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# A Recession in European Stock Markets

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**A recession in European Stock Markets**

**By**

**Racha Mohamad Menhem**

**Economics 498-99**

**Thursday, April 12th 2012**

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## Abstract

The economic crisis experienced by EMU countries as a result of the global recession emanating from the U.S. in 2008 effectively ended the convergence process towards a German model. This thesis argues that initially euro-membership for periphery countries such as Greece and Ireland generated ready access to credit at relatively low cost. After the accession to the Union, investors were engaged in a massive lending spree which led to a housing boom in the aforementioned countries. Furthermore, the negative spillover effects generated from policy failures and unregulated debt burdens has exacerbated the crisis, particularly in Greece. In this thesis, we use a GARCH model to explain the volatility of the Athens' Stock Exchange General Index. After deriving measures of liquidity risk, country-specific risk factors, international risk aversion, and real exchange rate risk, we examine the implications of risk factors on ten-year government bond pricing and momentum trading for several countries over the pre-crisis and crisis periods. This study assesses the impact of ECB policies on the euro area and examines the economic effects of a likely Greek default, along with a general loss of credible commitment to the European Monetary Union. On the basis of the EGARCH estimates for the Athens stock market, this study suggest appropriate policy lessons to pave the way for Greece to end years of recession.

**Aknowledgements**

This research project would not have been possible without the support of many people. I would like to warmly thank Rachael Barlow for providing the necessary data to run the models. Also, I wish to express my gratitude for Professor Carol Clark and Professor Racha Ahmed for their devoted assistance in developing the thesis and providing helpful feedback. At last, I could never thank enough my advisor, Professor Miguel Ramirez, for invaluable knowledge and counsel. I was devised by him when a work was unfinished and incomplete. Professor Ramirez's involvement and experience in Economics has pushed this thesis to new, interesting and challenging heights.

# Introduction

The European project of monetary integration started with the EMU in 1999, and it has traced a contradictory pattern of divergence and convergence among its members. Since the beginning, new members showed differences in their level of economic development and inflation rates. Still, the introduction of a single currency has generated significant trade creation and linkages among Eurozone members. The Maastricht Treaty signed in 1992 by seven members of the European Community was the initial official agreement on a European Union. However, the Maastricht Treaty imposed four main criteria on the inflation rate, government finances, the rate of exchange devaluation, and the level of long-term interest rates. Based on Article 121 of the European Community Treaty, member countries were required to maintain an inflation rate no higher than 1.5 percentage points than the best performing three states, and keep the public deficit to GDP ratio at a level lower than 3%, and the ratio of government debt to GDP below 60%. Furthermore, these countries were expected to join the Exchange-Rate Mechanism under the European Monetary System (EMS), and supposedly keep interest rates under the 2% threshold. With respect to the "Real Convergence" theory, the Maastricht Treaty was designed to steer these economies towards these objectives via a gradual process of stabilization and growth.

In addition, the Stability and Growth Pact, implemented in 1998, allowed for fiscal monitoring of member countries by the European Commission and the Council of Ministers. It laid emphasis on the criteria of government finances, which states that the annual fiscal deficit to GDP ratio should not exceed the limit of 3% and that the government debt-to-GDP should be no more than 60%.

Unfortunately, these fiscal requirements were not carefully monitored in several economies, particularly Greece and Ireland. For example, Philips Lane (2006) argues that member countries followed counter-cyclical fiscal policies during the growth period before the onset of recession in late 2007. These policies were expected to minimize debt and maximize revenues. However, the euro-membership established a low interest rate environment, which in turn reduced debt servicing costs. Hence, many countries exceeded the limit for deficit levels and debt to GDP ratios, including the founding members France and Germany in the post-2001 period. Critics of fiscal policy in the Eurozone attacked the lack of coordination in the system and the absence of a federal fiscal authority to oversee all members. Moreover, antagonism between national policies and diverging macroeconomic fundamentals led to different policy responses to business cycles and shocks inside the EMU. Therefore, the financial crisis revealed asymmetric expectations in terms of dealing with liquidity risk, international risk, and macroeconomic risk factors.

When did these countries start to diverge away from their common macro objectives? Why did Greece, in particular, exhibit higher bond yield spreads than other members? How do we build a framework of analysis that enables us to assess the series of economic/financial losses incurred by some peripheral economies? The empirical model developed in this thesis should enable us to explain the fluctuations in the Greek stock market as well as the role of macro-fundamentals before and during the crisis.

An empirical analysis of the spillover effects of the Greek debt crisis on the European Union will also be attempted. An event study will cover financial rescue mechanisms, bailouts, a likely sovereign default by Greece, and austerity measures imposed by national governments. A policy of austerity consists of mainly increasing taxes, lowering spending, reducing the public sector deficit, and cutting benefits and public services.

The question of euro zone sustainability will be addressed in light of the significant losses that would take place under an exit scenario from the EMU. Moreover, this idea has been discussed by Arghyrou and Tsoukalas (2010) in their paper entitled, "The Greek debt crisis: likely causes, mechanisms and outcomes"; they provide convincing evidence for their hypothesis using a theoretical model which treats the crisis in the market for Greek government bonds. The model they use combines three key factors explaining the Greek crisis: deteriorating macro-economic fundamentals, lack of commitment to the EMU, and lower expectations of a fiscal guarantee on Greek debt.

Following the 2008 global recession, the weaknesses in Greece's macroeconomic fundamentals aggravated the domestic crisis as international risk aversion hindered any prospect for recovery. In general, international risk is defined as the global risk of investing in sovereign bonds relative to safer substitutes (German or French assets) in periods of downturn.

The Greek sovereign debt crisis is given special treatment in my thesis, given that the country has had to endure policies which have failed to heal the economy. So far, Greek bailouts have failed to reverse adverse market expectations and generated a negative spillover effect on other countries. Moreover, policies similar to those implemented in Greece are being prescribed in Portugal, Ireland, Italy and Spain at the moment.

