

The Dyonisus tale of modern times: New evidence on the Greek debt crisis and its related costs

Preliminary version

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ABSTRACT. In March 2012, Greece pressures its private creditors into agreeing a debt relief of 53% of its privately-owned debt, amounting at euro 100 billion. Using a game theory approach, we determine the optimal size of debt reduction which makes the default option unattractive. We estimate the costs associated to this debt reduction as well as the potential risks and costs of contagion within the Euro zone, especially on large European economies like Italy and Spain. We show evidence that the Greek sovereign debt crisis cannot be handled similarly to previous experiences such as the Argentinian sovereign debt crisis. The membership of a monetary union that fails in reaching the economic convergence of the member countries makes the Greek sovereign debt crisis unique with significant spillover effects on the other European economies within the Euro zone, especially regarding the potential costs of another credit event.

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I. Introduction

When a sovereign becomes unable to insure its debt service, the question of default or debt restructuring becomes crucial. Das *et al.* (2012) define debt restructuring as the process of exchanging outstanding debt instruments for new ones with longer maturity (debt rescheduling)/ lower principal value (debt reduction) or for cash (debt buybacks); meanwhile, a default implies a failure in the debt repayment of interest and/or principal following a particular schedule. All these situations will be thereafter referred to as credit events.

The analysis of debt crises has significantly developed over the past years. The literature aims at understanding the causes that may lead a country to restructure its debt or to declare itself in default, the costs of such a decision and the whole negotiation process when looking for a way out of crisis. Greece is going to be at the core of the present analysis as we will try to understand why this country is prone to default on its debt and why this default has been delayed in time, transforming the Greek crisis into a European sovereign debt crisis.

In this article, we follow the methodology developed by Hayri (2000) to estimate the costs associated to the Greek debt relief in terms of loss in principal value, creditors' coordination and administrative costs linked to the implementation of the debt exchange once the agreement has been reached. Moreover, we aim at understanding why Greece can be considered as a unique example by conducting a comparison with one other sovereign debt crisis which occurred during the 21st century, namely the Argentinian crisis of 2005. Finally, we try to explain how Greece's membership of the Euro zone may have impacted the other peripheral countries by applying the same model for four other countries, *i.e.* Italy, Spain, Portugal and Ireland. We estimate the potential debt restructuring costs for several levels of debt reduction to determine the debt restructuring costs for each country.

Our study uses a game theory framework which provides the optimal size and timing for creditors to agree on the last debt reduction they can grant to Greece taking into account several macroeconomic characteristics such as GDP, debt level, government revenue, savings and domestic debt levels as a percentage of GDP. Moreover, the model allows determining the optimal timing for a sovereign to default on its debt when the coordination costs become higher than the default costs for creditors.

We provide evidence that Greece, despite a low savings level and a high proportion of its debt held by domestic financial institutions, benefits from the lowest cost of raising funds compared to Argentina. Moreover, our model estimates that in 2012, when the debt reduction is implemented in Greece, the agreement manages to eliminate the attractiveness of the default option. However, this intervention highlights significant spillover effects within the Euro zone. Finally, when we apply the model to the four other European countries, the costs associated to credit events are positively related to the size of the debt reduction for all the countries while the remaining revenue after default is negatively correlated. One country in our sample, namely Italy, presents exacerbated trends.

The article is structured as follows. Section 2 sketches a brief literature review on sovereign debt crisis, starting with the difficulties Greece faces to reimburse its debt until the final agreement the country reached with private creditors. Section 3 is dedicated to the description of our data and methodology. Section 4 presents our results while section 5 concludes.

II. Literature Review

Greece or the result of three centuries of authoritarian regimes

Between 1453 and 1821, Greece is in the thrall of the Ottoman Empire which notably lays down its own laws and fixes taxes to take advantage of its dominant position. During these years, Greece follows a completely different path when compared to the Western European countries. In the western part of Europe, liberal practices dominate and lead to an increase in the size of the middle class. On the contrary, Greece is characterized by a large share of small enterprises, a boom in the housing industry, a high level of corruption and a strong influence exerted by the state (Manolopoulos, 2011). When Greece becomes independent in 1821, implementing a new democratic regime based on a large public support for the political leaders appears to be a significant challenge. Priority is given to the public sector at the expense of the development of the private industry. This policy is accompanied by favoritism through networking and nepotism. Government control is very strong and leads to financial embezzlement in favor of groups of interest, bureaucracy and corruption (Manolopoulos, 2011). Moreover, during the 20th century, between 1946 and 1949, a civil war takes place followed by a military dictatorship from 1967 to 1974. The succession of several authoritarian regimes has a devastating effect on the public finances as it deeply entails the reputation of the governmental authorities (Manolopoulos, 2011).

Political regimes have often been discussed in the literature when trying to understand the reasons explaining why a country may be prone to default on its debt; this literature underlines the decision making process of a government as well as the different domestic policies devoted to sustaining economic growth. Hence, the probability of sovereign credit events is supposed to be higher when the political system is authoritarian due to a lack of political monitoring tools and institutions (McFadden *et al.*, 1985; Bulow and Rogoff, 1989; North and Weingast, 1989; Stasavage, 2002; Amador, 2003; Glaeser *et al.*, 2004; Van Rijckeghem and Weder, 2009; Kohlscheen, 2010). However, Van Rijckeghem and Weder (2009) argue that the absence of credit events in an authoritarian regime can be linked to the regime's stability in terms of political objectives (Brewer and Rivoli, 1990; Lee, 1993; Cole *et al.*, 1995; Reuss, 1996; Tornell and Lane, 1999; McKenzie, 2002; Chang, 2003; Manasse *et al.*, 2003; Manasse and Roubini, 2005; Talvi and Vegh, 2005; Tomz and Wright, 2007; Amador, 2010; Kohlscheen, 2010). The political context also has an impact on the quality and credibility of the domestic financial institutions and overall financial and banking system, with potential catastrophic effects on the ability of the country to meet its debt obligations (North, 1981; Caballero and Krishnamurthy, 2001; Eichengreen *et al.*, 2003; Manasse *et al.*, 2003; Kraay and Nehru, 2006; Kohlscheen, 2010). For example, the ability of the Greek government to implement credible strategies and credible policies is entailed by the political history of the country (Krugman, 1979; Felix, 1987; Portes and Eichengreen, 1989; Eichengreen *et al.*, 2003; Manasse *et al.*, 2003; Reinhart *et al.*, 2003; Catão and Kapur, 2006; Kraay and Nehru, 2006). The government becomes unable to raise taxes to compensate and refund its debt as the population becomes unwilling to trust the state (Barro, 1979; Bohn, 1998, 2005; Jeanne and Zettelmeyer, 2005). Basu (2010) provides a slightly different point of view in the sense that if the financial system of a country is too strong, the country will have more difficulties to raise international funds as the sovereign will be able to efficiently protect its domestic economy, transferring the costs of default on external creditors.

