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A modern Dionysus' tale: new evidence on the Greek debt crisis and the related costs

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Abstract

In March 2012 Greece pressured its private creditors into agreeing a 53% write-off of its privately-held debt, amounting to €100 billion. Using a game theory approach, we determine whether debt reduction was optimal in reducing the probability of default. We estimate the costs associated with the reduction as well as the potential risks and costs of contagion within the eurozone, especially for large European economies such as Italy and Spain. We show evidence that the Greek sovereign debt crisis could not be handled in the same way as previous experiences. Greece's sovereign debt crisis is unique insofar as the country belongs to a monetary union that has failed to reach economic convergence among its members. This creates significant spillover risk for the other eurozone economies, especially regarding the potential costs of another credit event.

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1. Introduction

Between 2003 and 2011 the Greek public debt increased from €167 billion to €355 billion. This was made possible by the country's membership of the European Monetary Union (EMU), which gave it with a low interest rate and a common, strong currency.

This paper examines the specific features of the Greek debt crisis in the context of EMU, as well as the efficiency of the debt reduction scheme implemented in 2012 and the consequences on Greece's probability to default. We estimate the costs associated with the 2012 debt relief package in terms of loss in principal value and the coordination and administrative costs to creditors resulting from the debt exchange. Moreover, we want to understand why Greece can be considered as a unique example by conducting simulations on a total of nine countries: four belonging to EMU countries and five in the European Union (EU) but not the eurozone. For each country, we estimate the potential costs of debt restructuring and default for different levels of debt reduction. By comparing simulated results with the "real" Greek case, we provide new insights into the differences in terms of debt management inside and outside EMU as well as into the characteristics of debt relief within the eurozone.

In a monetary union like the eurozone, constraints such as a currency over which members have no control (De Grauwe and Ji 2013) and a lack of independent monetary policy may have prevented Greece from properly managing its competitiveness, due to increases in prices and wages (Lachman 2010). In 2008 the subprime crisis highlighted the weaknesses of the Greek industrial structure, i.e. high levels of outstanding debt and low economic growth. De Grauwe and Ji (2013) show that eurozone member countries with limited access to domestic credit were more exposed than standalone countries to negative self-fulfilling market sentiment because they were more dependent on international credit markets and on investors' anticipations. In 2008 investors started differentiating European sovereign debt, which drove up the interest rate on Greek sovereign debt to 18% while Germany's rate was fluctuating around 2% (Alessandrini *et al.* 2014, and Martin and Waller 2012). The sustainability of the Greek sovereign debt was then called into question. From the sovereign's point of view, the default option was ruled out, as it would have eventually implied a potential exit from the eurozone, entailing significant economic, political and social costs (Deo *et al.* 2011, Eichengreen 2010, and Mitchener and Weidenmier 2010). But the analysis by the European Central Bank (ECB 2006) shows that the euro area business cycles were increasingly correlated and that the risk of contagion and political tensions were substantial. A large proportion of the Greek sovereign debt was held by the banking systems of eurozone members, significantly increasing the exposure of European banks to the default risk of peripheral countries (Blundell-Wignall and Slovik 2010). Mink and de Haan (2013) argue that events related to the implementation of a bailout plan had an impact on the stock prices of 48 European banks, even those not exposed to Greece, and that countries such as Ireland, Portugal and Spain were more sensitive to all announcements related to Greece. Reboredo and Ugolini (2015) show that the Greek debt crisis significantly contributed to an increase in systematic risk for struggling countries such as Portugal. The only remaining option for Greece was then to negotiate with its creditors and agree on a debt restructuring. However, from the creditors' perspective, it was hard to reach a first agreement as they had to settle a plan that not only eliminated the default risk and potential contagion to other European economies but also minimized their loss whilst limiting the risk of moral hazard in future (De Santis 2012). The countries providing support wanted to make sure that imbalances would be avoided in future while also limiting the consequences on their own banks.

In 2010, EMU members started to arrange rescue packages to support Greece, reduce sovereign default risk, and limit spillover effects. The quid pro quo for this support was the implementation of austerity measures to correct for imbalances. However, these measures also led to huge social costs, causing an increase in unemployment, a decrease in purchasing power and rising social unrest. In addition, the implementation of rescue packages within the eurozone made the EU financial system highly interconnected, increasing the exposure of all EMU members (IMF 2011). Through the European Financial Stability Facility (EFSF), Germany provided 27% of the first tranche amounting to €440 billion, France 20%, Italy 18% and Spain 12%, based on their share in the capital of the ECB. These huge amounts created potential future financial difficulties for EMU members, thus enhancing contagion risk and uncertainty about future sovereign debt repayments by all eurozone countries. The global financial stability report produced by the IMF (2011) highlighted that the sovereign crisis in Greece had spread unevenly to the EU banking system through the cross-border asset holdings and different rescue packages.

Finally, in March 2012, after three meetings, Greece's creditors managed to agree on a 53% reduction, amounting to approximately €100 billion, in privately-owned debt. The agreement was signed by more than 90% of Greece's private creditors (Martin and Waller 2012). When finalizing the agreement, Greece threatened creditors with a unilateral default if the 90% threshold was not achieved. This position confirmed the bargaining power of a sovereign debtor compared with a private debtor. Was this solution optimal considering the economic situation of Greece? What were the costs of this debt reduction? Several potential answers to these questions are provided in the following sections. The next section describes our data and methodology. Section 3 presents our results, and Section 4 concludes.