1) Integration in the European Monetary Union.

In the first stages of EU membership, investors were disregarding Greek macro-fundamentals and sending excessive inflows of short-term capital into the economy. Investors did not base their decisions on important macro variables such as inflation, the fiscal deficit, and unemployment rates. Full commitment to an expanding union and the possibility of a European (primarily German) guarantee on national debt promoted foreign inflows of investment. The accession to the Union was considered a best case scenario. Therefore, signs of a bubble were observed in the market in the form of rapidly rising real estate prices, higher rates of inflation, and overvalued bonds. For example, it can be shown that the probability of losing full commitment to the EMU in the presence of fiscal guarantees was almost equal to zero, despite the high level of overvaluation reached by the real exchange rate in Greece. In other words, expectations of a “safe haven” in the European Union were protecting the country against any costs arising from real exchange rate overvaluation and the presence of a market bubble. This phenomenon was not just present in Greece since inflation appeared in other economies such as Ireland, Finland, and Italy.

The extant literature and empirical studies have debated whether a bubble in the real estate market was present long before the advent of the Greek crisis. In the article entitled, “The real effects of European Monetary Union” by Lane (2006), the author argues that convergence of poorer countries towards developed nations was anticipated after the euro was introduced into world markets in 1999. Joining the EMU provided protection against liquidity or default risks, since each country was "promised" a bailout when debt burden became overwhelming. The large movement of capital caused an unsustainable supply of money, leading to inflation and a housing bubble in the absence of price adjustments and national monetary policies. However, trade creation overwhelmed trade diversion, since these disadvantages were trivial compared to the benefits of market openness.

In the pre-crisis period, investors did not base their decisions on macro variables such as the rate of inflation, fiscal deficits, and unemployment rates. The entrance to the Union was perceived as a best case scenario. Economic adjustments to fulfill the Maastricht requirements e went smoother than expected, and benefits were perceived in terms of capital inflows. However, full commitment to the EMU created a housing and financial bubble in Greece and in other economies.

In this connection, Dominguez (2006) argues that since the creation of Eurozone institutions, Europeans are becoming increasingly worried about losing their national identity and sovereignty. This inherent nationalism hinders the ability of the ECB to efficiently undertake monetary policy and promote competitiveness of the Euro against the dollar in global financial markets. She argues that the true "test of longevity" of the European Monetary Union has yet to come. Further, the author expands on possible reactions to shocks, namely, it will create an opportunity for some governments to overtake leadership roles.

2) The crisis initiation and spillovers:

The yield on government sovereign bonds is a measure of a country's risk of default. Bond spread values are estimated by differencing a country's yield to Germany's bond yield. After the introduction of the euro in January 1999 and up until the subprime crisis hit global financial markets in mid-July 2007, government bond spreads had moved within a low margin. The stability of these yields was interpreted as a sign of successful integration within the European Union. However, after the onset of the global recession, financial assets and government bonds have been adversely affected by various risk measures.

In his paper "From Bear Sterns to Anglo Irish", Mody (2009) concludes that the higher spreads, observed after July 2007, were explained by domestic factors and international risk aversion. These fluctuations in spreads can persist for a long time, since the volatility of stocks tends to reinforce itself over time. Hence, countries transitioned to a new unstable equilibrium. The rescue of Bear Stearns and other financial institutions generated moral hazard and dependence on government bailouts in the United States. The paper argues that this dependence subsequently became a weakness of the country's financial sector. More recently, countries have also been rated based on their public debt-to-GDP levels. Countries with higher debt ratios are penalized more in terms of debt servicing. Janssen (2010) claims that the bailouts are just another transfer of the banks' debt burden to the public sector. The major holders of Greek debt are the UK, Ireland and France.

It is argued below that the weakness of macro-fundamentals, prospects of default and international risk aversion have hindered recovery by shifting expectations in the market. The delivered bailouts in Europe caused a wide range of market speculation. CDS, or credit default swaps, are a financial swap agreement in which the borrower (seller of CDS) will redeem the protection for the buyer (or buyer of CDS) in the event of a loan default. CDS can be used by investors for speculation and hedging, for example when investors bet on the default risk in the midst of public panic. At the peak of the crisis, sovereign credit-default swap quotes increased rapidly, signaling rightly or wrongly the imminent default on government debt. Buyers of CDS should make periodic payment to the insurance seller, and receive a large installment when the seller defaults. Trading CDS does not mean ownership of debt, which increases the cost of insurance and the witnessed credit risk of the bonds.

According to Arghyrou and Kontonikas (2010), the large spread difference between countries was caused by international risk and country-specific factors. On the other hand, the economic disadvantage of holding debt without fiscal guarantees is associated with a default risk. Finally, they argue that an adverse shift in market expectations took place after the loss of full commitment to the EMU and the loss of a bailout guarantee. The fixed exchange rate was the exchange rate established between Greece and Germany upon Greece’s entry to the union. The spread between the implied exchange and the fixed exchange rate is a measure of overvaluation. Given that the rate of inflation is higher in Greece relative to Germany, appreciation in the real exchange rate has occurred. Arghrou and Kontonikos (2010) also generate a model which describes the capital costs of maintaining EMU participation under three different regimes as a function of the level of real overvaluation. These estimated costs also depend on the existing market expectations and bond spreads analysis.

I will explore these important questions using econometric analysis. Insofar as international risk and domestic factors, I will examine the underlying risk factors which have had an impact on monthly ten-year government bond spreads. Two sets of regressions will be obtained: one generated for the pre-crisis period and the other obtained for the crisis period. Furthermore, I will estimate any contagion effects on stock markets in other EMU countries. In addition, I will graph potential economic losses that might arise under different regimes: with or without full commitment to the EMU.

