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Sovereign Debt, Bail-Outs and Contagion in a Monetary Union*

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Abstract

The European sovereign debt crisis is characterized by the simultaneous surge in borrowing costs in the GIPS countries after 2008. We present a theory, which can account for the behavior of sovereign bond spreads in Southern Europe between 1998 and 2012. Our key theoretical argument is related to the bail-out guarantee provided by a monetary union, which endogenously varies with the number of member countries in sovereign debt trouble. We incorporate this theoretical foundation in an otherwise standard small open economy DSGE model and explain (i) the convergence of interest rates on sovereign bonds following the European monetary integration in late 1990s, and (ii) - following the heightened default risk of Greece - the sudden surge in interest rates in countries with relatively sound economic and financial fundamentals. We calibrate the model to match the behavior of the Portuguese economy over the period of 1998 to 2012.

Keywords: EMU, sovereign debt crisis, contagion, bail-out, interest rate spreads.

JEL Classification Numbers: F33, F34, F36, F41.

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1 Introduction

The sovereign debt crisis in the euro area is characterized by the simultaneous surge in borrowing costs in Southern Europe after 2008. As we document in figure 1, at the dawn of the crisis in late 2008 the spread on Greek government bonds (relative to German bonds) rose from 50 basis points (bps) to 200 bps within a couple of months, and further increased to 1000bps by 2012. Shortly after the outbreak of the Greek debt trouble, the bond spreads started to rise in Portugal, Italy and Spain as well (Fig.1). As we also present in figure 1, by the time the European Monetary Union was first established back in late 1990s, these Southern European countries experienced a convergence in their government bond spreads vis-à-vis Germany an empirical pattern, which is almost the mirror image of the diverging spreads between 2008 and 2012.

In this paper, we present a theory, which can account for the behavior of sovereign bond spreads in Southern European countries between 1998 and 2012. Our key theoretical argument is related to the bail-out guarantee - and its limitations - provided by a monetary union. We incorporate this theoretical foundation in an otherwise standard small open economy DSGE model and explain (i) the convergence of interest rates on sovereign bonds following the European monetary integration in late 1990s, and (ii) - following the heightened default risk of Greece - the sudden surge in interest rates in countries with relatively sound economic and financial fundamentals, Portugal in particular.

In our theoretical setting, we explicitly model the endogenous bail-out decision of the European Monetary Union (EMU). We assume that for EMU the cost of bailing out a country is taking over a fraction of the debt burden of that particular country. To the end of benefits of bailing out, we first assume that a country who defaults on its sovereign debt can no longer remain in the monetary union.[1] Building upon this assumption, we introduce an explicit value function for the union, which measures by how much the monetary union values each country's membership. This value function exhibits a local increasing returns to scale property such that the marginal loss associated with letting a country leave the union is the highest if that particular country is the first one to leave. This mechanism reflects the credibility loss associated with the *first-exit*. Specifically, the union desires to stay as a whole with all of its union members. Once the first country is gone, letting a second country default and leave the union is not that costly anymore.

Our theoretical mechanism implies endogenous bail-out guarantees for members of the

[1]This assumption is based on the observation of the Eurozone Crisis, where the countries were bailed out to prevent them from exiting the union. Although this motivation is of political nature, one could think of economic reasons why a defaulting government that is being cut off from financial markets needs the power to print its own currency to finance its spending.

currency union. A bail-out guarantee for a risky country reduces the interest rates on its sovereign debt, since investors expect their losses to be partially covered by the bail-out funds of the monetary union. The situation changes for an untroubled - yet risky - country, such as Portugal, after a troubled union member (Greece) ends up at the door of the currency union for an actual bail-out. From this moment on, any additional bail-out decision will need to be considered simultaneously with the first one. Because of the particular shape of the currency union value function the maximum debt level that can be supported for untroubled countries suddenly contracts - leading to the contagion of sovereign debt default risk to those countries with sufficiently high sovereign debt levels.

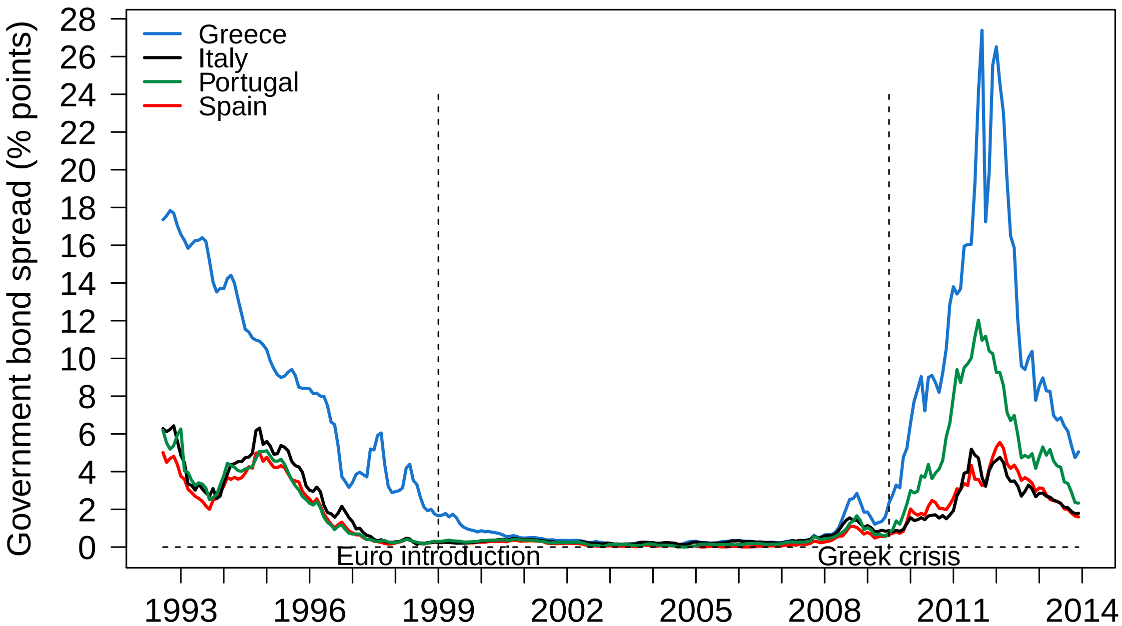

Figure 1: Spreads on government bonds of GIPS (relative to German bonds). Monthly data on long-term yields, obtained from Eurostat.