2. Methodology and Data

We follow the methodology proposed by Dixit (1989, 1992) and Hayri (2000). We use a debt pricing model under uncertainty, combined with a debt reduction game. Based on the game theory framework, this modelling process allows us to estimate the different costs associated with a credit event. In addition, the proposed model makes it possible to determine the optimal size of a future debt reduction as well as the optimal timing for implementing it.

In the strategic game, illustrated in Appendix A, two players follow their own particular strategy: the sovereign aims at optimizing its costs by selecting the best option between servicing its debt and defaulting, whereas the creditors[1] aim at eliminating the default risk while minimizing their loss. A backward induction process is used to solve the game, i.e. we begin with the sovereign's decision problem to determine the optimal strategy for creditors.

The first step is to determine the threshold, called the Marshallian trigger (M), at which the sovereign becomes indifferent between debt service or default:

$$\frac{D}{r_D} = \left[\frac{X}{r_D-\mu} \times (1-\eta)\right] + \left[\frac{X}{r_D-\mu} \times \eta \times \varphi\right] \tag{1}$$

Where D is the total debt outstanding, r_D is the borrowing cost for the sovereign, also called rate of time preference, X is the sovereign's revenue, μ is the trend of sovereign's revenue, η is the percentage of remaining revenue for the sovereign after creditors have applied sanctions and φ is the percentage of the remaining revenue after the default, which would be paid to creditors as a lump sum. The cost of servicing the debt is estimated as being equal to the present value of the debt outstanding while the cost of default is divided into two parts. The first part, $\frac{X}{r_D-\mu} \times (1-\eta)$, accounts for potential creditors' sanctions, such as interruptions in international trade or capital market exclusion, which may lead to a decrease in the sovereign's revenues by $(1-\eta)$. Once creditors' sanctions have been established, both the lenders and the sovereign start negotiating to agree on an exit deal. They have to find an agreement on the lump

[1] In order to render the design and estimation of the model tractable, we opted for the concerted approach between the creditors to the debt reduction scheme. Even if the creditors are heterogeneous before the debt reduction scheme is implemented, they will have to coordinate and become a single bargaining unit which generates coordination costs.

sum payment, $\left[\frac{X}{r_D-\mu} \times \eta \times \varphi\right]$, that will be allocated to creditors in exchange for relieving the sovereign from its debt obligations and the associated sanctions.

However, if the sovereign has short-term problems in paying its debt, the game will first consider the advisability of raising funds to meet the deadline and/or a potential upside move of X instead of directly planning the debt restructuring. Dixit (1989, 1992) developed a model to value the option of waiting before making a decision. As such, the sovereign will have difficulties servicing its debt, starting with the moment when raising new funds becomes impossible, i.e. when the effective cost of paying back the debt becomes higher than the cost of defaulting. A higher cost of fundraising for the sovereign translates into a higher default risk. Hence, the optimal timing for the sovereign to default (S) is supposed to be somewhere below M. The difference between the two triggers is the value of the waiting option. This option depends on the sovereign's sensitivity (v), which illustrates how the sovereign values its default option following a one percentage point decrease in its revenues. This parameter v is the solution of a closed-form of Itô's Lemma and allows us to compute the default threshold (S) :

$$S = s \times D = \left(\frac{v}{1+v} \times \frac{r_D - \mu}{r_D \times (1-\eta\times(1-\varphi))}\right) \times D \tag{2}$$

$$\text{with} \quad v = -\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right) + \sqrt{\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right)^2 + \frac{2r_D}{\sigma^2}} \tag{3}$$

Where σ is the volatility of the sovereign's revenue. To establish their own optimal strategy, the creditors will thus try to estimate this default threshold as well as the settlement costs (C) associated with managing the default[2]. They will use available information on the country to anticipate the optimal timing (H) for implementing a debt reduction that would eliminate the default risk. Therefore, the timing function will be highly correlated to the sovereign's sensitivity v. Meanwhile, the creditors must also determine the optimal size (D) of the debt reduction in order to minimize their loss and maximize the remaining debt amount. Hence, the size function will depend on the debt capacity of the sovereign, i.e. the creditors' willingness to lend money to it (h); it will also depend on the creditors' sensitivity to a change in the sovereign's revenues (α)[3]. The Nash equilibrium of the game ($H^*; D^*$) is given by the crossing point of both the timing and size functions, as follows[4]:

$$H^* = h \times D = \left(r \times \frac{s^{\alpha}}{r} - \eta \times \varphi \times \frac{s^{1+\alpha}}{r_D - \mu} \times (1+\alpha)\right)^{\frac{1}{\alpha}} \times D \tag{4}$$

$$D^* = \frac{1+v}{h^{v} + \frac{1+2v}{h} \times (1+v)} \tag{5}$$

When the sovereign's revenues decrease to reach the first threshold H, the optimal decision for the creditors is to accept a debt reduction in order to reestablish the sustainability of the debt and reduce the default risk. The Nash equilibrium requires H^* to be the last optimal time the sovereign will wait for a debt reduction, while D^* maximizes the total value of remaining debt claims. This decision integrates both the coordination cost (K)[5] linked to the time creditors will need to reach an agreement and the loss of principal value due to debt relief. H is thus considered as the last optimal time to accept a debt reduction. Beyond this limit, the model

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[2] The settlement costs are a percentage of the sanctions applied by the creditors following the decision to default.

[3] α is very close to v but computed based on the risk-free interest rate (r) instead of the rate of time preference (r_D).

[4] The intersection of the timing and size functions (the equilibrium) exists only when $h \leq 1$. The equilibrium point is a breakpoint situation that balances two concerns: on one hand, a debt reduction large enough to ensure that the sovereign will continue servicing its debt and, on the other hand, small enough to avoid creditors' spoliation.