Finally, I will model the effects of a change in the stock market variables resulting from major announcements such as bailouts, adjustment programs, and fiscal cuts by the Greek government. The estimation of these variables will be undertaken via a GARCH methodology. In particular EGARCH models will be appropriate to model the volatility of the Athens' Stock Exchange General Index. In my thesis, I propose an analysis of the opportunities and challenges that arise from the creation of the euro zone for individual countries, such as Greece. I will include some dummy explanatory variables which highlight the timeline of the crisis. Further, I will also try to forecast volatility and assess the impact of austerity measures. The details of the models will be discussed in the upcoming chapters.

3) Outline

The rest of the paper is structured as follows. Chapter 2 provides a description of the extant literature on the EMU sovereign debt crisis. It briefly covers the period after the introduction of the Euro and mainly focuses on the currency crisis and impact on bond markets. Chapter 3 explains, via a conceptual framework, the passage of Greece through different regimes. It also esplains the OLS models used for the ten euro countries specifying bond market determinants. This chapter also describes the GARCH methodology and introduces the variables. The fourth chapter presents the statistical results and analysis. Finally, Chapter 5 summarizes the reported findings and offers some policy prescriptions.

# 2. Literature Review

In this chapter, I will provide the reader with a brief introduction on the causes and mechanisms of the crisis. I will list the prevalent risk factors and their association to intra-euro government yield spreads. Further, I will incorporate some articles which have been debating the implications of a Greek default on local and regional markets. Using Van Overtveldt's analysis of the future of the Eurozone, I will outline the progressive movement of the crisis leading to possible disintegration inside the EMU. Finally, further papers will be discussed which provide empirical evidence for the risk of contagion and the rising costs of staying in the EMU.

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The European Union was inaugurated on the eve of the Second World War, with the intent of reuniting conflicting nations. Former political leaders, who praised this project, seized this opportunity to revitalize state sovereignty and political power. Upon joining the EMU, these countries gave up their national currencies and freedom of implementing monetary policies; in return, they were promised greater international competitiveness, freer trade, and financial integration. Further, investors engaged in risky opportunistic investment, blinded by very low interest rates.

The Balassa-Samuelson model predicts the effects of trade on productivity or productivity growth rates. In general, workers have higher productivity in the traded sectors than other countries. Hence, this productivity rise in the tradable sector will pull up wages in the other sectors (such as the non-tradable sector). Such wage increases in the non-tradable sector will in turn raise prices and generate inflation since productivity growth is almost null in this sector.Greece’s risk premium almost vanished, higher international competitiveness pushed wages higher and increased dependence on international currency money.

Further, the Central Bank promoted pre-crisis pro-cyclical policies that magnified fluctuations in the market. An example would be the effect of a single Euro zone interest rate in those countries in the Eurozone periphery with relatively higher inflation rates. It led to very low or even negative interest rates during an upturn which magnified the boom and property and asset price bubbles whose subsequent bust magnified the downturn.

On the eve of releasing unsustainable government debt in 2009, the Greek crisis erupted. The Greek government deficit for 2008 was revised from 5% of GDP as reported by Eurostat to 7.7% of GDP. Further, the government revised the planned deficit ratio for 2009 from 3.7% to 12.5% of GDP, suggesting that the country’s previous official statistics had been falsified. Yield spreads on Greek government bonds compared to Germany immediately soared upon this news and capital investment started fleeing. Several other governments also reported unsustainable deficit ratios: Spain, Italy, Ireland and Portugal.

Yield spreads show the difference in yields between two bonds or other securities with different credit quality. It is generally a sign of fiscal vulnerability, risk and default and its impact on investors’ confidence in the economy. Barrios, Iversen, Lewandowska, and Setzer (2009) discussed the determinants of intra-euro area government spreads during the crisis. An improvement in global risk perception has been correlated to narrowing intra-euro area bond yield spreads. Macroeconomic fundamentals, such as deteriorating fiscal debt or public finances, have a direct effect on spreads. The government is forced to encounter the crisis by nationalizing banks or undertaking private debt in order to avoid more severe difficulties. Hence, the government bears sovereign risk and international risk. As investors are concerned about the solvency in several economies, interest rates increase reflecting the difficulties in lending and borrowing activities. At this stage, fear could force investors to sell their bonds and refuse to buy new ones.

Kathryn Dominguez (2006) discusses the question of whether the European monetary Union is sustainable and the risk of contagion. The European Central Bank generally prescribes monetary policies, while governments only control fiscal policies. Regardless of their differences, countries share in fact the same interest rates, monetary policies and rules. This paper alerts the reader to the exposure of several Euro-zone members to contagion and bubbles due to the introduction of a common currency and open markets. The study predicted correctly the outcome of a crisis on the whole European community and raises doubtful questions about this monetary union. What will happen if France was in need of a fiscal stimulus package? How would the Union find the means for bailing out troubled economies?

The European Financial Stability Fund may not be capable of sustaining other debt crises in Italy, Spain and Portugal, which require bigger stimulus packages than in Greece. As mentioned by Nelson, Belkin and Mix (2011), at each country's downgrade, the EFSF is also downgraded, thus its effective lending capacity is reduced. Public downgrading limits the ability to raise more funding for governments. A default by Greece might trigger another round of downgrades, a tightening of lending, bank runs, and speculative attacks until another default hits the market.

Some economists argue that an exit of Greece from the EMU will cause a domino effect. Failure to manage the Greek crisis will damage the European monetary system, since banking sectors would collapse, private bondholders will face losses, and thus the Euro stability will be impaired. Furthermore, if there is no firewall backstopping credit to Spain, Portugal, Ireland and Italy, then we will observe bank runs and withdrawal of liquidity from the market. The absence of central banks in each country increases the risk of contagion. Without any preventive initiative, the “PIIGS” will face higher borrowing costs and a bigger debt burden. Moreover, a loss of confidence will cause capital to flee to safe havens such as Germany. France, with sizable holdings of Italian debt, could stumble. Further, the ECB has high stakes in the Greek crisis, if it takes a loss on its holdings of Greek debt.