We introduce this theoretical mechanism into a small open economy DSGE model together with two additional features. The first one is the explicit modeling of sovereign default as a random event, as proposed by Bi (2012), and Bi and Traum (2012), where a government is assumed to default whenever its debt level exceeds its fiscal limit - a random variable drawn from a known distribution. This simplification allows us to highlight the macroeconomic implications of the contagion mechanism for an untroubled but risky country in the monetary union.[2]

Second, we incorporate a sovereign risk channel that transmits the movement in sovereign

[2]This approach deviates from the traditional line of literature started by Eaton and Gersovitz (1981) where default is a strategic decision.

interest rates into domestic private interest rates. This assumption has been utilized for the context of the euro area crisis by Corsetti et al. (2014), and also more broadly when studying sovereign defaults in emerging markets by Mendoza and Yue (2012). The sovereign risk channel allows us to analyze the implications of the monetary union membership on the real economy. In particular we capture an initial prolonged period of low interest rates, which leads to high output levels and debt accumulation. Once a union member is troubled, the sudden surge in borrowing costs, caused by contagion, triggers a recession and may lead to a sovereign debt crisis.

We calibrate the small open economy model to match the key moments that we observe for Portugal over the period of 1998 to 2012. Portugal is particularly interesting for our analysis because it illustrates well the idea of a relatively sound country pushed to the edge of a sovereign debt crisis by contagion. Although it went through a period of slow growth prior to the crisis, its sovereign debt as a share of GDP was at the average euro area level, and the 2008-9 GDP contraction it experienced was milder than in most of the EMU. It seems that the Portuguese debt problems started with the surge of borrowing costs and the repeated downgrading by the main rating agencies that followed in 2010.[3]

We investigate the macroeconomic implications of two exogenous shocks: the introduction of the euro and the Greek crisis. Despite the relative simplicity of the framework, the model performs quite well in replicating the behavior of key macroeconomic variables, such as interest rates, GDP and unemployment.

The results from our theoretical as well as quantitative analysis advocate for strict coordination of fiscal policies within currency unions. It shows that a no bail-out policy within a monetary union cannot be credible and, hence, needs to be replaced by a more credible set-up.

Our paper is related to two strands of literature. Recent empirical studies discuss the spread puzzle in the euro area sovereign bond markets. Bernoth et al. (2012), Aizenman et al. (2013), Beirne and Fratzscher (2013) and Ghosh et al. (2013) using either yield spreads or CDS spreads document that sovereign interest rates were mostly insensitive to fiscal variables prior to the crisis, and that this changed drastically during the crisis. Moreover, Mink and de Haan (2013) and Ludwig (2014) find empirical evidence for contagion in sovereign debt markets within the EMU. Our paper complements the empirical literature on the spread puzzle by providing a theoretical framework.

Our work is also related to theories which aim to investigate the euro area crisis. Broner

[3]An interesting example of an opposite situation is Belgium, which had much higher debt levels, similar output performance and a series of political crises, which resulted in 535 days without a government in 2010-11, but experienced no sovereign debt crisis in this period. We come back to the case of Belgium in our discussion in section 5.

et al. (2014) build a small open economy model with creditor discrimination to explain the rapid increase in the share of sovereign bonds held by domestic investors in the southern euro area countries. Aguiar et al. (2013) and Corsetti and Dedola (2013) show how a credible central bank may prevent a self-fulfilling sovereign debt crisis in a stand-alone country and argue that this ability is lost within a monetary union. Corsetti et al. (2014) investigate in a two-region monetary union how high debt levels in one of the regions may lead to a self-fulfilling sovereign debt crisis in the whole union. Beetsma and Mavromatis (2014) consider different forms of debt mutualisation in a monetary union. Finally, the decision of a potential euro area break-up is considered by Alvarez and Dixit (2014).

The rest of the paper is organized as follows. Section 2 presents the basic mechanism of our theory. Section 3 outlines the small open economy model, which we use to consider the dynamic implications of the monetary union and regimes. Section 4 is devoted to the quantitative analysis of our model calibrated to the Portuguese economy. Section 5 considers potential extensions of the theory and its policy implications. Finally, section 6 concludes.

2 Basic mechanism

Let us consider a government of a country within a monetary union. Every period it issues some amount of one-period bonds, B_t. Those bonds pay a net return r_t^G and are traded on international markets. We assume that the international investors are risk neutral, which implies that the required expected return on government bonds has to equal the risk-free rate on world markets, r^*, which can be expressed in a no arbitrage condition:

$$1 + r^* = (1 - p(B_t))\,(1 + r_t^G) + p(B_t)(1 - \theta)(1 + r_t^G), \tag{1}$$

where $p(B_t)$ is the probability of default, and θ is the expected loss in the case of default, which - as will be explained in the next subsection - depends on the prevailing regime.

Following Bi (2012) and Bi and Traum (2012), default is defined here as a situation in which the debt level exceeds the fiscal limit, $B_t > B_{t+1}^*$. Since the fiscal limit is a stochastic variable with a known distribution, the probability of default is defined as $p(B_t) = P(B_t > B_{t+1}^*)$.

2.1 Monetary union and regimes

As already mentioned, the loss to the investors in case of default, θ, depends on the prevailing regime, or stated differently, on the institutional arrangements. For a country, for whom there is no one to step in to provide financial support, $\theta = \bar{\theta} > 0$. The scenario with no external support during troubled times will be referred to as the *stand-alone* regime. A country within a monetary union, on the other hand, may be bailed out by other member countries in the case of default, which would mean that the investors bear no losses, i.e. $\theta = 0$.[4] Such a bail-out may be explicit in the form of an international treaty, or implicit. An implicit guarantee results from the fact that investors anticipate that other countries in the union will support the troubled country to keep it within the monetary union.[5] In this paper, we concentrate on implicit bail-out guarantees. We call the scenario with ex-ante bail-out expectations as the *cooperative* regime.