[5] Coordination costs are a percentage of the debt level at time 0.

assumes that the coordination costs linked to an additional debt reduction will be too high, thus dissuasive.

The starting point of the estimation procedure is to determine the four country-specific parameters (μ, σ, r_D, η) in addition to the risk-free rate (r). Starting with the assumption that the sovereign's revenues (X) follow a Geometric Brownian Motion (GBM) (Aro and Pennanen 2014, Hayri 2000, and Kruse *et al.* 2005), we can determine their trend (μ) and volatility (σ).

$$E(dX) = \mu X dt + \sigma X dw \tag{6}$$

Where dw is a generalized Wiener process. An increase in default risk would be illustrated by a negative trend. Indeed, a country's debt sustainability is ensured as long as its economy is able to generate enough revenues to finance the debt. As such, a decrease in its revenues, X, will affect the debt service. Another parameter of the game is the borrowing cost for the sovereign, also referred to as the rate of time preference, r_D. This rate, influenced by investors' anticipations of default, represents the opportunity cost for the sovereign either to raise taxes, or to increase borrowing so as to continue servicing its debt. Based on the average domestic lending rate we compute the rate of time preference, taking into account economic and political variables which may impact the risk of sovereign default. We follow the scoring system suggested by Hayri (2000) which consists in adding (subtracting) one to (from) the average lending rate when the country's ratio of domestic debt-to-GDP is high (low) compared with the sample average; the same procedure is applied to the savings rate, the level of government revenues as a percentage of GDP and the price of sovereign CDS. We argue that when the sovereign default risk increases, the demand for sovereign CDS will increase along with their price. Based on the conclusions of Benzoni *et al.* (2015) and of an IMF report (2011), we use the price of sovereign CDS as a proxy for contagion risk in order to take into account the interactions between EMU members. Finally, in the scoring system, we also correct the rate of time preference for the presence of European financing mechanisms allocated to specific countries in the wake of the subprime crisis. This parameter strengthens the argument for the eurozone membership, of which it captures some of the particularities. We are thus able to highlight the risks specific to Greece, which belongs to EMU, compared with non-member countries. The last parameter of the game is the remaining revenue for the sovereign (η) once creditors have lifted their sanctions, obtained through an optimization method which minimizes the difference between the actual debt reduction implemented by creditors and the size of the reduction estimated by the model.

The country of interest in our study is Greece (GR). To further investigate the specific characteristics of debt management in countries belonging to a monetary union, we also run simulations for four additional EMU members, Ireland (IR), Italy (IT), Portugal (PT) and Spain (SP). We compare the results with one control group composed of countries in the EU but not in monetary union: the Czech Republic (CZ), Denmark (DE), Hungary (HU), Poland (PO) and the United Kingdom (GB). With these simulations, we want to estimate the debt restructuring and default costs, i.e. creditors' sanctions, coordination costs (K) and settlement (C) costs, and to identify the optimal debt reduction for each country. Our final goal is to highlight specific trends for EMU countries compared with the control group. We run two types of simulations. The first (Q) is conducted on a quarterly basis and covers the whole time period. The second simulation distinguishes between the pre-crisis period (until December 2007), referred to as QPC, and the crisis period, QC, starting in January 2008 (Laeven and Valencia 2010, and Ureche-Rangau and Burietz 2013). For each country, we collect the level of government's expenditures as a percentage of its total debt outstanding to proxy the series of its revenues[6] on a quarterly basis. The deterministic time trend and the volatility of the natural logarithm of this

[6] We select the level of government expenditure which allows to distinguish between a current account and a debt crisis.

time series are computed using a linear regression. Then, based on the average domestic lending rate of each market, we compute the rate of time preference on a quarterly basis, taking into account the level of savings, government revenue, the level of domestic debt as a percentage of GDP[7], the price of sovereign CDS[8] in each country, and the European financial assistance received by some EMU countries after the collapse of Lehman Brothers. The last parameter we use in our estimations is the risk-free interest rate, which is the one-year maturity Euribor for Greece and the other eurozone members in our sample and the average rate of the U.S. two-year government notes for EU members. This data is collected using statistics published by Bloomberg, the OECD and central banks. The period under study starts in December 2002 and ends in December 2011.

3. Empirical Evidence

Table 1, Panel A provides a brief overview of the economic situation in Greece through variables used to compute the rate of time preference. The quarterly average of the risk-free interest rate is 0.52%. This rate is significantly lower than the average lending rate for Greece (2.68%) over the time period under study thus highlighting investors' anticipations of a higher default risk associated with this sovereign. In terms of economic environment, Greece's government revenue is equal to 38.99% of GDP while the domestic debt, as a percentage of its GDP, equals 55.69%. Moreover, due to a very low level of savings, i.e. 8.24% of GDP, Greece appears to be highly dependent on European and international markets for funding economic growth or rolling over its short-term debt. This data already pictures a bleak outlook for Greece. As such, the annual rate of time preference for Greece is indeed higher (11.15%) than the average figure for our sample of eurozone countries (8.68%) and the same average cost of our sub-sample of EU, non-eurozone countries (6.44%). Greece thus has a higher opportunity cost of raising funds, either through taxes or new borrowing to roll over its debt. The trend and volatility of Greece's revenues are displayed in Table 1, Panel B. It can be noticed that government expenditure is characterized by a negative trend, illustrative of a lower capacity to sustain the debt. In addition, Greece's revenues have high volatility, implying that the probability of experiencing low revenues is significant. This is consistent with the figure for the rate of time preference, which highlights significant default risk and low bargaining power, potentially coming from Greece's EMU affiliation and the associated contagion risk.

