	-0.97	0.925	-1.50	-1.49	-3.34	1998:1
FN	0.972	-2.97**	-2.47**	0.988	-0.96	-0.31	0.96	-2.50	-2.28**	-5.75***	1996:1
BG	0.991	-1.52	-1.53	0.993	-1.02	-1.22	0.978	-0.82	-1.07	-3.12	1994:2
NL	0.984	-1.55	-0.97	1.003	0.17	0.33	0.946	-1.80	-0.91	-5.58***	1992:1
AT	0.972	-2.27	-0.75	0.932	-2.70*	-0.89	0.836	-3.01**	-2.37**	-4.88*	1997:4
IT	1.001	0.15	1.13	0.986	-1.15	-0.55	0.999	-0.06	0.52	-5.26**	1997:1
ES	1.019	2.36	2.94	0.896	-3.47**	-2.33**	1.003	0.15	-0.36	-3.58	2001:2
PT	0.999	-0.08	0.22	0.974	-1.77	-1.72*	0.997	-0.16	1.19	-3.64	1984:1
GR	1.016	1.52	1.59	0.951	-2.67*	-1.91*	1.022	1.03	0.21	-2.41	2000:1
Non-EMU											
UK	0.998	-0.22	-0.21	0.987	-0.82	-0.90	0.983	-0.54	-0.07	-3.98	1981:1
SD	0.988	-1.28	-0.70	0.989	-0.89	0.79	0.999	-0.09	0.51	-5.52**	1991:3
NO	1.004	0.64	1.07	0.996	-0.39	-0.43	0.981	-0.83	0.47	-4.54	1994:1
DK	1.002	0.18	-0.33	0.965	-1.54	-0.91	0.989	-0.51	0.31	-5.90***	1983:1

Notes: $\hat{\rho}_i$ is the estimated autoregressive parameter in (18). τ_{ADF} and τ_{ERS} are the Dickey-Fuller test statistic and the Elliot-Rothenberg-Stock test statistic. ZA is the Zivot-Andrews test. *, **, and *** denote the significance level at 10%, 5%, and 1%, respectively.

for sub-periods and subsamples combined. Third, the assumption of a homogeneous ρ is not very restrictive in our context because all ρ's are close to one. In particular we group countries with similar autoregressive coefficients, i.e. France, Finland, Belgium, Netherlands, Austria ("North w/o DE") vs. Germany, Italy, Spain, Portugal and Greece ("South w DE"). Note that the former group tends to operationally sustainable debt accumulation while the reverse holds for the latter group. We, again, consider a control group of European non-EMU countries including the United Kingdom, Sweden, Norway and Denmark. To check the robustness of the results regarding the choice of the breakpoint, we apply the unit root test also to sub-samples with breakpoints in 1994 and 1999. The results are robust, if not reported otherwise.

We estimate (18) employing the procedure by Breitung (2000) and Breitung and Das (2005). The test assumes that all panels have the same autoregressive term and tests the null hypothesis that all panels contain a unit root, i.e. $\rho = 1$, against the alternative that $\rho < 1$. The Breitung test is a modification of the Dickey-Fuller test by taking into account panel specific mean and trends which are eliminated by transforming the data before computing the Dickey-Fuller regression. The standard Dickey-Fuller t-statistics apply. An advantage of the Breitung test is that it is robust to cross-sectional dependence.

The Breitung test assumes the data to follow an AR(1) process with a Dickey-Fuller representation of

$$\Delta b_{i,t} = \bar{b}_i + (\rho - 1) b_{i,t-1} + \varepsilon_{i,t} \tag{19}$$

In case of n-th order process with $n > 1$, $\varepsilon_{i,t}$ is serially correlated. To make $\varepsilon_{i,t}$ i.i.d, a prewhitening procedure is applied which removes the autoregressive components of $b_{i,t}$ exceeding the first order. This is achieved by substituting $\Delta b_{i,t}$ and $b_{i,t-1}$ by the residuals of two auxiliary regressions which relate $\Delta b_{i,t}$ and $b_{i,t-1}$ to the n first lags of $\Delta b_{i,t}$, respectively. In the subsequent analysis, we assume