The decision of the other countries whether to bail out a troubled member of the monetary union is modeled as a comparison of the costs of the bail-out and the benefits of keeping the country within the union. We assume that a defaulting country has to leave the monetary union, unless it is bailed out. The other countries in the union attach some value M to the monetary union, which depends on the number of countries that remain within the union, k

$$M(k) = \begin{cases} m_0 + m_1 k & \text{if } k = N \\ m_1 k & \text{if } k < N. \end{cases}, \tag{2}$$

where $m_0, m_1 > 0$ are parameters, and N is the total number of countries within the union. This simple specification assumes that the countries attach some constant value to keeping each member within the union, m_1, but they also attach some value to keeping all countries within the union. This local increasing returns to scale feature reflects the idea that the first country leaving a monetary union would prove that this may indeed happen and, hence, undermine the credibility of the whole union.[6] We refer to this as the *first-exit* effect.

The cost of a bail-out equals to the expected losses that need to be financed because of the bail-out, i.e. $\bar{\theta}(1 + r_t^{G,h})B_t$. In normal times the probability of multiple countries running into debt trouble at the same time is very low, implying, the bail-out decision to be considered separately for each member of the union. This means that the bail-out condition boils down to

$$\bar{\theta}(1 + r_t^{G,h})B_t < M(N) - M(N-1) = m_0 + m_1. \tag{3}$$

It is important, however, to keep in mind that the interest rate depends on the regime.

[4]One could imagine a bail-out with partial losses to investors. Nevertheless, to keep the model simple we will assume that $\theta = 0$ whenever there is a bail-out.

[5]For a discussion of implicit bail-out guarantees in the context of the East Asian crisis see e.g. Corsetti et al. (1999).

[6]The linear functional form is used only for simplicity. In fact, all the result in this section hold for any $M(k)$ that exhibits local increasing returns to scale, such that the marginal loss associated with the *first-exit* is the highest, or stated differently, the results hold for any $M(k)$ that satisfies $\forall_{N>k>1} M(N) - M(N-1) > M(k) - M(k-1)$.

Therefore, the conditions for the prevailing regime can be stated as

$$\text{Regime} = \begin{cases} \text{Cooperative,} & \text{if} \quad B_t < \underline{B}, \\ \text{Multiple equilibria,} & \text{if} \quad \underline{B} \leq B_t < \bar{B}, \\ \text{Stand-alone,} & \text{if} \quad \bar{B} \leq B_t, \end{cases} \tag{4}$$

where $\underline{B}$ is the level of debt, which solves (3) with equality under the stand-alone regime, and $\bar{B}$ is the solution to the same under the cooperative regime. Due to the effect the regimes have on interest rates, it always holds that $\underline{B} \leq \bar{B}$.

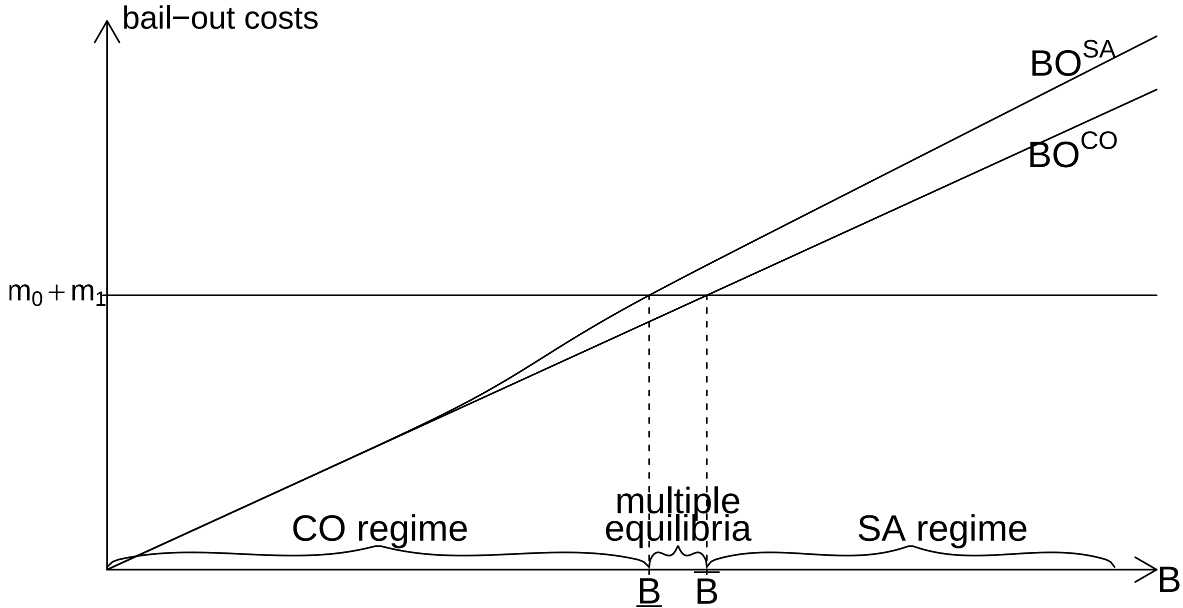

Figure 2: Determination of the prevailing regime. Bail-out costs (BO) are weighed against the cost of the country exiting the union ($m_0 + m_1$).

The above condition states that if the expected bail-out costs are lower than the maximum bail-out size, m_0+m_1, then the other countries are expected to intervene and the cooperative regime prevails. If, on the other hand, even the costs under the cooperative regime exceed the maximum bail-out, then investors expect no intervention, hence, the stand-alone regime prevails. Finally, if the result of a comparison of the expected costs and benefits of a bail-out depends on the prevailing regime then both regimes are self-fulfilling equilibria. Stated differently, in this case, if the investors expect one of the regimes to prevail they will charge the appropriate interest rate. If the government happens to default then the costs of a bail-out depend on the previously chosen interest rate. This implies that there will be no bail-out if investors expected the stand-alone regime to prevail, and charged a higher interest rate. On the other hand, the country will be supported if investors expected the cooperative regime to prevail and, hence, charged lower interest rates.

This analysis is also presented in a graphical form in figure 2. The two curves named BO^{SA} and BO^{CO} represent the expected bail-out costs under the stand-alone and the co-operative regime, respectively. The points where they cross the horizontal line representing the maximum bail-out, m_0+m_1, determine the threshold debt levels, $\underline{B}$ and $\bar{B}$, respectively. Those points divide the horizontal axis into three areas, with different regimes prevailing, as discussed.