Table 1: Greece's characteristics

Panel A: Main variables[9]

Savings	Government revenue	Domestic debt	Sovereign CDS
8.24	38.99	55.69	280.29

Panel B: Parameters[10]

Deterministic time trend (μ)	Estimated volatility (σ)	Rate of time preference (r_D)	Debt reduction (D)
-0.0001	7.84%	2.68%	53.00%

[7] A country's risk is higher if a larger part of the distressed sovereign debt is domestically held, since the entire domestic financial system may be disrupted by the default.

[8] With a maturity of 5-years, denominated in euro for EMU members and in U.S. dollars for the other countries.

[9] Figures for savings, government revenue and domestic debt are expressed as a percentage of GDP. The CDS price is in basis points (Sources: Central banks, IMF, Eurostat, World Bank and Bloomberg).

[10] Quarterly figures. μ, the deterministic trend and σ, the volatility, are both associated with the sovereign's revenue flow.

Table 2, Panel A presents the three other estimated parameters of the game. With v higher than α, a decrease in the sovereign's revenues impact the sovereign more than its creditors, making the default option more attractive. Moreover, the parameter h that measures the sovereign's debt capacity or the creditors' willingness to lend it money while also indicating whether the equilibrium solution between debt reduction and its timing is higher than 1. We may thus argue that the 53% debt relief conceded to Greece in March 2012 was not optimal in terms either of amount or of timing to cancel the default option incentive. The other estimated results should shed more light on this assertion. Table 2, Panel B reports a summary of the estimated results obtained for the 53% Greek debt reduction. In March 2012, more than 90% of the creditors agreed to implement debt relief equal to 53% of Greece's privately-owned outstanding debt, equivalent to a reduction of €106 billion, in addition to a swap for bonds bearing a lower interest rate. This debt reduction led to a €172 billion restructuring, which translated into a loss for bondholders of more than 85% of their investment. Our model estimates the coordination costs associated with the debt restructuring negotiations as 5.89% of privately-owned debt, equivalent to €12 billion. These costs include the time spent in negotiations, the financial expenses arising from the presence of financial and legal advisors, as well as the administrative costs such as travel expenses to set up the agreement (Das *et al.* 2012). However, when the debt reduction was implemented in March 2012, the ratio of government expenditure to outstanding debt plummeted to 59.50%, far below the threshold endogenously determined by the model for the last debt reduction (H)[11], estimated at 69.67%. Greece's historical data show that the ratio under study was comparable to the debt reduction threshold as early as September 2010 (i.e. 70.78%) and continued to decline afterwards. We could thus argue that March 2012 was already too late for a debt reduction, even if the amount of the haircut may have been appropriate[12]. Hence, the default option could not be considered unattractive.

Table 2: Estimated results for Greece

	Definition	**Estimated value**
	Panel A	
α	Creditors' sensitivity to a change in sovereign's revenue	0.8847
v	Sovereign's sensitivity to a change in its revenue	2.8414
h	Debt capacity of the sovereign	1.4824
	Panel B	
Debt reduction		
K	Coordination costs	5.89%
H	Debt reduction threshold	69.67%
Default		
S	Default threshold	39.00%
η	Remaining revenue	84.85%
$(1-\eta)$	Creditors' sanctions	15.46%
C	Settlement costs	2.48%

If we consider a potential default scenario for Greece, our modelling framework estimates the default threshold is reached when the ratio of government expenditure to outstanding debt is 39.00%. It is worthwhile remembering that it is optimal for a sovereign to default when the level of its revenues reach this default threshold as an additional reduction would be more expensive than a default. The sanctions associated with a potential Greek default are estimated at 15.46% of revenues. This implies that following the default and the associated potential sanctions, such as temporary exclusion from capital markets or trade and output losses, the

[11] This trigger is supposed to determine the optimal timing for implementing the last debt reduction.
[12] Edwards (2015) shows that the « appropriate » haircut for Greece ranges from 81% to 52%.

remaining revenue for Greece would represent only 84.54% of total revenue before default. The settlement costs associated with a Greek default are established by the model at 2.48% of the creditors' sanctions.

The size of the debt reduction (53%) was also not appropriate. The coordination costs of the agreed-upon 53% reduction are significantly higher (5.89%) than settlement costs induced by the default option (2.48%). The breakeven point at which the two costs would have been equal is obtained with a debt reduction of 56%, equivalent to €112 billion i.e. a difference of €6 billion with the reduction effectively implemented. Beyond this point, i.e. for higher percentages of debt relief, the settlement costs of a default become significantly higher than those of a debt reduction. For a reduction of 56%, the debt reduction trigger (H) is lower, at 65.21%. Even in the case of this larger debt relief, the figures for Greece's revenues fell below this trigger during the first half of 2011.

The Greek sovereign debt crisis highlights more general issues related to debt management in developed countries especially when they are members of a monetary union more exposed to spillover risk. What would have been the issues of implementing debt reduction in Italy rather than in Greece, which had a debt of €1,898 billion in 2012, five times that of Greece[13]? Is debt management similar in the EMU and in countries which are not in the monetary union?

For each country in our simulations, as described above, we estimate different levels of debt reductions from 30% to 60%, including the rate applied for Greece in March 2012. For each level of debt reduction and for each country, the model provides the remaining revenue after a potential default (η) as well as an estimation of both the settlement cost (C) associated with this default and the coordination cost related to the debt reduction (K). To identify the specific features of EMU countries, we form three new groups according to GDP level of the nine countries in the sample[14]. Figures 1 and 1bis illustrate the results of the simulation Q. Figure 1 plots the remaining revenue for the different levels of debt reduction while Figure 1bis plots the breaking point between coordination and settlement costs, highlighting the optimal debt reduction for the three new groups.