To understand a country's difficulties to refund its debt, one has to consider the country's credit history. In 1821, when Greece starts its war of independence from the Ottoman regime, it has to borrow to finance the war. As such, between 1824 and 1825, Greece manages to raise two loans amounting at pounds 472,000 and 1.1 million respectively. These loans are issued on the London Stock Exchange and end up in default. Since that moment, Greece has defaulted four times on its debt (1843, 1860, 1894 and 1932). To summarize up, Greece has been in default for 90 years since its independence, which represents 50% of the time. Greece is therefore on the list of serial defaulters¹ along with countries like Venezuela and Ecuador. The literature develops the idea that past repayment problems can damage a country's credit rating as well as its capacity to borrow (Hajivassiliou, 1989, 1994; Özler, 1993; Cole and Kehoe, 1995; Cantor and Packer, 1996; Eaton, 1996; Obstfeld and Rogoff, 1996; Kletzer and Wright, 2000; Reinhart *et al.*, 2003; Kraay and Nehru, 2006; Kapur *et al.*, 2007; Borensztein and Panizza, 2009; Panizza *et al.*, 2009).

1999: New member of the European Monetary Union (EMU) - an economic disruption

In 1998, Greece applies for the first time to join the EMU but is rejected because of high deficits and debt level. The following year, its second application is accepted as a result of significant improvements in its economic situation even if this improvement is nowadays questioned (Manolopoulos, 2011).

This major success represents a real opportunity for Greece. Thanks to the EMU membership and the new exchange rate regime, Greece benefits from the convergence of interest rates within the Euro zone and the presence of a common, strong currency. The country is therefore able to raise funds at very low costs and hence tremendously increases its debt. The supposed substitutability of the debts within the monetary union increases investors' confidence in the abilities of its less performing members, like Greece, to sustain their public debts. The EMU membership is supposed to reduce the risk of Greece as the integration process is based on the five criteria introduced by the Maastricht Treaty (1992) for the convergence of the long-term interest rates, the convergence of the inflation rates and the exchange rate targets and the Stability and Growth Pact (1997) for public deficit and debt level limits. In reality, empirical evidence shows that once a country joins the EMU, these criteria are no longer respected even by countries like France or Germany (Manolopoulos, 2011; Martin and Waller, 2012). In a more general context, this highlights why the management of the monetary policy through interest rates is crucial for a country or a monetary union in order to avoid a boom of credit which can lead to an explosion in government spending and an increase in debt out of control (Felix, 1987; Calvo, 1988; Eichengreen, 1991). Without a decrease in the borrowing costs, we may suppose that Greece would not have been able to borrow so easily and hence increase so dramatically its debt level.

Between 2003 and 2011, Greece becomes heavily indebted; its public debt explodes from euro 167 billion to euro 355 billion representing an annual growth rate of 10%. Greece's capacity to refund its debt is deeply affected. The higher the level of debt is compared to the GDP or to exports, the higher the propensity of a country is to default as it becomes unable to reimburse its debt using existing revenues or get access to new credit to meet the short-term deadlines (Feder and Just, 1977; Eaton and Gersovitz, 1981; Edwards, 1982; Eichengreen and Portes, 1985; McFadden *et al.*, 1985; Bulow

¹ A serial defaulter or debt-intolerant country is defined by Reinhart *et al.* (2003, p.8) as a "countr[y] that ha[s] defaulted on [its] external debt [...] so repeatedly".

and Rogoff, 1989; Sachs, 1989; Hajivassiliou, 1994; Cole and Kehoe, 1996, 1998, 2000; Cline and Barnes, 1997; Min, 1998; Cohen, 2000; Detragiache and Spilimbergo, 2001; Catão and Sutton, 2002; McKenzie, 2002; IMF, 2003; Manasse *et al.*, 2003; Kruger and Messmacher, 2004; Aguiar and Gopinath, 2006; Kraay and Nehru, 2006; Mendoza and Ostry, 2007; Reinhart and Rogoff, 2008; Guembel and Sussman, 2009; Oosterlinck and Ureche-Rangau, 2012). Despite the consensus that seems to emerge from a large strand of literature on the idea that the debt burden is a good indicator for a potential debt rescheduling in the future, this conclusion is also challenged by some existing studies which do not find significant impact of a large debt burden on default risk (Paladino and Stein, 2001; Reinhart *et al.*, 2003). The situation of the Euro zone is an illustration of this argument. Martin and Waller (2012) underline the fact that Greece is currently facing a severe sovereign debt crisis despite a relatively low debt level compared to its neighbors. The potential contagion within the EMU makes the Greek crisis so frightening, more than the crisis *per se*. Hence, the debt level is an important factor but it surely is not the only factor that may explain a sovereign debt crisis.

Moreover, borrowing cannot be considered as a bad signal only, as it is one major source of funds in an economy. However, in Greece, borrowed funds are not dedicated to develop the country's industrial infrastructure. Instead, they finance consumption and public expenses, boosting imports, and finally altering the current account balance. The result is a fictitious economic growth based on leverage and an increase by 88% of its current account deficit from -8% of the GDP in 2000 to -15% of the GDP in 2008. A large proportion of these borrowings are also used to finance political groups of interest (Manolopoulos, 2011).

2008: The fall from the Olympus

In 2008, the combination of high debt outstanding, political corruption and low economic growth engendered by the Greek industrial structures are highlighted by the subprime crisis and contribute to significantly damage Greece's economic environment while financial difficulties show up (Krugman, 1979; Amador, 2010). When the financial crisis bursts, a country with weak economic environment like Greece is prone to default due to a decrease in its GDP (Eaton and Gersovitz, 1981; Cline, 1984; Eichengreen and Portes, 1985; McFadden *et al.*, 1985; Berg and Sachs, 1988; Catão and Sutton, 2002; Manasse *et al.*, 2003; Kraay and Nehru, 2006; Levy-Yeyati and Panizza, 2006; Kohlscheen, 2007; Tomz and Wright, 2007; Reinhart and Rogoff, 2008a; Panizza *et al.*, 2009; Van Rijckeghem and Weder, 2009), high inflation (Goldstein, 2003; Manasse *et al.*, 2003; Van Rijckeghem and Weder, 2009) and GDP volatility (Catão and Kapur, 2006; Kapur *et al.*, 2007; Arellano, 2008; Panizza *et al.*, 2009). In the specific case of Greece, between 2008 and 2011, the GDP decreases by 7%, from euro 236 billion to euro 220 billion, while the inflation rate rises by 9%.

The subprime crisis also shows evidence that Greece has significantly increased its current account deficit by 88% as the volume of its imports with leverage expanded. As such, if the current account deficit tends to be too significant, a debt crisis is more likely to occur as the revenues of the sovereign do not manage to cover its financial obligations anymore (Eichengreen and Portes, 1985; Felix, 1987; Lindert and Morton, 1989; Catão and Sutton, 2002; McKenzie, 2002; Manasse *et al.*, Van Rijckeghem and Weder, 2009). Nevertheless, these results have to be taken with caution as they are heavily influenced by the assumptions of the model (Hajivassiliou, 1989; Cline and Barnes, 1997; Detragiache and Spilimbergo, 2001; McKenzie, 2002). These authors do not find any significant

evidence of macroeconomic determinants like the volume of imports or exports provided by industrialized countries.