Weisbrot, Ray, Montecino and Kozameh (2011) argued that the only way to solve the crisis is to allow a Greek default. Austerity sacrifices growth, weakens productivity, and reduces revenues which, in turn, raises public sector deficit again. The cycle of debt accumulation and austerity may harm the economy; eventually, a Greek default cannot be averted.

They have recently referred to the Argentine default in 2001 as a success. The country experienced a high rate of growth, while facing difficulties borrowing from international financial markets over the past nine years and reduced FDI inflows. Hence, the country relied on internal sources of revenues, by devoting itself to social spending and investing in social programs. Their model calculates actual, projected and 20 year trend Real GDP for Argentina, Ireland, Greece, Spain, Italy and Portugal. The Argentine experience has provided an alternative to European countries planning to default. Once a country chooses to default, it can choose to devalue its new currency and gain from future lower debt value. This scenario could be favored over austerity and conservative policies patronized by the Troika_ the European Union, the European Central Bank, and the IMF. The economic outlook could be enhanced in terms of output, employment, poverty reduction, and reduced inequality according to the forecasts estimated by the model. If Greece pursued the same path of default, it is expected to reach its pre-crisis GDP level in 9 years. On the other hand, Greece reported €32.357 billion in the first eight months of 2010, against €31.333 billion ($41.12 billion) for the same period in 2009. Hence, the European restructuring package is failing to generate growth and revenues, to which the authorities respond with more fiscal cuts. And so, Greece faces a downward debt spiral and negative growth projections.

The paper by Janssen (2010) debates and questions the significance of the Greek adjustment package and series of bailouts. The author argues that Greece will be facing an even higher fiscal burden; further, he shows how Greek sovereign debt is transferred from the balance sheets of banks to the balance sheet of European governments. Austerity is untenable. This article questions the validity of austerity and fiscal reforms imposed by the EMU. Janssen argues that the Argentine experience can provide an alternative to European countries facing a slow and painful process of debt repayment. They could choose the path of default and devaluate their currency. This potential solution has some benefits over austerity and conservative policies patronized by the troika. The economic outlook could be enhanced in terms of output, employment, poverty reduction, and reduced inequality. After the peso was separated from the dollar in 2002, the currency was allowed to float freely in the market; devaluation caused a loss in the peso traded value of 70%. However, Kirchner's government didn't sacrifice growth by trying to fight inflation. As previously mentioned; the government engaged in reforms to encourage real income growth, employment, wage equalization; despite the high traced inflation figures.

Others argue that Greece should not imitate the Argentine model. The country should not be tempted to leave the currency, or else it will cause mayhem in Europe. In return for bailout funds, it will be forced to restructure its debt but the costs of restructuring are still lower than a default following Argentina's model in 2002. Greece should try to reform its economy under soft budget constraints, allowing for limited rescue funds to cover their spendthrift policies from the past.

The destiny of the Eurozone is in the hands of the Germans; Merkel has been controlling and dictating bailout clauses/conditions for sovereign debt. Johan Van Overtveldt (2011) calls it: the "Bismarck's Power Play".[1] Further, the German government is tied to the opinion of the public and German taxpayers relentlessly losing commitment to assist fragile economies.

Upon joining the monetary union, members signed a non-bailout clause in the Maastricht treaty to ban fiscal transfers. A rescue package was awarded to Greece of €110 billion ($144 billion) in 2009. Further, Greece worked on restructuring its banking system: into a more

[1] The end of the euro: The Uneasy Future of the European Union by Johann Van Overtveldt, 2010, Agathe Imprint, p.185

balanced and diversified banking system - with public, private and cooperative banks. Currently, the crisis calls for re-regulation and supervision of the financial and banking sectors. Greek debt was also restructured recently in 2011; private bond investors feared haircuts on their interest income, which increased bond yields spreads. Hence, several peripheral countries faced harder access to funds and higher interest rates. Any debt restructuring was conditional upon Greece improving tax collections, enforcing expenditures cuts, privatizations and structural reforms. In July 2011, another bailout package of $157 billion was implemented by enlarging the roles played by the EFSF. However, austerity pushed the country deeper into recession. The prime minister appealed to the European authorities to agree on a bigger haircut of 50%; hence, banks and pension funds were forced to accept these losses. Other countries lost confidence in the Euro and rumors carried the news that even France's fiscal position could be damaged and debt downgraded from triple A plus. Indeed in the beginning of 2012, nine Eurozone governments were downgraded by S&P rating agency. This caused a wider bank panic in the area. Further, Ireland (Nov 2010), Greece (May 2010, Sept 2011) and Portugal (May 2011) already sought emergency loans to finance their deficit. The bailout money was originally transmitted through EFSF funds (national government and credit from the IMF) and credit from ECB (bonds from secondary market).

Van Overtveldt (2011) projects the future of the crisis in three different stages. The first phase would feature the persistence of austerity measures. However, the Greek economy has limited liability, since downgrades will limit the borrowing capacity and sovereignty of the government. Debt restructuring is certain although a haircut does not in general improve international competitiveness and the lowering of interest is often insufficient. The second phase will take place when Greece chooses to exit the EMU; international competitiveness will be improved according to the author. In 2001, Argentina successfully regained it when it broke its peg to the dollar and defaulted. However, implementing capital controls and recapitalizing the internal banking sector are crucial for recovering from default.

Why would Greece leave the Eurozone? Would the country be better off restructuring its economy outside the currency union? Would it return to the drachma?

The PSI or Private Sector Involvement is unique to Greece and does not apply to any other bailout. Another round of bailout means that the country in question has lost its sovereignty to the point it cannot decide for itself which course to follow to rectify its continuous debt problem. Greece has still not emerged from its financial debt crisis although two bailout programs have been approved already. Hence, it might consider leaving the Eurozone.