First, the general trend of the three parameters is similar for all the countries under study. The remaining revenue (η) after a potential default tends to decrease when the level of the debt reduction is higher. Indeed, when the reduction represents a large percentage of the total outstanding debt (cf. situations 3 and 4 in Appendix A), investors will give up a larger share of their initial investment. Therefore, if the country later decides to default on its remaining debt despite a large reduction (situation 3), the loss for creditors will be smaller to the one following this last reduction. As such, following a large debt reduction, creditors will ask for heavier sanctions since they know they will be unable to earn a high return on their investment. This explains why, after the debt reduction decision and the sanction, the remaining revenue (η) is even smaller. In addition, both coordination costs (K) and settlement (C) costs seem to increase. The larger the debt reduction, the harder it is to reach an agreement with all creditors involved in the process. Regarding settlement costs, as mentioned previously, a large debt reduction implies a larger loss for creditors. Therefore, if the country decides to default, creditors will expect a large share of the remaining revenue as compensation. The agreement between creditors and the sovereign will then be more difficult to reach, increasing the settlement costs.

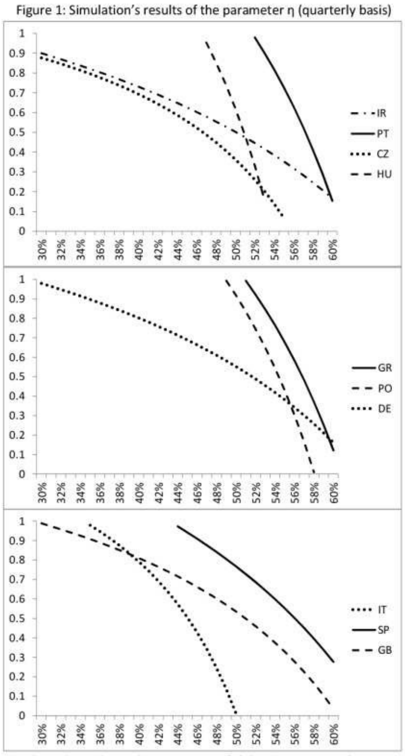
Second, a particular trend can be identified for EMU countries with respect to those in the control group. More specifically, considering the entire period under study, i.e. between December 2002 and December 2011, EMU countries seem to suffer from heavier creditors' sanctions, especially in group 3 (IT, SP and GB). The consequences of a default in the eurozone

[13] Bi and Traum (2012) show that the probability of default is higher in Italy than in Greece for a given debt level despite a higher willingness of the Italian government to repay its debt.

[14] Group 1: IR/PT-CZ/HU; Group 2: GR-PO/DE; Group 3: IT/SP-GB. We also group the nine countries according to their level of debt, and the results remain robust.

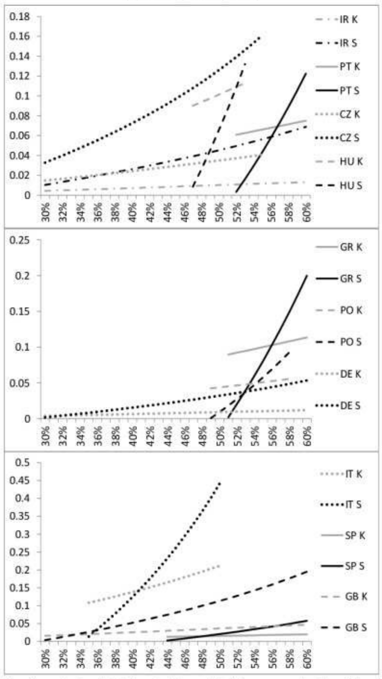
would make the country leave monetary union with a high risk of contagion within the other EMU members (De Santis 2012). Therefore, the risk for creditors of facing serial defaults within the same monetary union is higher. As such, to prevent EMU countries from defaulting on their debt, creditors have to impose larger sanctions. Portugal and Greece present the same trend, with remaining revenue plunging from 100% to almost 0% at a faster pace for the same level of debt reduction compared with other EMU members. With the fiscal profligacy in Greece and the lack of flexibility of export prices in Portugal, public imbalances became larger and larger. In addition, both countries suffered from a decrease in wage competitiveness (Blanchard 2007, Darvas *et al.* 2011, and Giavazzi and Spaventa 2010), increasing the default risk. Larger creditors' sanctions made the default option unattractive.

Figure 1: Simulation's results of the parameter η (quarterly basis)



The three charts depict the parameter η (%) for three groups of countries classified according to the level of their GDP and for several levels of debt reduction (from 30 to 60%). η is the remaining revenue for the sovereign after the sanctions have been applied by creditors. It is obtained through to an optimization method which minimizes the difference between the actual debt reduction implemented by creditors and the size of debt reduction estimated by the model.