Besides the economic environment, other determinants like the exchange rate regime may disturb the management of a sovereign debt. If the regime is not flexible enough (Manasse *et al.*, 2003) or too flexible (Eichengreen *et al.*, 2003), the probability of a credit event will rise. In the case of the Euro zone, the exchange rate regime may appear as too rigid for countries like Greece which often manage their competitiveness via the devaluation of their currencies. In addition, the use of seigniorage is also impossible in the monetary union which makes the process of refunding short-term debts even more complex (Martin and Waller, 2012). Therefore, a member of the Euro zone, without access to the domestic credit market, will be highly dependent on the international credit market as well as on investors' anticipations. Debt crises can also be due to/exacerbated by investors' self-fulfilling expectations regarding the behavior of the debtor as well as that of other creditors (Calvo, 1988; Jeanne and Zettelmeyer, 2005; Manolopoulos, 2011). If creditors anticipate a high credit risk for a sovereign, they will not accept to continue financing that particular sovereign which may indeed lead to the expected credit event as the borrower will be unable to get access to credit to either boost its economic growth or refund its short-term debt (Giavazzi and Pagano, 1990; Detragiache, 1996). The same scenario may apply if investors anticipate that the other creditors are unwilling to provide funds to the sovereign: their behavior will become identical and the sovereign will experience a credit shortage that may lead to a credit event (Sachs, 1984; Alesina *et al.*, 1990). Chamon (2007) uses the term "investor panic" to describe such phenomena.

In line with the "investor panic" argument, the literature also stresses the fact that the closer the country is to the crisis breaking-point, the higher is the cost of its debt service along with its debt burden (Hajivassiliou, 1994; Manasse *et al.*, 2003). The interest rate associated to the debt will therefore increase as a result of investors' anticipations. Hence, a heavily indebted country which wants to raise new funds will have to pay an interest rate more sensitive to the volume of the new borrowing compared to a country with a lower debt level (Cole and Kehoe, 1996; Aguiar and Gopinath, 2006). In 2008, following the subprime crisis, investors start realizing that European sovereign debts cannot be considered as being perfect substitutes. The immediate consequence is a huge increase of the interest rate on the Greek sovereign debt which skyrockets to 18% when the German interest rate equals 2% (Martin and Waller, 2012). The credit ratings of several countries in the EMU are downgraded as financial markets start fearing the potential contagion effects induced by the different rescue packages implemented in countries like Greece with a slow economic growth and significant fiscal challenges. In addition, in the EMU, the risk of contagion is even more significant that a significant share of the Greek sovereign debt is held by the banking systems of the Euro zone members. Blundell-Wignall and Slovik (2010) show evidence that the exposure of European banks to the default risk of peripheral countries in the monetary union is significant. This situation highlights the importance of understanding the distinction between debt held by domestic agents and external debt (Reinhart and Rogoff, 2008a). In addition, the implementation of rescue packages within the Euro zone leads to a situation in which heavily indebted countries like Italy, Spain and, to a further extent, France and Germany are involved in providing liquidity for countries like Greece at the expense of not being able to manage their own debt. As such, the distinction between domestic and external creditors becomes difficult to assess within the Euro zone, as the members of the monetary union are all related; the risk of default for all the countries viewed as a group may therefore increase (Martin and Waller, 2012). When the European Financial Stability Fund (EFSF) is first

introduced to provide European members with liquidity, Germany brings 27% of the first slice amounting at euro 440 billion, France 20%, Italy 18% and Spain 12%, according to their share in the capital of the European Central Bank (ECB). These large amounts invested to rescue Greece highlight potential future financial difficulties for the other members of the EMU thus enhancing the uncertainty regarding sovereign future debt repayments.

The tragedy: debt reduction versus default

Once the financial difficulties of a sovereign come into the light, the decision on the path to follow comes at stake. Several questions have to be asked. Should the sovereign continue to increase its debt level via new credits or should the amount of debt be decreased? If the last solution is privileged, should it be applied through an increase of the debt maturity, through a debt reduction or through a default? The arbitrage between all these possibilities requires a costs and benefits analysis as a credit event is generally supposed to be costly (Dooley, 2000; Kletzer and Wright, 2000; Wright, 2002; Arellano, 2008; Basu, 2010).

One of the first default costs highlighted by the literature is the loss of reputation. An important number of studies focuses on the consequences of sovereign default in terms of potential permanent capital market exclusion viewed as a sanction for the disruption of the debt service (Eaton and Gersovitz, 1981; Grossman and Van Huyck, 1988; Marichal, 1989; Worrall, 1990; Atkeson, 1991; Cole and Kehoe, 1995; Eaton and Fernandez, 1995; English, 1996; Amador, 2003; Aguiar and Gopinath, 2006; Sturzenegger and Zettelmeyer, 2006; Tomz and Wright, 2007; Arellano, 2008; Amador, 2010). Greece already experienced such a sanction following its 1843 default that led to its exclusion from the international capital markets for decades. However, this reputational argument is questioned by another strand of literature that provides evidence on the fact that a credit event does not have any effect on reputation (Eichengreen and Lindert, 1989; Fernandez and Rosenthal, 1990; Enderlein *et al.*, 2008; Basu, 2010) or has to be considered in conjunction with several other factors that affect the decision to restructure a sovereign debt (Rogoff and Zettelmeyer, 2002; Arellano and Heathcote, 2008). This strand of studies also underlines that the exclusion from the world capital markets is more temporary than permanent, thanks to “short memories” of credit markets (Fishlow, 1989; Reinhart *et al.*, 2003; Gelos *et al.*, 2004; Arráiz, 2006; Richmond and Dias, 2008; Borensztein and Panizza, 2009; Panizza *et al.*, 2009; Levy-Yeyati, forthcoming).

In addition, identifying the financial difficulties experienced by a sovereign may itself induce additional costs. As such, borrowing costs may increase through a rise in the sovereign spread as investors anticipate a higher default risk (Özler, 1993; Obstfeld and Rogoff, 1996). The announcement of a credit event may lead to an immediate increase of sovereign spreads (Kapur *et al.*, 2007). As mentioned previously, Greece’s difficulties in repaying its public debt is followed by an increase of its interest rate by 14% in three years, thus enhancing its debt burden. Moreover, the defaulting sovereign may alter its economy in terms of GDP and inflation as well as its relationships with the different counterparts, leading to trade sanctions and political tensions (Mitchener and Weidenmier, 2005). In Greece for example, prior to the crisis, the economic environment is already in distress as investments in industrial infrastructures are neglected while consumption is favored which in turn negatively affects the current and financial accounts balances. Therefore, when EMU members settle the different rescue packages to support sovereigns experiencing financial difficulties and limit the spillover effects, they require as compensation the implementation of several austerity

measures to correct for these imbalances. These measures may provide a temporary solution to solve the confidence crisis and encourage better governance. However, they may also lead to huge social costs, enforcing the increase of unemployment, the decrease of purchasing power and the rise of social unrest.

Finally, when a country decides to restructure its debt or to default, the debt crisis has to be solved through negotiations with creditors in order to reach an agreement. If both parties agree to reschedule the debt, there is no credit event as the debt falling due will be repaid with a new bond. However, if they do not succeed in reaching an agreement, a credit event will occur. For example, finding an accepted solution to a debt crisis may indeed be difficult when creditors fail to find an agreement due to coordination costs (Hayri, 2000; Bi *et al.*, 2011). In the specific case of the euro zone crisis, the history of the EU has to be taken into account to understand why, in 2012, the Euro zone members have met three times to finally find an agreement regarding the Greek problem. The EU is a political mechanism aiming at installing durable pacific relations between the countries on the European continent in addition to the initial goal of sharing energy-resources like coal and steel². The common interests of the members within the group are supposed to be higher than their potential divergences. The simple idea that a country can choose or is forced to quit the union was completely ignored. As such, the default option is totally ousted as it would have eventually implied a potential exit of the country from the Euro zone. This original approach may provide an explanation of the fact that when dealing with Greece's debt restructuring, so much time and energy are necessary to reach a first agreement; the tradeoff between the risk of moral hazard behavior and the risk of contagion has to be considered with care. Moreover, in this context of crisis, countries like Germany have difficulties accepting a bailout in countries as different as Greece in terms of economic perspectives and growth. First, they want to make sure that imbalances will be avoided in the future. Second, they want to limit the consequences on their own banks as the banking systems of the EMU members are interconnected, through holdings of Greek sovereign debt among others.