The barriers to leaving are high: taxpayers are no longer willing to bear the burden of profligate countries. The German banking sector is heavily exposed to Greek, Irish, Portuguese and Spanish risk and is one of the most leveraged banking sectors in Europe. There's a fear of never-ending financial support for the weakest states. Greece, Portugal and Ireland as argued by Overtverldt (2011) will soon be left with the safe bet to leave the European Monetary Union, in the state of dire growth prospects.

The last phase consists of restructuring the union. Four conditions should be met in order for monetary union to function: political union, fiscal integration, labor mobility, price and wage flexibility. Political disagreement on the management of the EU has failed to improve the economic situation. Lack of coordination in the EMU financial sector will only hurt the economies. According to Overtveldt (2011) The authorities should work on the following: “rebuilding the European banking sector, restoring the long-term sustainability of public finances, improving structural growth and, most important of all, rebuilding the institutional framework of the monetary union to make it more durable and efficient.” If the authorities fail to adjust the system, then Germany, the largest and best performing economy will try to exit the system before its monetary and financial stability collapses. Hence, the EMU project will disintegrate once the pledge to the Euro becomes very costly.

Lane’s paper (2006) focuses on the impact of contagion effects inside the EMU and the selection of appropriate fiscal policies by the government. He finds that trade creation overwhelmed trade diversion: “it was not exclusive; euro-usage boosted imports from non-Eurozone nations almost as much as it boosted imports from Eurozone partners, i.e. there was no trade diversion but rather external trade creation in addition to the internal trade creation. The best estimate of the external trade creation is 7%. The best empirical evidence suggest that this applies only the Eurozone imports, but some evidence suggests that it applies to Eurozone exports as well.”[2]

Negative effects in changes in the external value of the euro were still small to offset the efficiency of financial openness. His evidence is based on disparities in inflation rates, flows of foreign direct investment and changes in current account deficits and spreads of certain government bonds: “spreads across government bond yields have narrowed to very low levels: for instance, the end-June 2005 spread on ten-year sovereign bonds was just 30 basis points (that

[2] Richard Baldwin, *In or out does it make a difference?*. Graduate Institute of International Studies, Geneva, May 2006.

is, 0.3 percentage points) across the euro area"[3]. Further, differences in inflation rates translate into differences in real interest rates across member countries. A housing spree followed by a price bubble hit Greece once it accessed the Union. People had the impression that the country was protected against any fiscal risk or recession under the protection of the European Central Bank and was backed by the French and German government. This major asset bubble was accompanied by excessive credit creation, which might be the origin of the crisis as claimed by the author. In contrast, Arghyrou and Kontonikas (2010) emphasize the role played by macro fundamentals.

Is the EMU project sustainable? When is this depression going to end? "The EMU sovereign-debt crisis" by Arghyrou and Kontonikas (2010) offers an analysis of the European sovereign debt crisis, using an econometrics model of the Eurozone crisis. Once the true macro-fundamentals in each country were released, people started investing in sovereign bonds relative to safer substitutes (known as international risk). Market expectations also impacted countries by deteriorating their macroeconomic performance. Finally, the authors discuss the miscarried convergence to the German model during the pre-crisis period: this shows the unrealistic calculations that politicians have made upon joining the EMU. This paper shows how macro-fundamentals were disregarded in the case of Greece and reforms were relaxed which led to further divergence between countries. Their model which consists of a simple linear model will be extended in the next chapters using a GARCH specification.

"The Greek debt crisis: likely causes, mechanisms and outcomes" article by Arghyrou & Tsoukalas (2010) offers a treatment of the Greek crisis and argues that the nature of this crisis is

[3] Philip Lane, *The real effects of European Monetary Union*. Journal of Economic Perspectives, 2006.

caused by two main problems: A) the deterioration of the Greek macroeconomic prospective. B) a shift from a credible commitment to EMU participation and EMU guarantee of Greek fiscal liability to a regime of non-credible commitment without any fiscal guarantee. For example, given the high risk of default and the incapacity of Greece to conduct effective reforms, European fiscal guarantees begin to recede. The authors also show the severity of the risk of contagion and use an econometrics model marked by three different phases of the crisis. EMU accession caused net costs to increase in Greece because it was not conforming to the Maastricht criteria. Greece introduced default risk and moral hazard problems and planted the seed of contagion in the economy. The Germans were not prepared to help Greece unconditionally, to the general surprise of investors. The breakdown of the crisis into 3 phases has shed the light on the mechanism leading to an EMU exit under a withdrawal of fiscal guarantees and shifting membership expectations. They discover also that all countries included are highly sensitive to a risk of contagion.

The prevailing literature has shown that markets respond to three different factors: an international risk factor, a credit risk, and liquidity risk. International risk factor is experienced when a business faces risks from expanding its activities internationally for political or economic motives. On the other hand, credit risk measures a country's probability of default on its fiscal liabilities. Further, it is measured using current and previous indicators of fiscal performance. Finally liquidity risk, is directly related to the size of debt and represents capital losses in the case of a loss of liquidity for investors. Liquidity is a variable hard to measure, usually established in 3 forms: bid-ask spreads (how much a trader can lose by selling an asset and buying it back right away), price market depth (or volume of transactions), market resiliency (how long it takes for an assets that have fallen to bounce back? The share of a country's debt in total EMU sovereign debt was used as a proxy). Furthermore, the literature recognizes the high collinearity between market liquidity and the global risk factors, as mentioned by Attinasi, Checherita and Nickel (2009).

They explain in their paper the causes of the widening of the sovereign government bond spreads in the euro area during the period from July 2007 to March 2009. The authors argue that expected increases in fiscal deficits and debt ratio relative to Germany, and announcements of rescue mechanisms by the central bank contribute to higher spreads. They also discuss the transfer of private risk to the public sector. The liquidity risk and international risk aversion are two variables whose effects are estimated using yield spreads from econometrics regressions.