Figure 1bis: Simulation's results of coordination (K) and settlement (C) costs (quarterly basis)



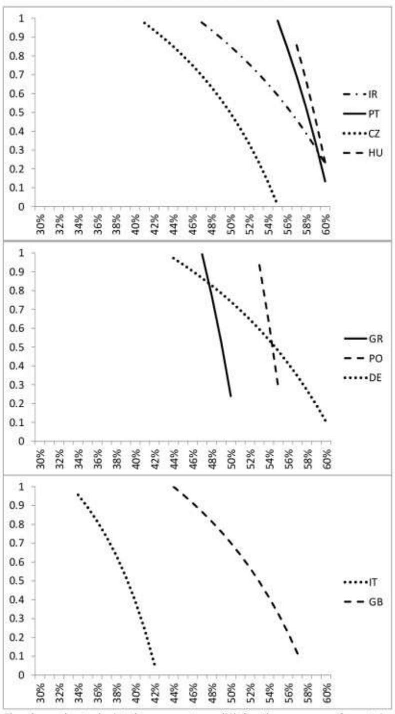
The three charts depict the breaking point between coordination (K) and settlement (C) costs computed as costs associated to creditors' negotiations in case of debt reduction and default events respectively for several levels of debt reduction (from 30 to 60%). The coordination costs are a percentage of the debt level at time 0 and depend on country's five parameters (μ, σ, r_D, r and η) as well as on its debt capacity (h) and the level of the debt reduction implemented (D). The settlement costs are a percentage of the sanctions creditors applied following the sovereign's decision to default and depend on three country-specific parameters (μ, rD and η) as well as on the default threshold (S).

The costs of debt restructuring and default processes, i.e. coordination and settlement costs, are higher for EMU countries than for the control group. For example, coordination costs are estimated to be above 6% of debt for Portugal and above 9% for Greece and Italy. Concerning settlement costs, the conclusion for these three countries is similar, in addition to the fact that they increased more quickly, from 0% to 12% of creditors' sanctions for Portugal, up to 20% for Greece, and 45% for Italy. These higher debt restructuring and default costs in the eurozone may be explained by the difficulty in reaching an agreement. A crucial objective was to limit spillover effects from the Greek debt crisis on other eurozone members for whom the rescue process would have been unavoidable and/or significantly more expensive. As highlighted by Figure 1bis, Greece and Portugal present a very close pattern for the two costs, particularly coordination costs.

Finally, estimating the breaking point for a country, where coordination costs equal settlement costs, allows us to determine the optimal size of the debt reduction needed to eliminate the sovereign's default risk. The larger the debt reduction, the higher the debt restructuring cost and the associated default cost. Before this point, the debt reduction is too small, implying that coordination costs (K) are larger than default costs (C). Therefore, the sovereign will choose default if creditors agree on a small debt relief program (situation 3 in Appendix A). Beyond the breaking point, debt reduction becomes a more valuable option as it significantly reduces the debt burden, making coordination costs less expensive than default costs. As such, the sovereign will be able to sustain the new level of debt, which in turn reduces the risk of default (situation 4 in Appendix A). Moreover, the break-even point is specific to each country and its economic situation. In the sample, even if the optimal size of the debt reduction required to eliminate default risk is low in absolute value for EMU countries such as Greece (56%, or €112 billion) in group 2, debt restructuring and default costs remain higher than those of the other countries with similar economic backgrounds, amounting to around 10% of the debt. In the case of Italy, the breaking point to eliminate default risk is associated with a debt reduction of 40%, i.e. €759 billion or approximately eight times the reduction accepted for Greece! This implies that a major debt reduction is required for Italy to eliminate the default risk. In addition, when the debt reduction is too small, the default option remains interesting, especially when the initial debt burden is significant.

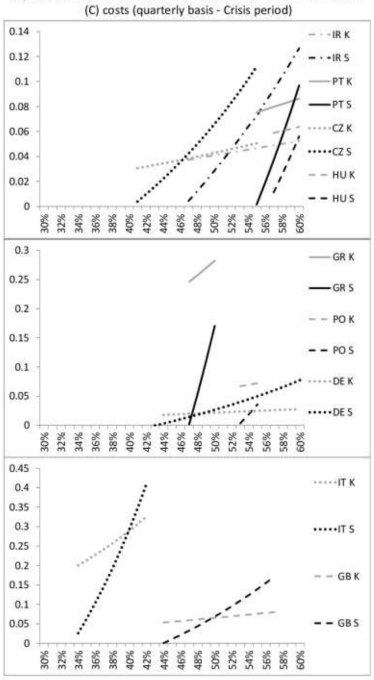
For a deeper analysis of debt restructuring and default costs, Figures 2, 2bis, 3 and 3bis illustrate the results of the second simulation, which compares the crisis period (Figures 2 and 2bis) with the pre-crisis one (Figures 3 and 3bis)[15].

Figure 2: Simulation's results of the parameter η (quarterly basis - Crisis period)



The three charts depict the parameter η (%) for three groups of countries classified according to the level of their GDP and for several levels of debt reduction (from 30 to 60%). η is the remaining revenue for the sovereign after the sanctions have been applied by creditors. It is obtained through to an optimization method which minimizes the difference between the actual debt reduction implemented by creditors and the size of debt reduction estimated by the model.

Figure 2bis: Simulation's results of coordination (K) and settlement (C) costs (quarterly basis - Crisis period)

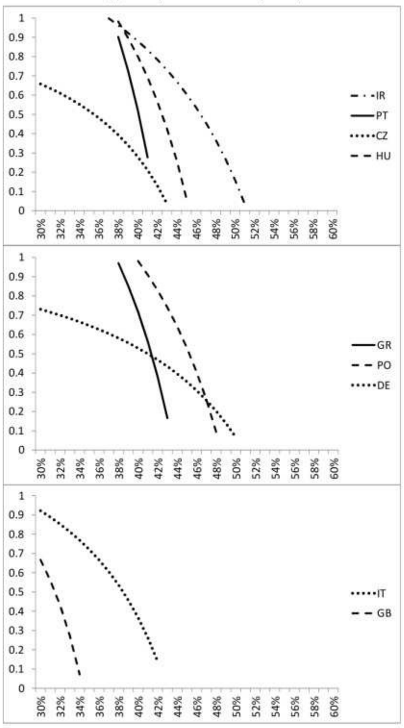


The three charts depict the breaking point between coordination (K) and settlement (C) costs computed as costs associated to creditors' negotiations in case of debt reduction and default events respectively for several levels of debt reduction (from 30 to 60%). The coordination costs are a percentage of the debt level at time 0 and depend on country's five parameters (μ, σ, r_D, r and η) as well as on its debt capacity (h) and the level of the debt reduction implemented (D). The settlement costs are a percentage of the sanctions creditors applied following the sovereign's decision to default and depend on three country-specific parameters (μ, rD and η) as well as on the default threshold (S).