2.2 Contagion

The bail-out decision looks different when one of the countries within the union undergoing debt trouble is already receiving financial aid. Then, any other contemporaneous bail-out decision will have to be considered jointly with the initial bail-out. This modifies the optimal bail-out condition to

$$\sum_{j=1}^{J} \bar{\theta}(1+r_{t,j}^{G})B_{t,j} < M(N) - M(N-J) = m_0 + Jm_1, \tag{5}$$

where J is the number of countries in need of a bail-out, and the subscript j denotes j-th country variables. In general, whenever some of the J countries may need a bail-out higher than their marginal value to the union, m_1, the maximal bail-out available to the remaining countries is lower than the one in equation (3). This shift in the maximum available bail-out may lead to a situation in which some countries exceed the debt threshold $\bar{B}$ and, hence, switch from the cooperative to the stand-alone regime.[7]

This situation is presented in figure 3. In this scenario, the country has a debt level B_t, which is lower than $\underline{B}$ if the maximum bail-out is $m_0 + m_1$. This means that the country operates under the cooperative regime. The situation changes, however, once the maximum bail-out falls from m_0+m_1 to a new, lower level (somewhere between m_0+m_1 and m_1). The country debt level does not change, but the debt thresholds do, and it leads to the situation where $B_t > \bar{B}'$. Hence, the country switches to the stand-alone regime and its borrowing costs surge, potentially leading to a higher accumulation of debt. This may turn an initially fiscally sound country into a highly troubled economy.

The risk of a regime switch depends on the initial sovereign debt level of a given country.

[7]This analysis looks only at the expected costs of a bail-out, hence, a regime switch does not mean that the country necessarily defaults.

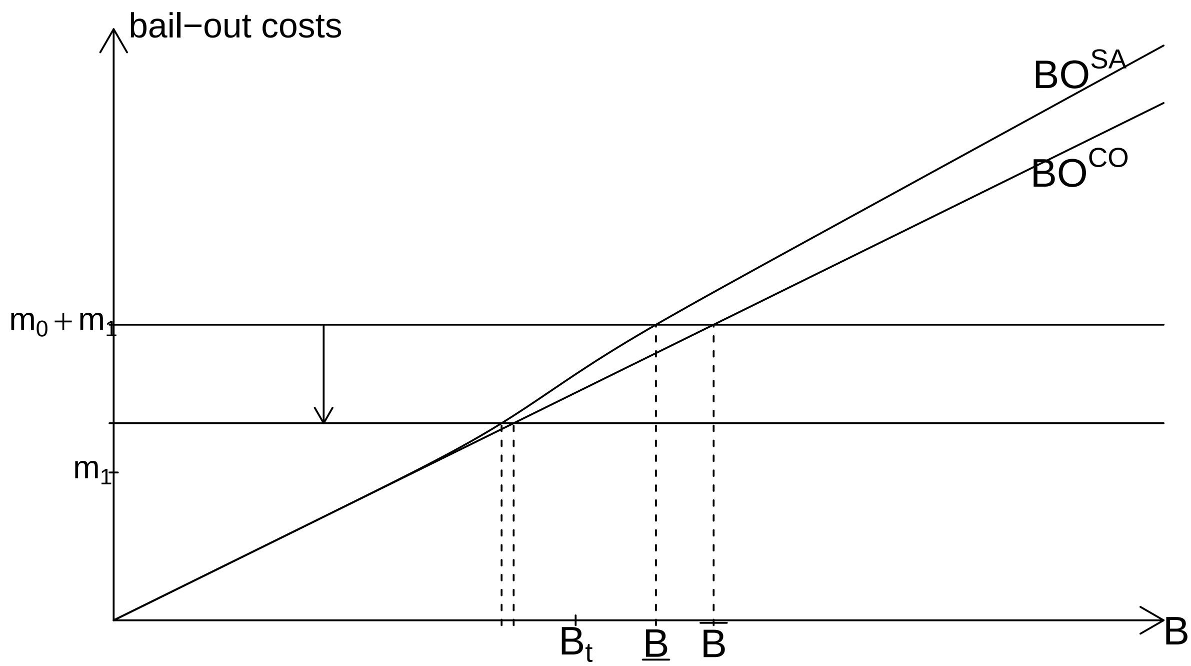

Figure 3: Contagion mechanism within a monetary union. A shift in the maximum available bail-out (from $m + m_0$ to a new, lower level) leads to a switch from the cooperative to the stand-alone regime.

In general, whenever the debt level satisfies

$$\frac{m_1}{\bar{\theta}(1 + r_t^G)} < B_t < \frac{m_0 + m_1}{\bar{\theta}(1 + r_t^G)}$$

this country may experience a regime switch caused by the sovereign-debt contagion. That risk depends on the fiscal position of the remaining countries in the union and their probability of a debt crisis.

Applying this mechanism to the situation in the European Monetary Union, one could expect two regime switches. The first one taking place around 1999 when the monetary union came into life and the creditors could expect the repayment of sovereign debts of every euro country to be guaranteed by the whole union. This would be a switch from the stand-alone to the cooperative regime.

The next switch might have taken place during the global financial crisis. The first country hit by the crisis was Greece, and the countries of the euro area were quick to react. But the amount of financial support granted to Greece might have been higher than the marginal value of keeping Greece within the monetary union, here m_1. If that was the case, then the maximum support the next troubled country, which requires a bail-out simultaneous to the Greek bail-out, would expect was going to be lower than in normal times, i.e. lower than $m_0 + m_1$. This would naturally shift down the maximum debt level supporting the cooperative regime, $\underline{B}$. In the case of countries with even moderately high debt levels, this could translate into a switch from the cooperative to the stand-alone regime, causing the sudden rise in borrowing costs as observed in peripheral Europe.

3 The DSGE model

To investigate the dynamic properties of the described mechanism and the potential consequences of regime switches it is necessary to incorporate it into a fully specified macroeconomic model. For this purpose we will consider a standard small open economy model, similar to the ones presented by Schmitt-Grohe and Uribe (2003), and Neumeyer and Perri (2005). The model is kept as simple as possible, except for three main innovations introduced to the basic framework. They are meant to modify the model to allow the analysis of the situation of a small country joining a monetary union. Two of those extensions have been already discussed in the previous section.