Table 3: Breitung panel unit root test for the debt-to-GDP ratio

	(a)	(b)	(c)		(d)	
	EMU countries	Non-EMU countries	EMU countries		non-EMU countries	
	1975:2-2011:2	1975:2-2011:2	1975:2-1996:4	1997:1-2011:2	1975:2-1996:4	1997:1-2011:2
λ	0.68	1.78	-1.81	1.20	-0.22	1.66
	{0.751}	{0.963}	{0.035}	{0.885}	{0.415}	{0.952}
# of obs.	1460	584	880	580	352	232

	(e)		(f)		(g)	
	North w/o DE	South w DE	North w/o DE		South w DE	
	1975:2-2011:2		1975:2-1996:4	1997:1-2011:2	1975:2-1996:4	1997:1-2011:2
λ	-2.64	2.70	-0.40	-1.97	-1.99	2.38
	{0.004}	{0.997}	{0.345}	{0.024}	{0.023}	{0.991}
# of obs.	730	730	440	290	440	290

Notes: λ is the Breitung test statistic robust to cross-sectional correlation. The p-values are in curly brackets.

b_t to be generated by an AR(3) process. Note that we exclude a time trend.

The test results are reported in Table 3. As opposed to the results of the Bohn test, we cannot reject the null of a unit root at the 5% significance level for the panel including all countries and covering the whole sample period as indicated in column (a). Hence, in average the accumulation of debt in the EMU was consistent with the IBC but not with the stronger criterion of stationarity. Also for the non-EMU countries, which apart from the UK managed to accumulate net assets, the unit root hypothesis cannot be rejected as reported in column (b). Since these results may be driven by structural breaks around the introduction of the euro as suggested by the country specific unit root tests, we also consider sub-samples.

Splitting the sample in 1997, we are able to reject the unit root hypothesis for the period before the implementation of the EMU criteria at the 5% level of significance.[29] Yet, for the period thereafter we cannot reject the unit-root hypothesis at any reasonable level of significance (column (c)). External debt accumulation seems thus to have become unsustainable on average in this second sub-period. For the non-EMU countries considered, the unit-root hypothesis cannot be rejected in any of the two sub-periods as reported in column (d).

One immediate cause of the rising imbalances between EMU members may be found in the Southern countries and Germany. Over the whole period, the northern low debt-persistence countries seem to exhibit a mean reverting average debt-GDP process as shown in column (e). The high debt-persistence countries in the South including Germany, however, seem to have accumulated debt and assets, respectively, without bounds. More details are given in columns (f) and (g). Whereas the low-debt persistence countries seem to have managed to stabilize imbalances in the era of the euro, the high-external debt persistence countries were unable to keep a stable debt-GDP ratio in that period. It is striking, however, that they were able to do so in the pre-euro era as indicated by a p-value of 0.023 which allows us to reject the null of a common unit root.

A remark is in order to qualify the above results in relation to Proposition 1, where sufficient – but not necessary – conditions under which the symmetric concept of operational sustainability is applicable in a stylized open economic area were stated. More specifically, we want to briefly discuss how deviations from these conditions affect the validity of the operational definition of

[29] This does not hold for the sub-samples until 1993:4 and 1998:4. The p-values are above but close to 0.1 in both cases.

sustainability. Thereby, we focus on Germany and the Southern countries as one might suspect that there exists some extent of symmetry between the former country's asset and the latter countries' debt accumulation.

The assumption of equal GDP growth rates across countries is required to avoid the time series properties of the external debt-GDP ratios to be driven by diverging developments of national GDPs. In fact, to some degree the observed imbalances between Germany and the Southern countries are aggravated by slower GDP growth in the former than in the latter. Between 1975:2 and 2011:2 the German nominal GDP in national currency grew, on average, by 1.02% per quarter whereas, for the four Southern countries, the corresponding number is 2.69%. Yet, our results are not driven by diverging growth rates. Unit root tests on a debt series normalized by a hypothetical GDP series with equal growth rates across countries confirm the results obtained.[30]