[15] Due to the shorter time periods under study, we are not able to display results for Spain.

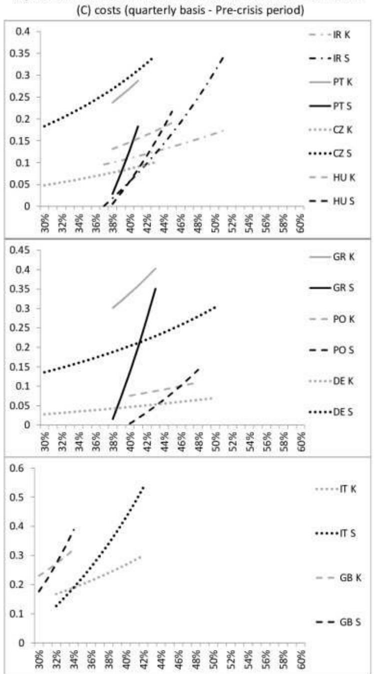
Figures 2 and 3 display the simulation results of the remaining revenue for different levels of debt reduction during crisis and pre-crisis periods respectively. During both periods, a larger reduction is associated first with heavier sanctions and then with lower remaining revenue. This observation is in line with the results for the whole period. Nevertheless, we notice a difference between the two sub-periods, i.e. an increase in size of the debt reduction required to eliminate the default option during the crisis for all countries. This may be related to the difficulty in reaching an agreement in such a context and to a higher sovereign default risk. For the EMU countries in group 1, the break-even point (Figures 2bis and 3bis), where the coordination costs of a debt reduction equal the settlement costs of a default, is reached at a higher level for both sub-periods compared with the simulation over the entire period. The difference is even more striking during the crisis period. This time period is characterized by highly stressed markets, and therefore, a larger debt reduction is required to reach the breaking point and to eliminate default risk. A closer look at the EU countries in group 1 shows that the breaking point is lower for the pre-crisis period and higher only during the crisis. This conclusion highlights a major difference between EMU countries and the others. It may also mean that even during quiet periods, a larger debt reduction may be required for monetary union countries to significantly decrease the probability of default and potential spillovers to other members of the union. These observations remain valid in the two other groups, but only for the EU countries with a lower (higher) breaking point during the pre-crisis (crisis) period. In the case of Greece, we are not able to reach an optimum for either of the two sub-periods. Indeed, this crisis period was highly critical for the eurozone members, especially Greece, and may explain the difficulties in attaining an optimal equilibrium. In addition, this result may also indicate the limits of the model when the study period is shorter.

Figure 3: Simulation's results of the parameter η (quarterly basis - Pre-crisis period)



The three charts depict the parameter η (%) for three groups of countries classified according to the level of their GDP and for several levels of debt reduction (from 30 to 60%). η is the remaining revenue for the sovereign after the sanctions have been applied by creditors. It is obtained through to an optimization method which minimizes the difference between the actual debt reduction implemented by creditors and the size of debt reduction estimated by the model.

Figure 3bis: Simulation's results of coordination (K) and settlement (C) costs (quarterly basis - Pre-crisis period)



The three charts depict the breaking point between coordination (K) and settlement (C) costs computed as costs associated to creditors' negotiations in case of debt reduction and default events respectively for several levels of debt reduction (from 30 to 60%). The coordination costs are a percentage of the debt level at time 0 and depend on country's five parameters (μ, σ, r_D, r and η) as well as on its debt capacity (h) and the level of the debt reduction implemented (D). The settlement costs are a percentage of the sanctions creditors applied following the sovereign's decision to default and depend on three country-specific parameters (μ, rD and η) as well as on the default threshold (S).

4. Conclusion

The objective of this article is to provide a more detailed description of the 2012 Greek debt relief program and its consequences in terms of the costs associated with the debt restructuring and default processes. In addition, the analysis seeks to understand to what extent EMU membership influenced the decisions made regarding the Greek debt crisis.

We provide evidence that, due to its EMU membership and a higher risk of contagion, Greece experienced fundraising costs that were higher than the average for other eurozone countries and also than the average cost for non-eurozone EU countries. Contagion risk may explain why Greece benefited from a debt reduction program. Nevertheless, the debt reduction program implemented in March 2012 did not eliminate the attractiveness of the default option. Indeed, our results show this agreement was implemented too late and that the relief provided was below the level that could have eventually led to an optimal outcome both for the debtor and the creditors. Finally, our simulations set forth that the debt restructuring and default costs for EMU members in the sample are higher than for other countries, and this is even more significant during the crisis period alone, between 2008 and 2012.