The first innovation is the way we approach government debt by explicitly modeling default risk as the probability that the debt level exceeds the fiscal limit. An approach that was first introduced by Bi (2012) and Bi and Traum (2012).

The second innovation is the introduction of the bail-out decision by the remaining members of the monetary union.The member countries decide about their financial support by comparing the costs of a bail-out with the costs of an exit from the monetary union of the defaulting country. This decision, in turn, affects the losses that international investors have to bear on sovereign bonds. The described mechanism leads to the emergence of two regimes. Under the cooperative regime the country is expected to be bailed out by its partners whenever needed. Under the stand-alone regime, on the other hand, the country is not expected to be bailed out.

Finally, the last innovation is to assume that the country specific risk-free interest rate, which serves as the benchmark for determining the interest rate offered to households and firms, is equal to the interest rate on sovereign bonds. This allows the private interest rates to react to regime switches and is conceptually related to two alternative assumptions made in the literature on sovereign default. According to the first one, used by Mendoza and Yue (2012), private credit repayments might be partially diverted in case of sovereign default. The second one, made by Corsetti et al. (2013, 2014), introduces a 'sovereign risk channel', which makes private risk premia dependent on domestic sovereign risk. Both assumptions imply that private interest rates partially follow the dynamics of the interest rates faced by the government. Corsetti et al. (2013) provide evidence that this effect was economically significant in the euro area countries during the recent crisis.

3.1 Households

Consider a small open economy populated by an infinite number of identical households, which derive utility from consumption, c_t, and leisure as follows

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t, l_t), \tag{6}$$

where l_t denotes hours worked, $\beta \in (0,1)$ is the discount factor, and U is the period utility function of the form $U(c,l) = \frac{1}{1-\sigma}\left[c - \chi l^{\upsilon}\right]^{1-\sigma}$, and $\upsilon > 1$, $\psi > 0$.

Households own all the physical capital in the economy, k_t, which evolves according to

$$k_{t+1} = (1-\delta)k_t + i_t, \tag{7}$$

where $\delta \in (0,1)$ is the depreciation rate of capital, and i_t denotes investment in future capital.

The agents in this model face also a sequence of period budget constraints given by

$$b_t = (1 + r^H_{t-1})b_{t-1} + c_t + i_t + \Phi(k_{t+1} - k_t) + \Psi(b_t) - w_t l_t - u_t k_t + T_t - G_t, \tag{8}$$

where b_t is the household's net debt position at the end of period t, r^H_t is the interest rate on household debt, $\Phi(\cdot)$ are capital adjustment costs, $\Psi(\cdot)$ are portfolio adjustment costs, $w_t l_t$ represents labor income, $u_t k_t$ income from the rental of physical capital, and T_t and G_t denote a lump-sum tax and a lump-sum transfer from the government, respectively.[8] Capital adjustment costs take the functional form $\Phi(x) = (\phi/2)x^2$, where $\phi > 0$, while portfolio adjustment costs are assumed to be equal $\Psi(x) = (\psi/2)(x - \bar{b})^2$, where $\psi > 0$ and $\bar{b}$ is a constant parameter.[9]

We introduce the sovereign risk channel in the simplest possible way by assuming that the interest rate faced by households, r^H_t equals the interest rate on sovereign bonds r^G_t.

[8] All variables in this model are real and expressed in terms of consumption units and prices are assumed to be constant and equal to the overall price level in the monetary union. This simple approach follows from the assumption of purchasing power parity and a common currency in the whole monetary union. Price and inflation level differences within the EMU are a well known fact and have been reported by i.a. Turunen et al. (2011) and Estrada et al. (2013). The analysis of this issue is intentionally left for future research.

[9] Portfolio adjustment costs, also known as debt holding costs, are needed to guarantee the stability of the model. For alternative ways of closing a SOE model see Schmitt-Grohe and Uribe (2003).

The problem of the household, hence, can be represented as maximizing (6) subject to (7) and (8). The first order conditions associated with this problem are

$$\begin{aligned}
\beta(1+r_t^H)\mathbb{E}_t\left[\frac{U_c(c_{t+1},l_{t+1})}{U_c(c_t,l_t)}\right] &= 1+\kappa(b_t-\bar{b}), && (9)\\
U_l(c_t,l_t) &= -w_tU_c(c_t,l_t), && (10)\\
(1+r_t^H)\left[1+\mathbb{E}_t\Phi'(k_{t+1}-k_t)\right] &= \mathbb{E}_tF_k'(k_{t+1},l_{t+1})+1-\delta+\mathbb{E}_t\Phi'(k_{t+2}-k_{t+1}), && (11)
\end{aligned}$$

where the first is the intertemporal Euler equation associated with the debt/savings decision, the second one determines labor supply, and the third one is the Euler equation for capital.

3.2 Firms

Firms operate in a perfectly competitive environment. They rent capital and hire labor from households to produce the homogeneous good using a Cobb-Douglas production function

$$F(k,l) = Ak^{\alpha}l^{1-\alpha}. \tag{12}$$

Due to a friction in the labor market firms need to borrow the funds necessary to pay the wage bill at the beginning of the period (working capital constraint). This means that the profits earned by firms can be written as

$$\Pi(k,l) = F(k,l) - uk - (1+r^H)wl. \tag{13}$$

Each period firms choose production factors to maximize profits, which gives the following first order conditions

$$\begin{aligned}
w &= \frac{F_l(k,l)}{1+r^H}, && (14)\\
u &= F_k(k,l). && (15)
\end{aligned}$$

Since the production function is homogeneous of degree one the profits are always equal zero.