The assumption that each country's share of internal exports and imports are equal ensures that the unbounded expansion of assets (liabilities) relative to GDP implies that the share of these assets (liabilities) accumulated from internal trade also develop in an unbounded way relative to GDP. Then, an unbounded asset-to-GDP ratio in one country implies an unbounded debt-GDP ratio in another one and vice versa. Figure 4 plots the shares of exports to and imports from the countries considered for Germany and the four Southern countries from 1970 to 2009. In Germany, the shares of EMU exports and imports have been very close over time. Therefore, Germany did not dis-proportionally accumulate net assets from outside the euro area. Also for the Southern countries (apart from Spain), the assumption of equal internal export and import shares are not too far from reality. Yet, the internal import share increased slightly relative to the internal export share from the mid 1990s. Hence, to some extent, the southern countries – especially Greece – have accumulated net debt increasingly from inside the EMU. This is consistent with the view that, to some extent, the German external surpluses are a mirror image of the southern countries' deficits.

The assumption of constant internal export and import shares is not confirmed by the plots in Figure 4. Yet, one can show that, under the weaker and more realistic assumption of a stationary internal export and import share, a country A's debt-GDP ratio has a time-invariant mean if and only if a country B's debt-GDP ratio has a time-invariant mean, given that all other countries's debt-GDP ratios are stationary. Hence, it is a sufficient condition for the symmetry of mean-reversion but not for the symmetry of stationarity (as stated in Proposition 1). The assumption of constant shares also ensures the latter as it additionally implies that a country A's debt-GDP ratio has time-invariant auto-covariances if and only if a country B's debt-GDP ratio has time-invariant auto-covariances, given that all other countries's debt-GDP ratios are stationary.

In sum, there seems to be evidence that the German net asset accumulation and the Southern net debt accumulation are, to some extent, two sides of the same coin.

3.3.2 Non-parametric estimation results

Similar to the above analysis of the relation between the responsiveness of net exports to external debt and exchange rate flexibility, we analyze how the persistence of the debt series varies with the flexibility of the real exchange rate regime. Hence, we estimate

$$\Delta b_{i,t} = \bar{b}_i + f(z) b_{i,t-1} + \varepsilon_{i,t} \tag{20}$$

[30] For each country, this GDP series was generated by using nominal GDP in national currency in 2005:1 as the reference value, extrapolating the other values by using the growth rate averaged over all countries considered for each quarter and using the nominal exchange rate to denominate the series in US-Dollars.