Finally, when the decision is reached, the debt exchange can take place, and the participation of the different creditors as well as the level of their haircut has to be clearly stated. In March 2012, when the first agreement on the Greek debt is reached, Greece manages to get a debt reduction of 53% which is equivalent to approximately euro 100 billion. The agreement is validated by more than 90% of Greece's private creditors (Martin and Waller, 2012). To finalize this agreement, Greece threatens the creditors with a unilateral default if the threshold of 90% is not achieved. This position confirms the negotiation power of a sovereign debtor compared to a private debtor.

III. Methodology and Data

Methodology

The objective of the present study is twofold. First of all, we explore and value the cost associated to the different options a country may have regarding its future debt repayments. Sovereign debt restructuring may sometimes be more expensive than default. However, in the case of default, the country has to take into account the potential spillover effects; this is even more stringent for Greece which belongs to the Euro zone. Our second objective will be to analyze some specific features that

² The first name of the Union in 1951 is the European Community of Coal and Steel.

characterize the situation in Greece and the way these particularities may have influenced the debt restructuring process.

To do so, we follow the methodology proposed by Hayri (2000). Using the game theory framework, this modeling allows estimating the different costs associated to a credit event. The proposed model enables determining the optimal size of a future debt reduction as well as the optimal timing for implementing it. We thus use a debt pricing model under uncertainty combined with a debt reduction game. We apply this modeling framework to estimate the costs associated to the Greek debt relief implemented in March 2012 and compare these results with those obtained for one frontier country that also experienced a debt relief in the recent past.

Hayri (2000) uses a debt pricing framework in which there is a stochastic limit to the ability of a sovereign to pay back its debt. In this setting, instead of an assumption regarding the way creditors deal with arrears once the limit is attained³, Hayri (2000) uses a strategic debt reduction game. In this game, illustrated in the appendix, before the occurrence of a debt restructuring, the sovereign has an initial fixed payout, D_0 per unit of time, to service its debt. Its debt sustainability is maintained as long as its economy is able to generate enough revenues to finance the debt. However, a decrease in its revenues, X , will affect the debt service while eventually the country may suffer from creditor sanctions, such as interruptions in international trade or capital market exclusion. This additional decrease in revenues due to sanctions is characterized by a geometric Brownian motion and will be used by the sovereign as a criterion to anticipate and estimate the potential costs associated to a default on its debt. Another criterion developed by the literature that also stands as a parameter of the game is the borrowing cost for the sovereign, also referred to as the rate of time preference, r_D . This rate, depending on investors' anticipations of default, represents the opportunity cost for the sovereign either to raise taxes, or to increase borrowings to continue servicing its debt. Thus, if the sovereign has short-term problems of paying its debt, the game will consider first the opportunity to raise funds to meet the deadline instead of directly planning the debt restructuring. The sovereign will have difficulties to service its debt starting with the moment when raising new funds becomes impossible. Therefore, the higher the rate of time preference⁴, compared to the world safe interest rate is, the higher the default risk is.

The debt restructuring process starts when the country does not have the financial capacity to meet the deadline anymore. Then, the two players of the game have to make a decision. First of all, creditors have to decide whether they are going to implement a debt reduction or not. Following this decision, the sovereign determines the value of its default option. Backward induction provides the solution of the game and allows determining the thresholds for the optimal time for the sovereign to default (S) and then the optimal last debt reduction accepted by creditors (H) as follows:

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

$$H = h * D = \left(r * \frac{s^\alpha}{r} - \eta * \varphi * \frac{s^{1+\alpha}}{r_D - \mu} * (1 + \alpha) \right)^{\frac{1}{\alpha}} * D \quad (2)$$

³ These mechanistic assumptions may include the roll-over or the forgiveness of claims like in Bartolini and Dixit (1991) or Claessens and Van Wijnbergen (1993) among others.

⁴ The rate of time preference stands for the cost of raising funds by the sovereign.

where μ , the deterministic trend and σ , the volatility, are both associated to the sovereign's revenue flow, v is the sensitivity of the sovereign's value of its default option when its revenues decrease by one point, α , very close to v but computed with r (the world safe interest rate) instead of r_D , is the sensitivity of the sovereign to a change in its revenues, φ is the percentage of the remaining revenue of the sovereign after the default which would be paid to creditors, η is the remaining revenue after the creditor sanctions due to default have been applied. In the second equation, h may be considered as the debt capacity of the sovereign or the creditors' willingness to lend money to the sovereign.

When the sovereign's revenues decrease to reach the first threshold H , the optimal decision for creditors is to implement a debt reduction from D_0 to D . The aim is to reestablish debt sustainability and to reduce the default risk. This decision integrates both the coordination cost linked to a failure of creditors in finding an agreement and the loss in the value of principal due to the debt relief. H is thus considered as the last optimal time to provide the sovereign with a debt reduction. Beyond this limit, the model assumes that the coordination costs linked to an additional debt reduction will be higher than the default and the settlement costs for creditors. Despite the debt reduction, if the sovereign's revenues continue to decrease to finally reach the default threshold, S , then it will be optimal for the sovereign to default on its debt. Given that the level of revenues will be very low in this case, the sovereign's cost of servicing its debt would become higher than another additional decrease in revenues due to creditor sanctions. Then, after creditor sanctions have been established, both lenders and the sovereign start the negotiations to agree on an exit deal. They have to find an agreement on the lump sum payment which will be allocated to creditors in exchange for relieving the sovereign from its debt obligations and the associated sanctions.

In the case of a default, following Rubinstein (1982), a lower rate of time preference provides the sovereign with a higher bargaining power and hence, a higher amount from the revenue flow net of the cost of default. In the case of a debt reduction, the equilibrium is attained when the debt reduction is large enough to allow the sovereign service its debt while the loss incurred by creditors is also limited. As such, a sovereign would prefer a small debt reduction earlier in the bargaining process whereas creditors would like to wait even if such a situation could lead to accepting a higher debt reduction. The issue of the game will depend on the characteristics of the sovereign. When the sovereign's revenue after default is low, creditors will get less through the bargaining process; therefore, they are more inclined to lend money to the sovereign with a high trend and a low volatility, and agree for a lower size of debt reduction. On the opposite, if creditors manage to perceive a large amount if the country defaults, they will be more willing to proceed to a higher debt reduction.

For each country in our sample, we proceed to the identification of the variables required by the estimation of the model.

Data

The country of interest in our study is Greece due to the important role it plays in the burst of the European debt crisis but also to the particular default track record of this debtor country. Following

the MSCI criteria, Greece may be classified within the category of emerging countries⁵. The objective is to determine the costs associated to Greece's debt relief and compare them with those of one frontier country which experienced similar debt problems over the past decade, namely Argentina. We aim at highlighting the characteristics of a debt relief within the Euro zone and shedding some light on the potential consequences for other European sovereign debtors such as Italy and Spain.

The country used in our comparison, *i.e.* Argentina, also experienced debt relief of 76.8% in 2005 (Allen, 2006; Das *et al.*, 2012). The size and timing of this debt relief are extracted from Das *et al.* (2012). As such, the debt relief is computed as the difference between the present value of the previous amount of debt and the new debt level following the debt reduction; it is then expressed as a percentage of the present value of the initial debt level. The use of the present value of the initial debt instead of the face value allows taking into account the real loss recorded by creditors following their acceptance of the debt exchange.