3.3 Government

The government finances its spending, G_t through taxes on households, T_t and debt, B_t. The budget constraint of the government takes the form

$$G_t + (1+r_{t-1}^G)B_{t-1} = B_t + T_t. \tag{16}$$

As in Corsetti et al. (2014), we define the tax revenues to behave according to a reaction function

$$T_t = \tau^Y \left[\rho^\tau Y_t + (1-\rho^\tau)\bar{Y}\right] + \tau^B \left(B_{t-1} - \bar{B}\right), \tag{17}$$

where both parameters τ^Y and τ^B are positive, and $\bar{Y}$, $\bar{B}$ are steady state values of output and debt, respectively. This form of reaction function indicates that tax revenues increase with the improvement in economic activity, as well as with rising debt. Additionally, τ^B is assumed to be large enough to prevent debt from exploding. At the same time we assume government spending to be constant over time, $G_t = \bar{G}$.[10]

Finally, following Bi (2012) and Bi and Traum (2012), we specify the cumulative density function of the fiscal limit distribution as a logistical function. Then the default probability takes the form:

$$p(B_t) = \frac{\exp(\eta_1 + \eta_2 B_t)}{1 + \exp(\eta_1 + \eta_2 B_t)}, \tag{18}$$

where η_1 and η_2 are time-invariant parameters dictating the shape of the distribution.

4 Quantitative analysis

Since the presented model has no analytical solution, in this section we turn to describing its quantitative properties. We first calibrate the model to match the Portuguese economy and then consider a scenario with two regime switches, i.e. a switch from a stand-alone to the cooperative regime at the time of the introduction of the euro, and then a switch to the opposite direction by the time the global crisis hit Europe and Greece got into debt trouble. Next, we compare those results with the actual dynamics of macroeconomic variables within this period, in order to assess whether our model can capture some of the developments observed in the economies of peripheral EMU countries.

For the simulations of the model we use the perfect foresight approach with the exception that the regime switches are unexpected.[11] In practice, this translates into calculating two transition paths between two different steady states. First, the economy is assumed to be in the stand-alone steady state directly before the introduction of the euro, and that is also the starting point for the transition path to the cooperative regime. The second regime switch takes place ten years after the first switch, and there is no anticipation of the switch. This

[10] Since neither taxes, nor government spending are distortive in this model, the role of taxes and government spending is limited to the role played by the primary surplus. Therefore, the assumption of constant government spending and reactive tax revenues is not restrictive as it is equivalent to any other combination of the two that yields the same behavior of the primary surplus.

[11] An exception from the perfect foresight approach is also made for the fiscal limit, hence, also for the default decision. In the considered scenarios a sovereign default is always considered *ex ante* as possible, but it never occurs.

means that the second transition path is simply calculated as a separate perfect foresight path starting at the eleventh year of the previous transition path and converging to the stand-alone steady state.

Assuming that the regime switches are unexpected is an obvious simplification. The first switch has been, of course, anticipated, so one could assume that all the results around this period should have been smoother. The assumption is definitely more plausible in the case of the second regime switch as the Greek sovereign debt crisis was indeed unexpected. First of all, investors and policymakers failed to realize how the financial crisis is going to spread. The picture of the Greek fiscal situation was additionally blurred by manipulations in official statistical reports.

4.1 Calibration

We calibrate the model to the Portuguese economy, with one period being set to one year.[12] All the parameter values are presented in table 1. The long-run tax rate, τ^Y, is set equal to the average ratio of tax revenue to GDP in Portugal in the years 1997-2008. The parameter ρ^τ is set to 0.25 to reflect the low variability of tax revenues in the pre-crisis period. The level of government expenditure, G, is chosen so that in the steady state the primary surplus of the government allows to cover the interest payments on debt, with a steady state level of debt equal to 65% of GDP. This debt level reflects the average for the period 1997-2008.

Table 1: Parametrization of the model

Households		**Government**	
Discount factor	$\beta = 0.95$	Steady state tax rate	$\tau^Y = 0.40$
Utility curvature	$\sigma = 5.00$	Sensitivity of taxes to output	$\rho^\tau = 0.25$
Labor curvature	$\upsilon = 1.60$	Long-run government spending	$G = 0.36$
Relative weight of labor	$\chi = 2.48$	Expected losses on bonds	$\theta = 0.10$
Depreciation rate of capital	$\delta = 0.10$	Fiscal limit distribution	$\eta_1 = -11$
Capital adjustment costs	$\phi = 8.00$		$\eta_2 = 11$
Portfolio adjustment costs	$\psi = 0.50$	World risk-free interest rate	$r^* = 0.05$
Firms			
Technology parameter	$A = 1.67$	Effective capital share	$\alpha = 0.33$

Since there are no cases of default of developed countries in the modern history, the parameters of the fiscal limit distribution, η's, and the expected losses in case of default

[12] The most popular alternative would be to set one period to a quarter. We have chosen one year because data on the government sector are usually reported on an annual basis. Another argument for this choice is the medium term focus of this paper, as compared to traditional business cycle DSGE models.

have to be based on data for emerging countries and the current risk evaluation in the euro area. Therefore, we assume $\theta = 0.1$ following the calculations of Bi (2012) for the effective losses on bonds of emerging market countries in case of default. Having set this coefficient, we calibrate the parameters of the fiscal limit distribution to follow the actual relationship between Portuguese debt levels and the spread between Portuguese and German sovereign bond interest rates during the debt crisis. The obtained parameters, $\eta_1 = -11$ and $\eta_2 = 11$, are smaller but close to the values obtained for Italy and Greece by Bi and Traum (2012) with Bayesian estimation methods. Finally, the risk-free interest rate was chosen close to the average interest rate on German sovereign bonds, i.e. $r^* = 5.3\%$.

The parameters governing the household's problem are mostly chosen based on values traditionally used in macroeconomic studies. This way, the discount factor, $\beta = 0.95$, and the depreciation rate of capital, $\delta = 0.1$, are annual equivalents of the commonly used values of 0.98-0.99 and 0.025, respectively, used in macroeconomic models calibrated for quarterly data. The parameters of the relative utility weight of labor, and of labor curvature are taken from Neumeyer and Perri (2005).

The portfolio adjustment costs parameter, ψ, was chosen to obtain the dynamics of capital flows similar to what is observed in the southern euro area countries. The same approach was taken for the capital adjustment parameter, ϕ, whereas it is interesting to mention that the model was rather insensitive to any changes to ϕ, as long as it stayed positive.

The last two parameters define the production function. The effective share of capital, α, is chosen to equal one third, following most macroeconomic models, and is consistent with data for Portugal. The technology parameter, A, is set to 1.67 as a normalization of the steady-state production level to unity.