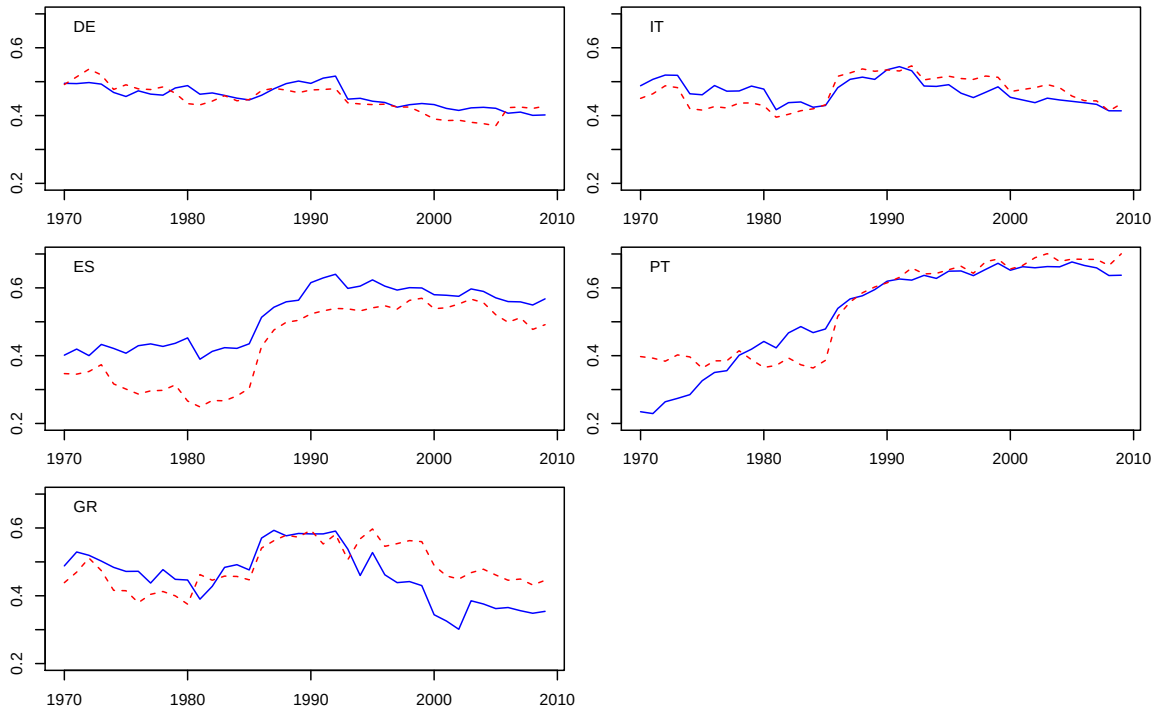

Figure 4: The shares of exports to (solid line) and imports (dashed line) from the EMU countries considered for Germany, Italy, Spain, Portugal and Greece from 1970 to 2009 (Source: IMF, Direction of Trade Statistics)

where we use a smoothing function $f(\cdot)$ in the real effective exchange rate volatility, i.e. $z = v_{i,t}$.

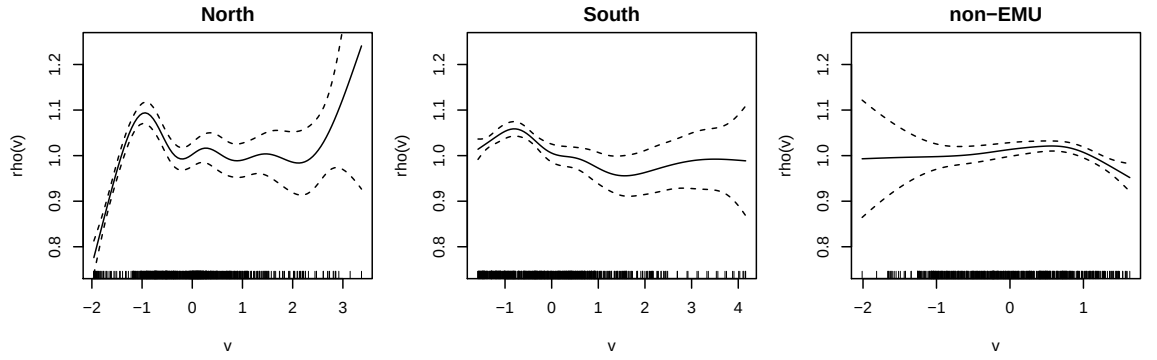

Figure 5: The relationship between the persistence of the external debt-GDP ratio and real effective exchange rate flexibility from 1975:2 to 2011:2 and the 95%-confidence interval

The auto-regressive coefficient as a function of the exchange rate volatility, $\rho(v_{i,t}) \equiv 1 + f(v_{i,t})$ is plotted in Figure 5 for the North excluding Germany, the South including Germany and the group of non-EMU countries. The exchange rate flexibility measure used is the same as for the Bohn test. The main results, however, are fairly robust to the volatility measure considered. Even though less significant and more difficult to interpret, our results are broadly in line with the

findings of the non-parametric Bohn tests. In the North, the adjustment of the debt-GDP ratio to a long-run mean seems to slow down with increasing exchange rate volatility for extreme values of the independent variable.[31] For moderate values, the data exhibits an inverse relationship. In the South and Germany, only a modest decreasing trend can be observed. However, low levels of flexibility seem to be associated with auto-regressive coefficients significantly exceeding unity.[32] For the non-EMU countries no interesting trend can be observed.

4 Concluding remarks

In this paper, we sought to assess empirically whether the growing current account imbalances in EMU countries are sustainable and whether the rise in these imbalances may be associated with the reduction of exchange rate flexibility resulting from the introduction of the euro.

We motivated two criteria of debt sustainability: first, the validity of the inter-temporal budget constraint which can be shown to hold if the response of the net exports to a one-unit change in external debt is positive Bohn (1995, 1998, cf.); second, mean-reversion of the debt-GDP ratio. Using parametric as well as non-parametric estimation techniques we tested for *TC sustainability* and *operational sustainability* of external debt for 14 European countries from 1975:2 to 2011:2.