They use the Feasible Generalized Least Squares (FGLS) model to find the determinants of sovereign bond yields spreads. They discover that the liquidity of government bonds plays a crucial role in widening spreads, while international risk aversion increases them. Further, an increase in the ECB refinancing operations rate of countries in difficulty leads to larger sovereign bond spreads for the period of study. They estimated the weights of each factor on the change in government bond yields spreads.

Euro area sovereign yields have exhibited a high degree of volatility as well as changes in interest rates, consumption, and investment decisions. According to Caceres, Guzzo and Segoviani (2010), the valuation of sovereign bonds depends on several factors. As the market price for risk goes up, investors look for higher compensation and choose fewer assets with reduced riskiness. On the other hand, the contribution of policy authorities to supporting financial institutions in trouble, involves in their paper two channels: domestic at first and external as the crisis reaches an acute phase. Their paper assesses the impact of global risk aversion on fluctuations in euro sovereign spreads using a General Autoregressive Conditional Heteroskedasticity model (GARCH (1,1)) for several countries including: Germany, France, Italy, Spain, Belgium, Netherlands, Austria, Greece, Ireland, and Portugal. The swap spread was subject to several explanatory variables: the Index of global risk aversion (IGRA), spillover coefficient (SC), and two specific fiscal variables, namely the overall balance as a percent of GDP and the debt-GDP ratio. The SC captures contagion effects within the EMU (or conditional distress), the IGRA captures the market price of risk, and the last two variables identify each country's level of debt and budget deficit as a percent of GDP. The authors find that global risk aversion increases fluctuations in country's sovereign spread. They recommend that governments emphasize debt management and provide financial stability.

I will explore these important questions using econometric analysis; in particular GARCH models will be utilized in order to model the volatility of stock market instruments in the Euro zone. I will model the effects of a change in the stock market variables. I will try to evaluate the impact of monetary policy announcements and the impact of country-by-country fundamentals and fiscal policies on the variations in spreads. Then, referring to international risk and different risks stemming from a pattern of high fiscal deficits, I will estimate the potential economic losses that might arise with or without full commitment to the EMU. Finally, using GARCH models, I will show any contagion effects on stock markets in other EMU periphery countries.

# 3. Methodology and data presentation

**3.1. Theoretical model:**

The sovereign debt crisis will be analyzed in three different sections. The first analysis will present a regime-switching model exploring different stages of the Greek crisis: the first stage representing full-commitment to the EMU and presence of a full-fiscal guarantee, the second stage representing a loss of credible commitment to the EMU, and the third stage accounting for a loss of credit guarantee and a risk of default. These regime-shifting expectations are based on changes in macro fundamentals, investors' confidence and volatility of equity markets. This analysis allows us to clearly convey to the reader the method of pricing of liquidity risk, default risk, and exchange rate risk in periods of real exchange rate appreciation.

With a long sample period covering different crisis episodes, we can recreate a regime switching model based on fiscal indicators of Greece's financing and key fiscal policies. We refer to the model of rational exit from the EMU developed by Arghyrou and Tsoukalas (2010). The hypothesis of a "currency crisis in disguise" states that the Greek drachma would have depreciated during the crisis if the country was on its own; however, the impact of the crisis has hit equity markets under the Euro regime. In light of this explanation, they assume one control variable for the government: the decision to stay or exit the Euro. They also assume that Greece's purchasing power has been falling consistently from the first breakdown of the crisis. Further, they value the cost of exit from the Eurozone as constant, which is not completely credible and inconsistent with higher debt obligations recurring over time.

A full commitment to the EMU would imply that the private sector recognize the success of the Euro project and agrees to the terms of the Maastricht treaty; thereby keeping exchange rates fixed and losing monetary independence. On the other hand, a lack of commitment to the EMU implies two possibilities: Greece may or may not have access to German guarantees on its fiscal liability. In this last regime, a default and an exit from the EMU will be anticipated. According to Arghyrou and Tsoukalas (2010), the cost of staying in the Eurozone should be graphed as a quadratic function of the real effective exchange rate[4]. An appreciation of the real exchange rate is linked to reduced international competitiveness, leading to lower output, higher external public debt and higher interest payments.

Under the first regime, Greece is committed to the EMU and outstanding fiscal liabilities are fully guaranteed.

$$L_1 = \gamma_1 q^2$$

Such that $\gamma_1 \geq 0$.

They decide that macro-fundamentals are not linked to interest rates on government bonds. Hence, government is expected to take any corrective action to macro-imbalances. This occurs at $\gamma_1 = 0$. In reality, markets have only missed or acted indifferently towards liquidity and deficit problems: all markets were counting on the success of the EMU. Once $\gamma_1$ takes on values greater than zero, the governments issues more bonds in the market. Losses are observable in higher costs of borrowing and costs of macroeconomic correction.

[4] The real effective exchange rate was calculated by taking the difference between the Purchasing Power of Parity exchange rate and the nominal exchange rate at which the country joined the Eurozone.

However, the government failed to implement the necessary corrective measures which created problems in the economy. A switch to the second regime is observed on November 2009, upon revision of spurious statistics on the Greek deficit in the previous years. The second regime exhibits a loss of commitment to the EMU. They assign an exchange rate premium ($\gamma_2$) resulting in even higher costs of public borrowing. Exchange rate risk is the result of unanticipated real exchange rate changes have on the value of the bonds.

$$L_1 = (\gamma_1 + \gamma_2)q^2$$

Such that $\gamma_1, \gamma_2 > 0$.

Finally, the last regime begins on January 2010 when probabilities of rescuing sovereign bonds decrease and European leaders disagree on the necessity of a Greek bailout. This regime would include both exchange rate and default premiums.

$$L_1 = (\gamma_1 + \gamma_2 + \gamma_3)q^2$$

Such that $\gamma_1, \gamma_2, \gamma_3 > 0$.