4.2 EMU and the two regime switches

In this section, we consider the dynamic effects of the two regime switches, with a transition from the stand-alone to the cooperative regime at the time of the euro introduction, and from the cooperative regime to the stand-alone regime as an aftermath of contagion following the Greek sovereign debt crisis. To make the exercise closer to the events in the EMU, government expenditure dynamics in the first years after the second switch follow the actual dynamics in the GIPS countries. This means an increase in government spending of ten percentage points in the first three years of the crisis, and then a gradual introduction of austerity measures.[13]

[13]Here, austerity is meant only in terms of spending cuts and/or tax increases, without any impact on the national economy, except for the indirect effect going through interest rates. This allows me to refrain from the fiscal policy oriented austerity versus stimulus discussion. For recent contributions to this discussion the

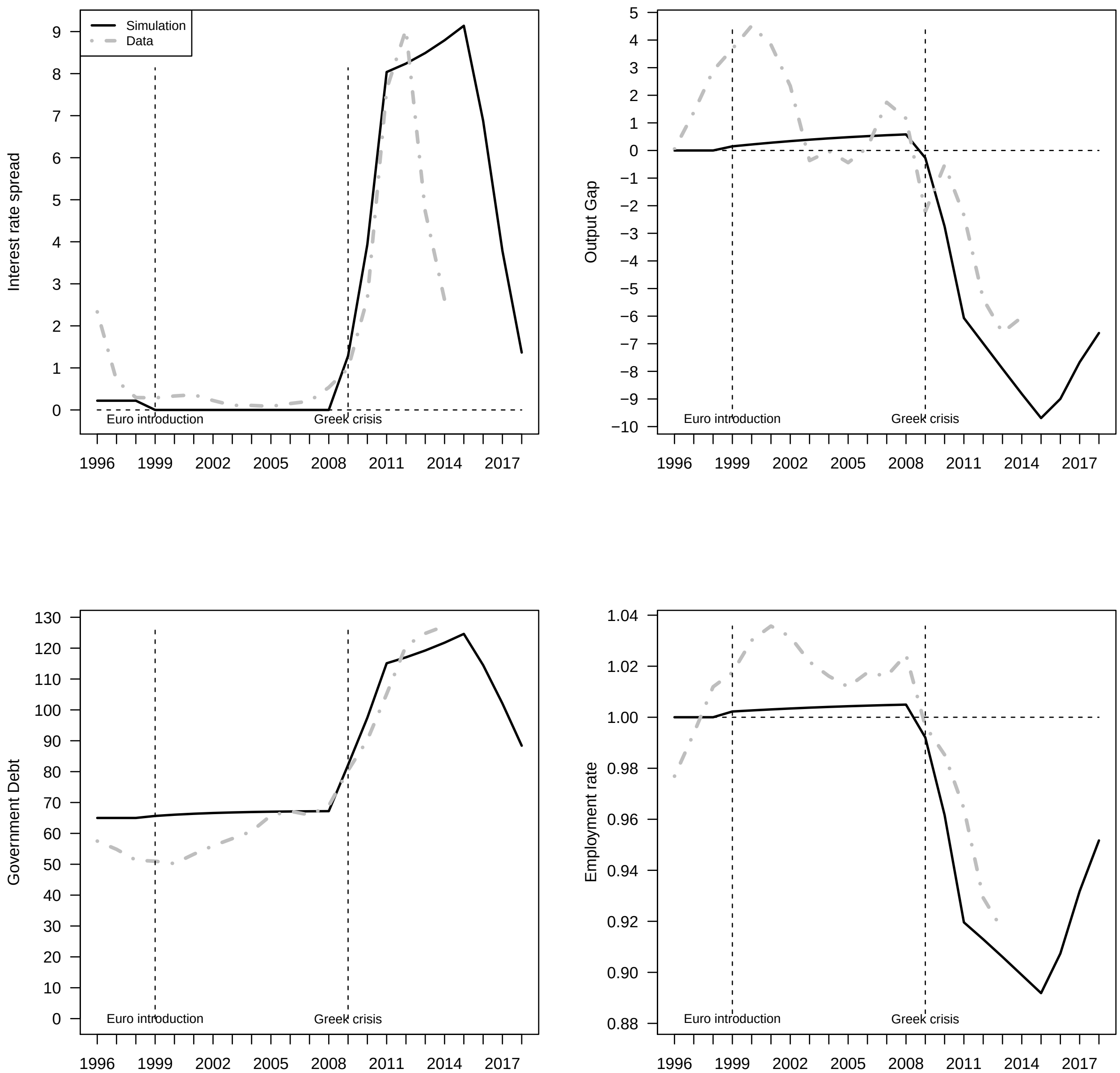

Figure 4: Effects of the introduction of the euro and contagion from the Greek crisis modeled as regime switches from the stand-alone to the cooperative and from the cooperative to the stand-alone regime, respectively. Data were obtained from the Eurostat and OECD databases.

Figure 4 shows the behavior of the model's variables when the economy transits to a steady state with zero spreads, and their reaction to the reemergence of spreads. The first drop in interest rates is relatively low. This results from the fact that the spread in the model reflects only default risk, whereas the pre-EMU spreads were largely driven by exchange rate

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reader may refer to i.a. Mendoza et al. (2014), Corsetti et al. (2013), and the discussion in Corsetti (2012).

risk in high inflation countries.[14]

What is more important, the model captures well the surge in borrowing costs from 2009 to 2012, i.e. up to the time of the statement made by the ECB president Mario Draghi on July 26, 2012 that "*the ECB is ready to do whatever it takes to preserve the euro*", which pushed the sovereign interest rates of the GIPS countries down. In terms of our model, we could think of the statement as increasing the credibility parameter, m_0, and pushing Portugal into a regime that is a hybrid of the two discussed regimes.

The model predicts also the positive effect of the euro introduction on output and employment, even though it underestimates it. This might be due to the simplicity of the used model and lack of any channel for the positive trade effects of exchange rate risk elimination. Nevertheless, the model captures very well the recession triggered by Greek contagion. It accounts for both the deepness and long duration of the economic downturn. According to the model predictions a recovery will be only gradual and will reach a lower steady state level.