Using an error correction specification we estimated the long-run response of the net exports-GDP ratio to the debt-GDP ratio for different groups of countries and sub-periods. We find for the period prior to the implementation of the convergence criteria in 1997 that, on average over all EMU countries studied, the external debt accumulation could be considered as TC sustainable. The trade adjustment mechanism seem to have avoided persistent imbalances in the current account prior to the euro era. However, the response coefficient seems to have become negative in the subsequent period implying that there is no evidence that debt accumulation has been TC sustainable. The response coefficient for the non-EMU countries analyzed is still positive in the period of the EMU. This finding is consistent with the view that apart from European economic integration the introduction of the euro may have exacerbated current account imbalances and impeded external adjustment. The non-parametric estimation of the response coefficient reveals that it has been mainly the southern countries which seem to have a decreasing response coefficient since the introduction of the euro convergence criteria. For the south, we find a slightly proportional relationship between the reaction coefficient and real exchange rate flexibility which is consistent with the hypothesis that the EMU contributed to the persistence of current account imbalances.

The analysis on the basis of the operational sustainability criteria reveals similar results. The Breitung panel unit root test indicates stationarity of the debt series on average for the period before the EMU implementation. Thereafter the unit root hypothesis cannot be rejected anymore indicating that the current accounts became operationally unsustainable. Here, Italy, Spain, Portugal, Greece on the one hand and Germany on the other, all of whom had external debt-GDP ratios deviating enormously from the mean, seem to contribute considerably to operational unsustainability. While the unit root hypothesis cannot be rejected for a group consisting of these countries, it can be rejected for the others. Further, the non-parametric estimations of the auto-regressive coefficients of the debt-GDP ratios reveal a slightly inverse relationship between the persistence of imbalances and the degree of exchange rate flexibility.

[31] Note that, to a great extent, the low response coefficients for low values of volatility are due to the spike of the Finish debt-GDP ratio around 2000 which was not associated with a corresponding increase in the trade surplus.

[32] Note that for Germany alone we find a negative slope for $\rho(v_{i,t})$.

The failure to find evidence for the validity of the inter-temporal budget constraint for the era of the euro suggests that the growing imbalances among EMU countries cannot be sufficiently explained by rising economic integration within the euro area as claimed by Blanchard and Giavazzi (2002) and Blanchard (2007). The seemingly unbounded accumulation of assets in Germany and liabilities in the southern EMU countries may pose a serious issue for economic stability and European economic recovery as has previously been argued by, among others, Arghyrou and Chortareas (2008), Jaumotte and Sodsriwiboon (2010) and Lane and Pels (2011). The EMU eliminated the nominal exchange rate mechanism, allowed for financial integration and borrowing booms in some countries, and the common monetary policy aimed at price stability reduced the flexibility of inflationary adjustment. This suggests that policy measures need to be implemented aimed at reducing current account imbalances.

References

Arghyrou, M. G., Chortareas, G. (2008): Current Account Imbalances and Real Exchange Rates in the Euro Area, *Review of International Economics*, 16(4), pp. 747–764.

Belke, A., Dreger, C. (2011): Current Account Imbalances in the Euro Area: Catching up or Competitiveness?, Ruhr Economic Papers 0241, Rheinisch-Westfälisches Institut für Wirtschaftsforschung, Ruhr-Universität Bochum, Universität Dortmund, Universität Duisburg-Essen.

Berger, H., Nitsch, V. (2010): The Euro's Effect on Trade Imbalances, IMF Working Papers 10/226, International Monetary Fund.

Bertola, G. (2000): Labour markets in the European Union : the European unemployment problem, *CESifo Forum*, 1(1), pp. 9–11.

Blanchard, O. (2007): Current Account Deficits in Rich Countries, *IMF Staff Papers*, 54(2), pp. 191–219.

Blanchard, O., Giavazzi, F. (2002): Current Account Deficits in the Euro Area: The End of the Feldstein-Horioka Puzzle?, *Brookings Papers on Economic Activity*, 2002(2), pp. pp. 147–186.