They take into account the higher costs of borrowing due to the increased selling of government bonds in all cases. An EMU exit would occur in the 3rd regime. The risk of default lies above a critical threshold for overvaluation.

Their model will be upgraded in order to represent any costs of staying in the EMU after consideration of inefficient austerity measures. We'll also consider the recent write off of more than half of Greece's debt at the expense of private creditors in March 2012. As Obstfeld (1996) and Arhgyrou (2010) underlined, our model also anticipates that a shift in expectations can result in "self-fulfilling prophecies" of EMU exit. We change one assumption from their model; the cost of exit will not remain constant but will depend mainly on the damages imposed by austerity.

We will extend and add a fourth regime which incorporates the loss of fiscal guarantee, the loss of commitment, and the failure of economic restructuring policies. Austerity and growth have been moving in a contradictory pattern in the Greek case, the austerity terms imposed on the country have in general failed to stimulate the economy. This stimulus package might plausibly fail in the future if ECB leaders can't find the right balance between austerity and growth strategies. [5]

European leaders confronted austerity with additional austerity whenever skepticism around the Euro rose. Austerity measures have only been successful in controlling government excessive spending: especially military expenditures. Otherwise, austerity has caused severe contraction in Greece, Ireland and Portugal:

**"**Critics argue the austerity measures are driving Greece further into recession, with the contraction accelerating to 7 percent in the last quarter of 2011, making it even harder for Greece

[5] Leitner, Monteiro & Shapiro. Europe's Policy Problem: Balancing Austerity with Economic Growth. Economy Watch, 29 December 2011.

to pay back its debts. The Greek economy has shrunk 16 percent since 2008, driving up unemployment to over 20 percent."[6]

$$L_1 = (\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4)q^2$$

Such that $\gamma_1, \gamma_2, \gamma_3, \gamma_4 \geq 0$.

The fourth equation will be a function of $\gamma_4$ illustrating the costs of unsuccessful reinforcement of strict policies. Compared to the country's condition in the pre-crisis period, Greece now faces exchange rate risk, default risk, and the contractionary effects associated with further austerity. As the country keeps on borrowing at higher and higher yield rates, there's a problem in finding taxpayers to support this risky economy.

These common factors and regimes explain most of the fluctuations in euro-area yields and spreads. The regime-switching feature of the model turns out to be particularly relevant in capturing the rise in volatility of 10-year government bonds over the years. The theoretical model shows the transition between calm and crisis periods by allowing for regime switching generation.

In the second model, we will explain using econometric regressions the developments inside the EMU during the period from January 2000 to November 2011. We will use a wide range of stock market prices and macroeconomic variables. Our first estimation model will re-estimate and extend the regressions obtained for the pre-crisis, crisis and contagion periods by Arghyrou and Kontonikas (2010).

[6] 'Greeks protest bailout cuts on eve of bailout decision', Reuters news, 19th February 2012.

### 3.2. OLS-HAC Model:

Yield spreads are defined as the premium required by investors to purchase government securities issued by a country in the EMU in exchange for buying equivalent securities issued by Germany. The premium obtained emerges from different factors such as: liquidity risk, international risk aversion and credit (default) risk.

There is a popular belief in the euro-area that government bond spreads are dependent on a common international risk factor. This international risk aversion factor depends on uncertainty over the future of European integrated markets. Investors withdraw their financial capital from countries plagued by sovereign debt. This "fear" index tends to elevate yields on sovereign bonds.

Economists reckon that macroeconomic fundamentals have changed from the pre-crisis period to the crisis period. The evaluation of macro fundamentals has changed; investors were disregarding general statistics on fiscal deficit in the pre-crisis period. International risk is usually captured by the volatility index (VIX) designed by the Chicago Board Options Exchange Market.

Fluctuations in spreads depend also on the liquidity risk premium. An exact measure of liquidity risk has yet to be generated. Liquidity risk arises when a country fails to sell quickly assets or securities before its redemption. Funding liquidity risk is mainly the ability to settle obligations immediately. Liquidity is captured by the amount of outstanding debt securities in each economy in this model. If liquidity increases, then liquidity risk is lowered as well as government yields.

Changes in credit risk assessment have a large impact on yield spreads. The credit risk is linked to the issuer's probability of default (PD). If investors assess that the PD of some indebted country is higher than in the past, the prices of bond issued by this country fall because expected loss increases. Hence, yields on bonds would increase as the risk of holding these bonds rises. As evidence shows, credit default spreads increased relative to Germany. Hence, buyers of CDS have been gaining from speculative attacks on debt restructuring. CDS have been triggered in March 2012, subsequently after a 50% haircut was imposed on private bondholders of Greek debt. A credit default spread analysis will be obtained for Greece and explained independently.

As shown in the paper by Brandt, Beber and Kavajecz (2008), investors revert to fixed-income investments or a safer bet such as German government bonds when they worry about uncertainty in equity markets. Uncertainty is explained by a persistent risk of default, contagion, failure in meeting debt payments and transitioning into different stages of business cycles. Flight-to-quality is an important issue in the Euro bond market. Credit quality explains yield spreads across credit of different quality.

Liquidity also plays an important role in low credit risk countries during downturns. Their analysis draws attention to European government bonds, and we should note that it only applies to this asset class in particular. They conclude that large streams of investments into bond markets chase liquidity, not credit quality. Their findings indicate a negative relation (not present in US treasury bonds) between credit quality and liquidity. During times of fiscal regulation, the credit quality on sovereign bond increases_ captured by low debt to GDP ratio_ while liquidity decreases_ which is captured by the size of outstanding debt. Hence, they conclude that differences in spreads from one country to another are better explained by liquidity (or the demand on bonds) in periods of stress.

In the presence of heteroskedasticity and serial correlation, we use the Newey-West HAC methodology. The heteroskedastic and autocorrelation consistent (HAC) estimator gives more robust and consistent results. We will be running similar regressions as the ones featured in Arghyrou and Kontonikas paper.