We may conclude that the specific characteristics of EMU played a significant role in the negotiations between Greece and its lenders. In the short term, the debt relief granted to Greece seriously damaged the currency union's credibility. Even though the 2012 debt agreement temporarily restored confidence within the eurozone by eventually reducing the need for debt restructuring schemes involving other major EMU players, the reopening of the Greek debt case during the summer of 2015 shows us that the long-term success of this agreement is very limited. Furthermore, our results also point out that a sovereign debt crisis such as the one experienced by Greece cannot always be solved by providing additional funds (as it was the case with the 2010 EFSF plan) or through a debt reduction as implemented in 2012, but maybe by lending differently. As such, a possible solution that emerged from the recent debates (see for example the proposals advanced in the media by S. Griffith-Jones and I. Kaul) may consist in transforming the existing Greek debt into bonds indexed on a growth measure of the Greek economy (government expenditure as used in our model for example). Such a solution would not only provide a grace period to Greece to implement the required structural reforms but also limit creditors' loss allowing Greece to fulfill its contractual obligations.

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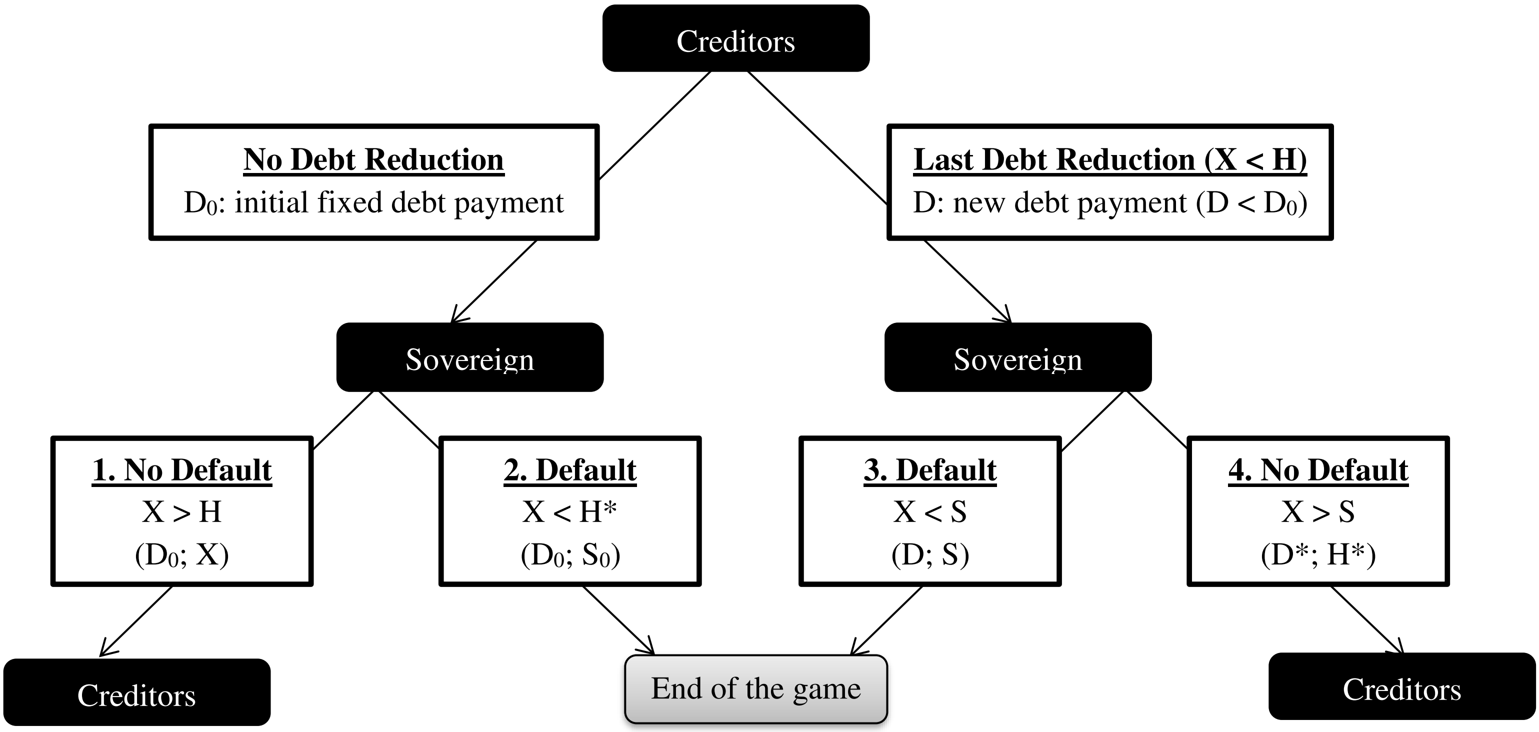
APPENDIX A: SOVEREIGN DEBT GAME



Note: Sovereign decision's explanation

1. Without debt reduction but with a sufficient level of revenues which allow the sovereign to reimburse its debt, there is no default. The level of the fixed debt payment remains D_0 and the level of revenue is X.
2. Without a debt reduction, if the sovereign suffers from a significant decrease in revenues, below the optimal threshold for the last debt reduction H^*, it will default on its debt. The level of the fixed debt payment is still D_0 while the revenues X reach the threshold S_0 for the optimal default without a debt reduction.
3. If the sovereign benefits from a debt reduction but its revenues continue to decrease below S, the trigger for the optimal time to default, the sovereign will default. The fixed debt payment becomes D following the debt reduction and the level of revenues is S.
4. A combination of debt reduction and an end to the decrease in revenues will allow the sovereign to sustain the debt service, thus reducing default risk. The model establishes the equilibrium (D^*; H^*) to determine the optimal size and timing of the last debt reduction to eliminate the default risk.