For each country, we collect the level of GDP as a percentage of its total debt outstanding to proxy the series of its revenues⁶. The deterministic time trend and the volatility of the natural logarithm of this Geometric Brownian Motion 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 taking into account the level of savings, the government revenue and the level of the domestic debt as a percentage of GDP in each country. The last parameter we use in our estimations is the average rate of the US two-year government notes which stands for the world safe interest rate. This data is collected using both Bloomberg and Central banks published statistics. However, the period under study is not identical for both countries as we have to consider the period before the debt relief. Therefore, we collect the data for Greece for the period between 2003 and 2011 while for Argentina, the period goes from 1997 to 2004.

IV. Empirical Evidence

First of all, we compute the rate of time preference for each country using the scoring system suggested by Hayri (2000). This scoring system consists in adding (subtracting) one to the average lending rate when the country's ratio of domestic debt-to-GDP is high (low) compared to the sample average; the same procedure is applied to the savings rate and the level of government revenues as a percentage of GDP. Thus, we can estimate the cost of raising funds for the sovereign taking into account its economic situation. The last parameter is the remaining revenue for the sovereign (r) after the sanctions have been applied by creditors. It is obtained through to an optimization method.

Table 1 reports our results.

Insert Table 1 about here

⁵ In June 2012, MSCI changes Greece's status as being under review to be considered as an emerging market starting in 2013 for not fulfilling the criteria that define a developed country. Moreover, its weight in the MSCI index plummets to the level of 0.03% in May 2012.

⁶ Instead of using the level of exports as a percentage of debt as in Hayri (2000), we select the level of GDP which is more significant for Greece and which considers the entire revenue of a country. Moreover, it allows us to make a difference between a current account crisis and a debt crisis. However, we run the test even though with the level of exports as a proxy for country's revenues. The robustness test allows us to confirm our results.

The average of the world safe interest rate equals 2.21% for the time period between 2003 and 2011 while it is a little bit higher, up to 3.47%, for the period between 1997 and 2004. Despite the difference, this rate is significantly lower than the average lending rates of the countries within our sample over their respective time period. This difference highlights investors' anticipations of a higher default risk associated to these sovereigns compared to the US. Based on the market perception of risk, the two countries can be ranked from the "safest" one which is Greece to the "riskiest" one which is Argentina. This goes in line with the MSCI classification which considers Greece as a developed country until the end of 2012 and Argentina as a frontier country.

In terms of economic environment, the government revenue of Greece, equal to 39%, is relatively higher than the figure recorded by Argentina, *i.e.* 24.60%, while the Greek domestic debt reaches a peak at 55.69%. This implies that a large proportion of the Greek debt is owned by its domestic financial institutions. If Greece decides to default, this will potentially represent a high cost for the Greek economy as it will seriously damage its banking system leading to a credit crunch which could be combined with a bank run. Moreover, due to a very low level of savings, *i.e.* 8%, Greece appears to be highly dependent on European and international markets in funding its economic growth or rolling over its short-term debt. This data already pictures a bleak outlook for Greece. However, Greece manages to record the lowest rate of time preference in our sample providing the country with the lowest opportunity cost of raising funds either through taxes or new borrowings to roll over its debt. This is probably linked to its EMU membership. Greece may benefit from the Euro zone and namely from potential anticipations of bailout from the other EMU members in case of debt repayment problems. In the estimations performed to get the trend and volatility of a country's revenues, we apply a Stochastic Differential Equation with a Wiener process on the series of GDP as a percentage of debt outstanding on an annual basis. Table 2 presents the parameters for the two countries in addition to the level of the estimated debt reliefs.

Insert Table 2 about here

We may notice that both countries have a negative trend, indicating a decrease in revenues over the period under study, hence eroding their capacity to reimburse their debt. This decreasing trend seems to be less significant for Greece compared to Argentina. As a member of the EMU, hence of the EU, Greece can benefit from being a member of the customs union where exchanges are facilitated. In addition, Greece has the lowest volatility, implying that the amplitude of potential fluctuations in the revenues is relatively small. This means that the probability of having occasional higher revenues is lower compared to Argentina, which should sometimes be able to benefit from an increase in revenues or record a lower decrease. However, we have seen that Greece has the lowest rate of time preference, synonym of a higher bargaining power with creditors which should be related to its affiliation to the EMU. This specificity reinforces its position despite a critical economic situation providing Greece with a competitive advantage compared to countries like Argentina. We also computed three other parameters that are presented in Table 3.

Insert Table 3 about here

First of all, we may notice that the values for α are lower than the values for ν as the sensitivities of all countries will be reduced when considering the world safe interest rate instead of the rate of time preference. These results confirm Greece's lack of flexibility in managing its debt, despite a low rate of time preference, as it appears to be the most sensitive country in our sample to a decrease of its

revenues. In addition, the negative trend that characterizes the evolution of revenues for Greece points out a higher default risk, as the value of its default option, following a drop in its revenues by one percent, will increase faster than for Argentina. However, Greece appears to present a slightly higher debt capacity than Argentina. In other words, creditors' willingness to provide Greece with new loans is slightly higher, despite the fact that Greece shows a very high default risk. This result may also be related to the low rate of time preference that characterizes Greece and its higher bargaining power due to the EMU membership.

Debt reduction

The results we obtain for Greece as well as for Argentina confirm the figures put forward by Sturzenegger and Zettelmeyer (2006, 2008), Cruces and Trebesch (2011) and the different media; however, they provide more detailed information regarding the costs associated to the debt reduction decision which is an important contribution of the present paper. In March 2012, more than 90% of the private creditors agree to implement a debt relief equal to 53% of the Greek privately-owned outstanding debt. Our estimates confirm that it represents a debt reduction of euro 106 billion in addition to a bond swap for securities with a lower interest rate. This leads to a euro 172 billion debt restructuring, which translates into a loss for bondholders that is higher than 85% of their investment. The estimated coordination cost, associated to the debt restructuring negotiations, is equal to 2.57% of the privately-owned debt, amounting to euro 5 billion. This cost includes the time spent in negotiations, the financial expenses induced by the presence of financial and legal advisors as well as the administrative costs like travel expenses to set up the agreement (Das *et al.*, 2012). When the debt reduction is implemented in March 2012, the level of Greek GDP as a percentage of the outstanding debt is 62.08%, a figure that is far below the threshold endogenously determined by the model for the last debt reduction, estimated at 110.87%. This trigger is supposed to determine the optimal timing to implement the last debt reduction when sovereign's revenues go below it. Compared to Argentina which has debt reduction threshold equals to 77.76%, Greece's threshold is sky-high. This can be linked to the low flexibility the country has in managing its debt due to the small trend and volatility associated to its revenues. It implies that even at a high level of revenues, a debt reduction may be required to eliminate the risk of damaging the situation even more, to anticipate a future default and to reestablish the debt service. Comparatively, Argentina seems to have benefited from a lower threshold while its GDP-to-debt ratio appears to decrease at a faster pace but with a higher volatility. This is linked to the debt level of the country which rises at a faster rate than its revenues over the period due to a confidence crisis and an increase in the sovereign spread (Allen, 2006). However, Argentina has the highest debt relief, which reduces significantly both its debt burden and the proportion of its revenues dedicated to service its debt. It is therefore easy to understand why the threshold is the lowest one as investors anticipate a lower default risk for Argentina, thanks to the debt reduction.