It is also illustrative to consider that in order to keep the model stable, it is necessary to assume a quick debt reduction, which is here equivalent to a high value of τ^B. Any scenarios without substantial debt repayments returned explosive debt paths and ever-shrinking economies.

5 Policy implications and extensions

The presented results seem to mirror the general pattern observed in the euro area, which was the main purpose of this paper. Therefore, they allow to understand at least partially the puzzling behavior of the interest rates on sovereign bonds of those countries as compared to those of Germany and other AAA core euro area countries. The model was kept simple intentionally, to allow a transparent presentation of the novel ideas and any future policy applications of the model will inevitably require several extensions of the theoretical framework.

If the model is to provide reliable quantitative predictions, a distinction between tradable and non-tradable goods is necessary. The inclusion of non-tradable goods would also allow to distinguish between domestic and union wide price levels, capturing another important dimension of the EMU problems. This might also allow the model to shed some light on the current account imbalances within the euro area, which are an important dimension of the crisis and were mostly neglected so far.

[14]This has been also argued by i.a. Kan (1998) and Bassetto (2006).

Also the government sector and the regime switch mechanism could be extended. One possibility to do so is by endogenizing the fiscal limit distribution. So far it has been assumed to be exogenous. This assumption is not too restrictive, since the distribution depends on the long-term ability of the government to repay its debt, which is only to a limited extent influenced by short term developments. Nevertheless, a prolonged recession could have an impact on the primary surplus that lasts for several years. This extension would require the introduction of distortionary taxes to calculate Laffer curves, as has been done in Bi (2012), as well as a more micro based approach to government spending.

Another improvement of the model would be a more sophisticated mechanism for regime switches and a more dynamic treatment of bail-outs. Whereas now we consider two exogenous regime switches, one could imagine a third, endogenous switch, back to the cooperative regime. This might happen at the time the country reduces its debt sufficiently.

The presented model is relatively simple since it is meant to serve rather as a framework for explaining and understanding the mechanisms within a monetary union. Nevertheless, as long as the limitations of the model are kept in mind, some general policy implications may be drawn based on this model.

First of all, the model shows how strongly interconnected are countries within a monetary union. The discussed contagion mechanism relies on the fact that fiscal problems in one of the countries within the union may spread to others through a regime switch, which triggers a surge in interest rates. This means that national fiscal policy has international effects and should, hence, be subject to international regulation. The idea is not completely new, as it has been already implemented in the EMU in the form of the Stability and Growth Pact. This suggests that the failure of the pact may be one of the main sources of the current crisis. This also means that a more robust mechanism is needed to avoid a repeat of the recent events.

Another institutional problem of the European Monetary Union highlighted by the model, is the existence of implicit bail-out guarantees. Despite the explicit no bail-out clause included in the Maastricht Treaty, the governments of Greece, as well as Ireland, Portugal, and Cyprus, received support from the other euro area countries. This proves that the no bail-out clause was unreliable from the beginning of the EMU, and markets behaved rational to perceive it as such. To solve this problem the euro area governments need to choose an institutional framework that is reliable. The creation of an explicit institution responsible for inter-governmental support, such as the European Stability Mechanism, is a move in the right direction but it does not solve the issue. The problem of the ESM is the limited funding it can manage. The current fund would not be sufficient to save one of the larger countries, as e.g. Italy or Spain. The crucial question is what would the other euro area countries do if one of the large countries needed support. The EMU will be prone to confidence drops triggering regime switches as long as the bail-out policy is not made clear and transparent, and countries do not take its limitations into account while setting their fiscal policy.

A related implication is also the economic importance of statements made by political leaders. Since in reality the values of m_0 and m_1 are not publicly known, any statement made by a policymaker about granting support, may influence the public perception of those values and shift the regimes. In fact, it might be argued that the ECB president Mario Draghi used exactly this power on July 26, 2012, when he made the pledge that "*the ECB is ready to do whatever it takes to preserve the euro.*" Therefore, negative statements made by other European leaders may have the opposite effect and contribute to the international debt problems.

This model might also offer a framework for explaining why the contagion effect was limited to peripheral countries and did not affect highly indebted core countries, as e.g. Belgium. This might not have been an effect of the core countries' higher fiscal reliability, but rather of their economic and political value, significantly higher than in the case of the other EMU members. Going back to the example of Belgium, its location in the center of the euro area, with a number of key EU institutions in Brussels, and sharing its official languages with two other core countries, makes it a vital member of the monetary union. One could expect, therefore, that other countries will be ready to save it at a much higher cost than e.g. Portugal. And this would mean that m_1 has a different value for different countries, making them more or less prone to regime switches.

6 Conclusions

The behavior of sovereign interest rates in the EMU countries is one of the new puzzles in international macroeconomics, with a large body of empirical literature documenting the insensitivity of governments borrowing costs to fiscal variables prior to the European debt crisis, as well as studies investigating contagion effects from Greece to other Southern European countries. The theory presented in this paper provides a possible explanation for the spread puzzle. It allows to understand the convergence of the interest rates on government bonds as the effect of implicit bail-out guarantees within a monetary union. At the same time, the reemergence of spreads in the aftermath of the Greek crisis is captured within our model as a second switch. Contagion in this model is equivalent to the switch from the cooperative to the stand-alone regime, which happens when potential bail-out decisions are taken for several countries at the same time and the threat of the credibility loss connected to the *first-exit* is weighted against the size of those multiple bail-outs.

We incorporate the optimal bail-out framework into a small open economy model to consider the dynamic effects of regime switches. The model is calibrated to key features of the Portuguese economy. Without introducing any further shocks, we show how the first regime triggers a modest expansion in economic activity, while the Greek contagion and the second regime switch cause a prolonged and deep recession. Despite the simple structure of the considered model, we are able to replicate the actual dynamics of GDP and employment in Portugal.

The results of our analysis are a strong argument in favor of fiscal coordination within a monetary union, as the fate of the union members is strictly interconnected and initially sound countries may be dragged down by contagion. On the basis of our model we also argue for a more transparent and explicit mechanism for inter-governmental support, as the no bail-out clause turned out to be not credible and creates more space for uncertainty about the sustainability of sovereign debt.

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