Blanchard, O. J., Milesi-Ferretti, G. M. (2010): Global Imbalances: In Midstream?, CEPR Discussion Papers 7693, C.E.P.R. Discussion Papers.

Bohn, H. (1995): The Sustainability of Budget Deficits in a Stochastic Economy, *Journal of Money, Credit and Banking*, 27(1), pp. pp. 257–271.

Bohn, H. (1998): The Behavior of U.S. Public Debt and Deficits, *The Quarterly Journal of Economics*, 113(3), pp. pp. 949–963.

Bohn, H. (2005): The Sustainability of Fiscal Policy in the United States, CESifo Working Paper Series 1446, CESifo Group Munich.

Bohn, H. (2007): Are stationarity and cointegration restrictions really necessary for the intertemporal budget constraint?, *Journal of Monetary Economics*, 54(7), pp. 1837–1847.

Breitung, J. (2000): The local power of some unit root tests for panel data., in: Baltagi, B. H., ed., *Advances in Econometrics, Vol. 15: Nonstationary Panels, Panel Cointegration, and Dynamic Panels*, JAY Press, Amsterdam, pp. 161–178.

Breitung, J., Das, S. (2005): Panel unit root tests under cross-sectional dependence, *Statistica Neerlandica*, 59(4), pp. 414–433.

Canzoneri, M. B., Cumby, R. E., Diba, B. T. (2001): Is the Price Level Determined by the Needs of Fiscal Solvency?, *The American Economic Review*, 91(5), pp. pp. 1221–1238.

Chinn, M. D., Wei, S.-J. (2008): A Faith-based Initiative: Does a Flexible Exchange Rate Regime Really Facilitate Current Account Adjustment?, Working Paper 14420, National Bureau of Economic Research.

Chow, G. C., Lin, A. (1971): Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Time Series by Related Series, *The Review of Economics and Statistics*, 53(4), pp. 372–5.

Clemente, J., Montanes, A., Reyes, M. (1998): Testing for a unit root in variables with a double change in the mean, *Economics Letters*, 59(2), pp. 175–182.

Durdu, C. B., Terrones, M., Mendoza, E. G. (2010): On the Solvency of Nations: Are Global Imbalances Consistent with Intertemporal Budget Constraints?, IMF Working Papers 10/50, International Monetary Fund.

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

Ghosh, A. R., Terrones, M. E., Zettelmeyer, J. (2010): Exchange Rate Regimes and External Adjustment, in: Wyplosz, C., ed., *The New International Monetary System: Essays in Honor of Alexander Swoboda*, Routledge International Studies in Money and Banking., London, pp. 90–106.

Hamilton, J. D., Flavin, M. A. (1986): On the Limitations of Government Borrowing: A Framework for Empirical Testing, *American Economic Association*, 76(4), pp. 808–19.

Hastie, T., Tibshirani, R. (1990): *Generalized Additive Models*, Chapman & Hall.

Holmes, M. J., Otero, J., Panagiotidis, T. (2010): On the Stationarity of Current Account Deficits in the European Union, Working Paper Series 0510, Rimini Centre for Economic Analysis.

Jaumotte, F., Sodsriwiboon, P. (2010): Current Account Imbalances in the Southern Euro Area, IMF Working Papers 10/139, International Monetary Fund.

Lane, P., Milesi-Ferretti, G.-M. (2007): The International Equity Holdings of Euro Area Investors, in: Anderton, R., di Mauro, F., eds., *The External Dimension of the Euro Area, Assessing the Linkages*, Cambridge University Press, Cambridge, pp. 95–117.

Lane, P. R., Pels, B. (2011): Current Account Imbalances in Europe.

Obstfeld, M., Rogoff, K. (1996): *Foundations of International Macroeconomics*, The MIT Press, Cambridge, MA.

Perron, P. (1989): The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis, *Econometrica*, 57(6), pp. 1361–1401.

Perron, P., Vogelsang, T. J. (1992): Nonstationarity and Level Shifts with an Application to Purchasing Power Parity, *Journal of Business & Economic Statistics*, 10(3), pp. 301–20.