Default

The modeling framework used in our analysis also allows us to derive some useful insights regarding the situation of default of a sovereign. First of all, the default threshold for Greece is estimated at 58.96% which is logically lower than the last debt reduction threshold equal to 110.87%. Hence, as soon as this threshold is attained, it is supposed to be optimal for Greece to default on its debt taking into account that an additional debt reduction would be more expensive than a default. The cost

associated to this default is estimated at 38.39% of the revenues at that default time. It implies that following the default and the associated potential sanctions, such as temporary exclusion from capital markets or trade and output losses, the remaining revenue would be equal to 61.61% of the total revenue before default. In the extreme case, at least in theory, creditors should apply sanctions equivalent to 100% of the sovereign's revenues to force it to service its debt until maturity. However, because all creditors as a group do not implement sanctions or disagree with the exit deal, the remaining revenue after sanctions have been applied is supposed to be different from zero. The settlement cost associated to the default is established by the model at 7.49% of the debt, which amounts at euro 15.5 billion.

The model can also be used to estimate the remaining revenue for Greece after its potential decision to default. It is computed as the present value of its revenues, after subtracting the default costs. The value provided by the model is 25.56%, which corresponds to the discounted value of Greece's future cash flows as measured by the ratio GDP to debt. From the remaining revenue, a lump sum, estimated at 16.15%, will be paid to creditors in exchange of relieving the sovereign from its debt obligation and the associated sanctions. It means that the remaining revenue for the sovereign, called the scrap value of the bargaining process, would be equal to 9.41%.

Considering the information and the figures provided by the model, the implementation of a debt reduction instead of a default seems to be correctly timed. Indeed, in March 2012, when Greece benefits from a debt reduction, the level of its GDP as a percentage of the total debt of the country, equal to 62.08%, is far below the threshold for the optimal last debt reduction, fixed at 110.87%, but still above the one for the optimal time to default, estimated at 58.96%. Thus, following the model, the debt reduction implemented in Greece by private creditors is correctly timed and sized. When one compares the coordination costs linked to the debt reduction, *i.e.* 2.57%, and the settlement costs linked to the default option, *i.e.* 7.49%, one can conclude that the agreement found to reduce the debt level of Greece manages to eliminate the attractiveness of the default option for the country. One potential explanation for implementing a debt reduction in Greece is linked to the subprime crisis of 2008 which led to a deep recession and a significant confidence crisis on the world financial markets. From 2008 to 2012, investors are reluctant to lend money, even to sovereigns; sovereign debtors lose the "risk-free" reputation due to their large debt burden and the different packages they implement to rescue their banking system (Ureche-Rangau and Burietz, 2012). Starting with 2009, Greece's capacity to sustain its debt service as well as the capacity of the European leaders to manage the contagion effects within the Euro zone are questioned. As such, the EFSF is implemented in 2010 as an answer to these fears. Moreover, the debt reduction choice in the Greek case represents a better option than the default given that the country belongs to the EMU. The aim is to eliminate the risk of activating the Greek CDS payments. It also limits the risk of contagion effect through the CDS contracts of the other members and the increase of their long-term interest rates while improving Greece's debt capacity to service the remaining share of its debt. The arguments set forth when trying to find a solution for Greece also take into account the political perspectives regarding a potential exit from the Euro zone which was and still is difficult to accept. The general objective is to create an example which could be useful to the other Euro zone members and renew investors' confidence in the ability of the Euro zone to manage its financial difficulties. As a result, Standard and Poor's increases the rating of Greece by 6 points in December 2012; this result may be linked to the efforts employed by the EMU among other.

However, we are aware of the limits of our approach when dealing with a country which belongs to a monetary union. First of all, the static feature of the model does not consider the inter-linkages of this country with the other members of the monetary union, namely the risk of contagion. The model is validated for a standalone country, with its own currency. The potential influence related to other countries' actions is included in the model through variables like the level of GDP and the percentage of domestic debt. However, Greece is a specific case due to its EMU membership which has to be taken into account to understand the dynamics of its debt level. The model would potentially benefit from the introduction of political variables for example to integrate the decision-making process within the Euro zone.

Simulation

The Greek sovereign debt crisis highlights more general issues related to debt management of developed countries. What would be the consequences of a "Greek drama" taking place in Italy or Spain? What would be the issues of implementing a debt reduction in Italy whose debt is equal to euro 1,898 billion, *i.e.* five times the debt of Greece? We use the same model in order to shed some light on these different questions.

More specifically, we run four simulations on Spain, Italy, Portugal and Ireland to estimate the potential consequences of implementing similar debt relief plans for these countries. We compare the simulation results with those we obtain for Greece. For each country, we estimate different levels of debt reductions from 35% to 53%, *i.e.* the rate applied for Greece in March 2012. The objective is to study the variation of the debt restructuring costs with respect to the level of the debt relief and to determine the optimal level of debt relief for each country in the sample. For each level of debt reduction and for each country, the model provides the remaining revenue after a potential default (r) as well as an estimation of the settlement cost associated to this default in addition to the coordination cost related to the debt reduction (K). Figure 1 plots the three parameters in three different graphs on a country by country basis in order to allow comparisons.

Insert Figure 1 about here

First of all, the general trend of the three parameters is similar for all the countries under study. The remaining revenue after a potential default tends to decrease when the level of the debt reduction is larger. Indeed, when the debt reduction represents a large percentage of the total debt outstanding, investors will lose a large share of their initial investment. Therefore, if the country decides to default later on its remaining debt, the loss for creditors will be smaller compared to the one following the last debt reduction. As such, if there is a large debt reduction, creditors will be willing to ask for larger sanctions as they know they will not be able to get a high return on their investment. This explains why, after the debt reduction decision and the applied sanction, the remaining revenue is even smaller when considering the probability of a sovereign default in the future. All countries appear to follow the same pace except for Italy, for which the remaining revenue decreases faster. Italy is the most industrial country in our sample. Hence, the impact of creditor sanctions in terms of trade relations and output growth may be larger, explaining a faster decrease in the remaining revenue. Moreover, the size of the Italian debt is significant, amounting to euro 1,898 billion when the sovereign debt of the four other countries is below euro 800 billion, *i.e.* euro 735 billion for Spain, euro 355 billion for Greece (before the debt reduction), euro 200 billion for both Portugal and Ireland at the end of 2011 respectively. This may explain why a larger debt reduction for Italy implies

a larger loss for creditors compared to the other countries. Creditor sanctions would therefore be more severe as their loss will be larger. Italy also shows specific results for the two other parameters. For the whole sample, both coordination and settlement costs seem to increase. The larger the level of a debt reduction is, the more difficult it is to reach an agreement with all creditors involved in the process. Regarding the settlement costs, as we mentioned, a large debt reduction implies a large loss for creditors. Therefore, if the country decides to default, creditors will expect to get a large share of the remaining revenue as compensation costs. The agreement between creditors and the sovereign will then be more difficult to reach, increasing the settlement costs. However, for Italy, both the coordination and settlement costs are extremely high and increase at a faster pace. As an example, a debt reduction of 53% will engender a coordination cost of 7% amounting to around euro 133 billion simply to implement the debt reduction while for Spain, Greece, Portugal and Ireland, the coordination cost for the same level of debt reduction will be lower than euro 10 billion, namely euro 9 billion, euro 9 billion, euro 4 billion and euro 2 billion respectively. This result is also linked to the debt burden of Italy which is much more significant and which makes the agreement more difficult to reach as the loss induced by a debt restructuring process may be huge. Finally, the huge amounts involved in the case of a debt reduction for Italy may explain the necessity to rescue Greece; a crucial objective is to limit the spillover effects on the other members of the zone for which the rescuing process would be significantly more expensive.

We can notice that Ireland has a specific trend too. Coordination costs appear to be smaller than those incurred in the case of the other countries while the settlement costs grow at a slower pace. First of all, the Irish sovereign debt level is one of the smallest in the sample under study. Moreover, similar to Greece, Ireland also benefits from the implicit guarantee provided by the Euro zone, especially via the EFSF. Having a small level of debt compared to other European countries makes Ireland a good candidate to benefit from the financial support provided by the fund as this support represents a limited financial cost. In addition, the economic activity of Ireland is mainly based on services, particularly financial services. Therefore, when the subprime crisis occurs in 2008, the Irish banking system is heavily damaged. As such, Ireland decides to implement austerity measures to restore its banking system and to support the economic growth. Through these measures, Ireland manages to decrease its fiscal deficit despite the necessity to continue boosting its economic growth and be able to sustain its debt service. However, the improvement of the Irish fiscal position combined with the reinforcement of the European coalition, may explain why investors seem to be less critical and less severe in the Irish case. The costs patterns displayed for Spain appear to be similar to those for Ireland. Coordination costs are relatively low and the settlement costs grow at a slower pace. This may be related to its weight in the EMU in terms of GDP which allows the country to manage a higher debt level. Therefore, in negotiations with creditors, the country will have a higher bargaining power as creditors may anticipate a higher capacity to generate revenues in the future to service the debt. Finally, Greece and Portugal highlight a very close pattern for both costs, particularly the coordination cost.⁷ The two economies are mainly based on tourism. Therefore, creditors' power in negotiations appears to be less significant which explains why the debt restructuring costs are relatively low. Moreover, the potential sanctions that creditors might apply already damaged these economies following the subprime crisis.

⁷ Applying our model on Portugal also provides us with a robustness check of the results obtained for Greece as they are two countries with similar economic structure and close debt levels.

For a deeper analysis of the debt restructuring costs, Figure 2 illustrates the coordination and settlement costs on a country by country basis.

Insert Figure 2 about here

As mentioned previously, the larger the debt reduction is, the higher the settlement cost associated to a potential default is. It means that in the case of a large debt reduction, the default risk decreases significantly as the option of default becomes more expensive. However, if the debt reduction is too small, the default is still a valuable option for the sovereign as the debt relief is not sufficient to allow the country to sustain its debt. For all the countries in our sample, there is a break-even point where the coordination cost of a debt reduction equals the settlement cost of a default. Before this point, the debt reduction is too small, implying coordination costs which are larger than default costs. Therefore, the sovereign will choose the default if creditors agree on a small debt relief. Beyond the breaking point, the debt reduction becomes a more valuable option as it reduces significantly the debt burden, leading to coordination costs less expensive than default costs. As such, the sovereign will be able to sustain its new level of debt, which in turn reduces the risk of default. Moreover, the break-even point is specific to each country and its economic situation. First of all, looking at Greece confirms that the debt reduction of 53% implemented in March 2012 provides the country with the incentive of servicing its debt as the settlement costs of defaulting become really expensive compared to coordination costs. Second, in our sample, the breaking point occurs at a higher level of debt reduction for Italy compared to the four other countries. It implies that a larger debt reduction, of more than 45%, is required for Italy to eliminate the default risk. In addition, if the debt reduction is too small, the default option is still interesting, especially when the initial debt burden is significant. If one considers the Italian case, the breaking point to eliminate the default risk is associated to a debt reduction of 45%, *i.e.* euro 854 billion or eight times the debt reduction accepted for Greece! Therefore, given the huge debt level of Italy, a default may quickly become very expensive both in terms of creditors' loss and contagion effects within the Euro zone. As such, the incentive to support one of the main industrial countries in the Euro zone, for which 84% of the public debt is owned by domestic financial institutions, by implementing debt reduction scheme, is more important. Regarding Spain and Ireland, both countries still highlight the same patterns, *i.e.* their breaking points occur for a debt reduction of less than 35%. This confirms our previous conclusions about the flexibility both countries have to manage a high debt level thanks to a high level of revenues and structural reforms respectively.

V. Conclusion

The objective of this article is to provide a deeper description of the Greek debt relief and its consequences in terms of costs associated to a debt restructuring process. In addition, the analysis tries to understand to what extent the EMU membership influenced the different decisions made regarding the Greek debt crisis as well as the potential consequences on other major players of the Union, namely Italy and Spain. To do so, we follow a methodology based on a debt pricing model combined with a debt reduction game.

In order to analyze the different characteristics that might have created/influenced the crisis situation in Greece, we apply the same modeling framework to one other country which also experienced sovereign debt crisis, namely Argentina. We show evidence that, thanks to its EMU membership, Greece benefits from a lower borrowing cost between 2000 and 2008 and even after,

compared to Argentina. During this period, investors are considering debts of the Euro zone members as substitutes. Hence, when the subprime crisis explodes, it highlights the issues related to the Greek sovereign debt management namely that borrowed funds are mainly used to finance consumption instead of industrial investments. The effect of the crisis is even more significant as it shows the failure of the Euro zone to promote economic convergence.

However, despite a worse economic situation compared to Argentina, Greece continues to enjoy a lower borrowing cost thanks to its Euro zone membership, which plays the role of a credible guarantee against a potential default. Nevertheless, when the Euro zone starts to rescue Greece with the EFSF and then with the debt relief in March 2012, it seriously damages its own credibility. The financial assistance provided via this fund further deteriorates the credit ratings of almost all the member countries, already downgraded due to slow economic growth rates and bleak previsions in terms of debt recovery induced by their own fiscal challenges. In addition, the contagion risk becomes more and more significant as investors start looking at each EMU member individually. This context may explain why Greece benefits from a debt reduction. Without this intervention, countries with more significant debt level like Italy would have been damaged by the spillovers effects leading to a much more expensive rescue package. Through a simulation, we estimate the optimal size and timing for a debt reduction in four other countries, *i.e.* Italy, Ireland, Spain and Portugal. We find that Italy, with its industrial economy and its particularly high level of debt, would require a much higher debt reduction to eliminate the default option. This would lead to very high coordination and settlement costs compared to the ones estimated for the three other countries, much closer to Greece in terms of debt restructuring costs.

Implementing a dynamic model instead of a static model would potentially improve the empirical analysis and allow better in-depth study. This would allow taking into account the market dynamics in addition to investors' anticipations regarding the sovereign debt risk. We leave this question for further research. Moreover, a better integration of the interaction between EMU countries in the model could also contribute to a better understanding of the European sovereign debt market and its specificities.