Pesaran, H., Pettenuzzo, D., Timmermann, A. (2007): Learning, Structural Instability, and Present Value Calculations, *Econometric Reviews*, 26(2-4), pp. 253–288.

Pesaran, M. H., Shin, Y., Smith, R. P. (1999): Pooled Mean Group Estimation of Dynamic Heterogeneous Panels, *Journal of the American Statistical Association*, 94(446), pp. pp. 621–634.

Pesaran, M. H., Smith, R. (1995): Estimating long-run relationships from dynamic heterogeneous panels, *Journal of Econometrics*, 68(1), pp. 79–113.

Trehan, B., Walsh, C. E. (1991): Testing Intertemporal Budget Constraints: Theory and Applications to U. S. Federal Budget and Current Account Deficits, *Journal of Money, Credit and Banking*, 23(2), pp. pp. 206–223.

Wilcox, D. W. (1989): The Sustainability of Government Deficits: Implications of the Present-Value Borrowing Constraint, *Journal of Money, Credit and Banking*, 21(3), pp. 291–306.

Wood, S. N. (2006): *Generalized Additive Models. An Introduction with R*, Chapman & Hall, Boca Raton.

Zivot, E., Andrews, D. W. K. (1992): Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis, *Journal of Business & Economic Statistics*, 10(3), pp. 251–70.

A Interpolation and extrapolation of net external debt

Since Lane and Milesi-Ferretti (2007) provide data on the net foreign liabilities only on an annual basis from 1970 to 2007, we employ the Chow and Lin (1971) procedure to compute a quarterly series ranging from 1971:1 to 2011:2. We suppose that there exists a relationship between a $4n \times 1$ vector of quarterly net external debt, B, and a $4n \times 3$ matrix, X, including a constant, a time trend and the quarterly cumulative current account balance of the form

$$B = X\beta + u, \tag{21}$$

where u is a random vector with mean zero and covariance matrix V which takes account of random revaluations of debt.[33] Using a dot to indicate annual data, we have

$$B. = CB = CX\beta + Cu = X.\beta + u., \tag{22}$$

with C being a $n \times 4n$ transformation matrix with the $[i, 4i-3]$-th element being one for $i = 1, \ldots, n$ and the others being zero. Assuming that the quarterly residuals follow a first-order autoregressive process with coefficient a, disturbances ϵ and variance-covariance matrix $E(\epsilon_t \epsilon_s = \delta_{ts}\sigma^2)$, Lane and Milesi-Ferretti (2007) show that the best linear unbiased predictor $\hat{B}_z$ of B_z, which is a $(n+m) \times 1$ vector with m denoting the number of quarters to extrapolate, is

$$\hat{B}_z = X_z(X.'V.^{-1}X.)^{-1}X.'V.^{-1}B. + (V_z.V.^{-1})\hat{u}. - [B. - X.(X.'V.^{-1}X.)^{-1}X.'V.^{-1}B.] \tag{23}$$

where

$$V = \begin{bmatrix} 1 & a & a^2 & \ldots & a^{4n-1} \\ a & 1 & a & \ldots & a^{4n-2} \\ a^2 & a & 1 & \ldots & a^{4n-3} \\ & & & \ldots & \\ a^{4n-1} & \ldots & a^2 & a & 1 \end{bmatrix} \frac{\sigma^2}{1-a^2} \tag{24}$$

where a is estimated by an iterative procedure. Taking an initial guess of the autocorrelation coefficient of the annual residuals, q, one computes a as the 4-th root of q and uses this value to generate V and the new annual residuals whose autocorrelation coefficient is taken as the q for the next iteration.

For all countries considered, Figure 6 plots the annual net external debt series as well as the interpolated and extrapolated quarterly net external debt series from 1975:1 to 2011:2.

[33] The cumulative current account balance uses the net external debt of 1975 as the initial value.