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Table 1 : Rate of time preference (r_D)

Country	Savings	Government revenue	Domestic debt	r_D
Greece	8.24	38.99	55.69	8.15%
Argentina	16.65	24.60	15.68	18.06%

Note: Figures for Savings, Government revenue and Domestic debt are expressed as a percentage of the country's GDP

Table 2 : Country's parameters

Country	Deterministic time trend (μ)	Volatility (σ)	Rate of time preference (r_D)	Debt relief
Greece	-0.0606	6.24%	8.15%	53.00%
Argentina	-0.2339	26.93%	18.06%	76.80%

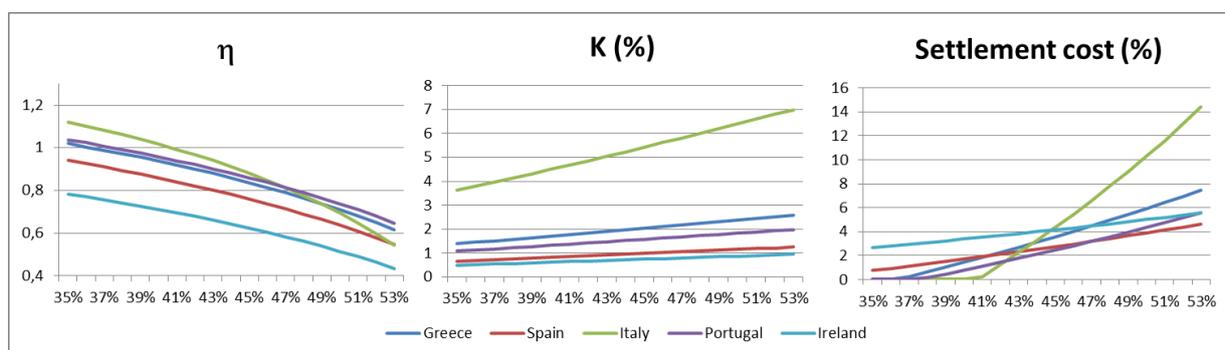
Note: μ , the deterministic trend and σ , the volatility are both associated to the sovereign's revenue flow

Table 3 : Country's characteristics

Country	α	ν	h
Greece	0.3494	1.2537	2.3588
Argentina	0.1263	0.6174	2.2465

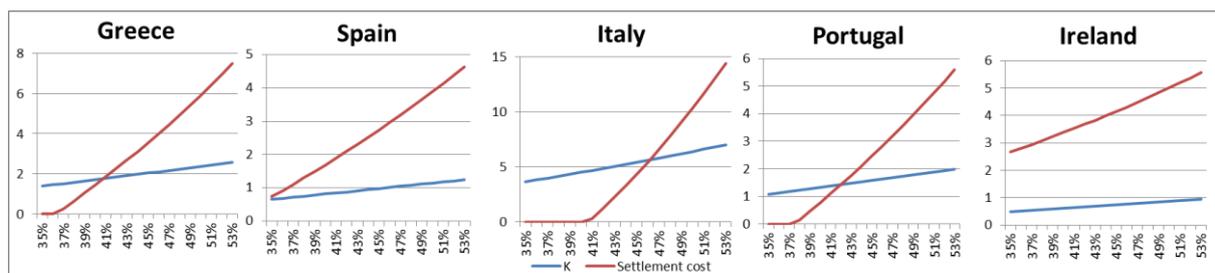
Note: α and ν stand for the sensitivity of the sovereign's value of its default option following a 1% decrease in its revenue, computed with r and r_D respectively; h stands for the sovereign's debt capacity

Figure 1: Simulations' results

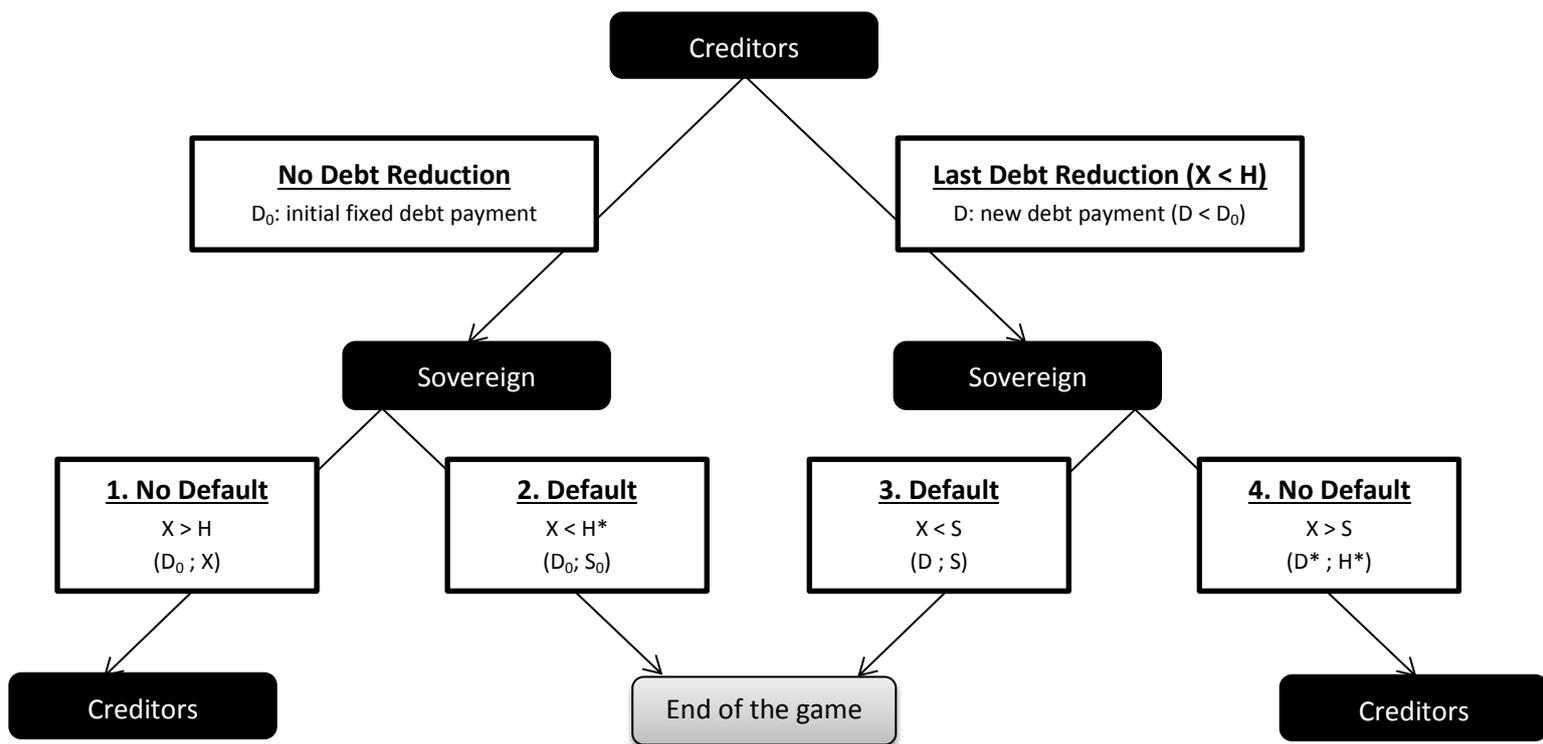


Note: K , the coordination cost associated to the debt reduction and the settlement cost associated to a default are expressed as a percentage of the outstanding debt for the relevant country. η is the remaining revenue after the creditors' sanctions due to default.

Figure 2: Debt restructuring costs



APPENDIX: SOVEREIGN DEBT GAME



Note: Sovereign decision's explanation

1. Without a debt reduction but 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 its 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. At that time, the level of fixed debt payment is always D_0 while the revenues X reached 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 became D after the debt reduction and the level of revenues is S .
4. A combination of a debt reduction and a stop in the decrease of revenues will allow the sovereign to sustain the debt service, reducing the 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.