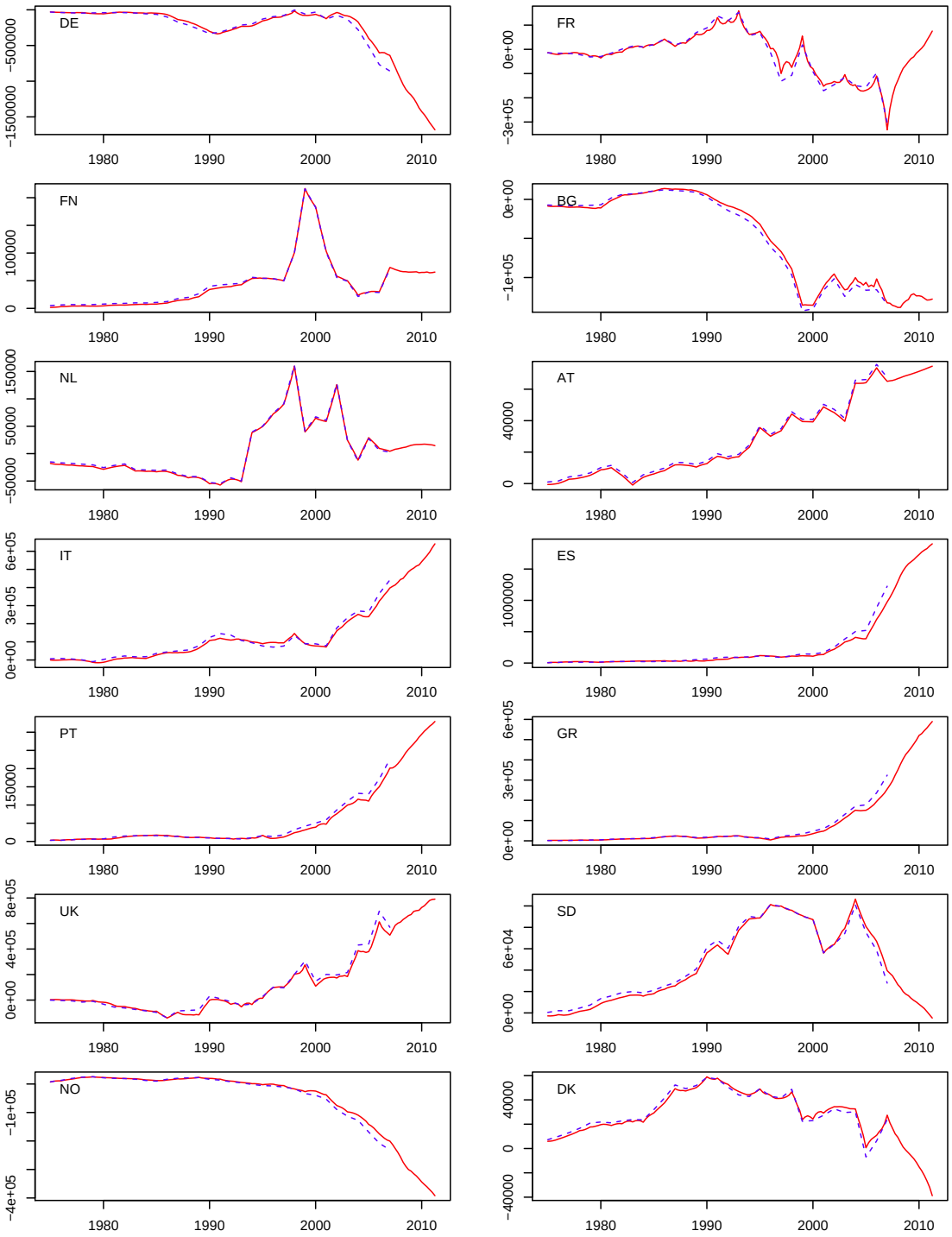

Figure 6: Annual net external debt (dashed line) and interpolated/extrapolated quarterly net external debt (solid line) from 1975:1 to 2011:2

Publisher: Hans-Böckler-Stiftung, Hans-Böckler-Str. 39, 40476 Düsseldorf, Germany
Phone: +49-211-7778-331, IMK@boeckler.de, http://www.imk-boeckler.de

IMK Working Paper is an online publication series available at:
http://www.boeckler.de/imk_5016.htm

ISSN: 1861-2199

Hans Böckler Stiftung

Fakten für eine faire Arbeitswelt.