***Pre-crisis analysis:***

The benchmark for our OLS estimations in the pre-crisis period is specified below:

$$spread_t = a_1 c + a_2 spread_{t-1} + a_3 vix_t + a_4 rexch_t \quad (1)$$

Where $spread$ represents the difference in yields on government bonds relative to Germany, c is a constant, $vix$ is the CBOE-VIX volatility index, and $rexch$ is the real effective exchange rate.

On the other hand, the second equation will incorporate a liquidity measure, expressed in the following form:

$$spread_t = a_1 c + a_2 spread_{t-1} + a_3 vix_t + a_4 rexch_t + a_5 liq_t \quad (2)$$

In this equation, $liq$ represents the number of outstanding debt securities issued by the central government in each country.

The third and fourth regressions will add, to the elements of previous regressions, some measures of macro-economic fundamentals. The variables of interest are: growth in industrial production, current account balance (as percent of GDP), and the level of outstanding debt.

The third regression is expressed as:

$$spread_t = a_1 c + a_2 spread_{t-1} + a_3 vix_t + a_4 rexch_t + a_5 liq_t + a_6 gind_t + a_7 cab_t \quad (3)$$

The fourth regression has the following specification:

$$spread_t = a_1 c + a_2 spread_{t-1} + a_3 vix_t + a_4 rexch_t + a_5 debt_t \quad (4)$$

***Crisis analysis:***

The benchmark for our OLS estimations in the crisis and period includes the yield spread on 10-year Greek government bonds:

$$spread_t = a_1 c + a_2 spread_{t-1} + a_3 vix_t + a_4 rexch_t + a_5 Greece\_spread_t \quad (5)$$

We will repeat the second regression of the pre-crisis period, including the yield spread for Greece. The model's extensions include a liquidity measure, government debt levels, the current account balance, and industrial production.

Finally we will add several dummy variables to mark key events or chapters in the EMU sovereign debt crisis. The first dummy will signal the change in expectations from a regime of fully credible EMU commitment under fiscal guarantee to a regime of non-credible fiscal commitment. The variable will be fixed on November 2009. This date was marked by the Greek Prime Minister George Papandreou's publishing of Greece's 2009 budget deficit which reached

12.7 percent of GDP, more than double the previous year's statistics. Further, Greece was reluctant to conduct any macroeconomic restructuring policies.

The second dummy variable will mark another regime switching event on January 2010, when leaders fell into disagreement on the necessity of a Greek bailout. Hence, Greece loses the privilege of full guarantee on its fiscal liabilities.

The third dummy will announce major events in May 2010. The most important headline was the announcement of a €110 billion loan for Greece, approved by the Eurozone countries and the International Monetary fund. However, this bailout is conditional on implementing severe austerity measures. Further, global policy makers agree on an emergency fund amounting to €750bn to support financial markets and rescue the Union against contagion from the Greek crisis.

The fourth and last dummy will be for June 2011. The crisis reached another breaking point in May and June when the Greek government pursued debt refinancing operations. The public was angry and dissatisfied with these austerity measures. In June, the government announced a new package of strict austerity. Moreover, Jean-Claude Juncker, head of the Eurozone finance ministers, announced that the private sector should participate in "soft restructuring" the Greek debt, also recommended by Germany. Hence, private creditors should bear some of the costs resultant from this deal. However, European leaders failed to cooperate on this issue, which further disturbed already stressed credit markets.

### 3.3. Explanation of the Variables:

The dependent variable in the model is the 10-year government bond yield spread, with Germany as a benchmark. The statistics were obtained from Haver Analytics Database. The European countries covered in this study are: Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain. However, Luxembourg and the latest members in the Monetary Union (Cyprus, Malta, Slovakia and Slovenia) are omitted.

There exists a high correlation between spikes in government bond yield spreads and crisis events in the European Union. Higher spread values generally shows loss of confidence in the credibility of sovereign bonds and higher borrowing rates for countries concerned. The trend for most euro countries has been an increase in bond yields. Ten-year Greek bonds' difference in yields reached 35 percentage points (3500 basis points) in January 2012 compared to German bonds, while French bond yield spreads averaged 1.44% points (144 basis points). Low interest rates first established by ECB triggered continuous excessive borrowing in peripheral economies. Interest rates on government bonds have been increasing due to several credit downgrades by S&P and Moody's. By January 2012, long-term interest rates in Greece reached 25.9%; while interest rates in France averaged 3.18%.

Explanatory variables were grouped in two categories: variables related to country-specific fundamentals and others related to international factors. Country-specific macroeconomic variables included the consolidated general government debt, the real effective exchange rate, the current account balance as a percent of GDP and industrial production growth rate. We use only the Chicago Board Options Exchange Market Volatility Index to capture international risk.

The real effective exchange rate is CPI deflated and obtained on a monthly basis from Haver Analytics. The real exchange rate measures the country's real purchasing power and its external competitiveness. While the nominal exchange rate, which is the rate unadjusted for inflation, is equivalent to the exchange rate for the Euro. Under purchasing power of parity, when two economies A and B exchange similar or identical goods, consumers in A and consumers in B are indifferent towards buying the product from either country. On the other hand, if the real exchange rate appreciates in A; then, consumers in B will give up more goods in order to buy goods from country A. Hence, country A's international competitiveness is affected adversely.

A measure of fiscal liability is the level of consolidated general government debt extracted from Haver Analytics. We want to show that bond spreads and government debt are positively related. Any increase in the debt values in terms of GDP is more likely to increase government bond spreads. However, this measure is not consistent with the rest of the variables since it is only observed on quarterly basis. Hence, its frequency has been adjusted such that the values of government debt remain constant over a period of three months, following the lead of Arghyrou and Kontonikos (2010). These values would change when new debt statistics are announced. Therefore, this variable suffers from unavoidable measurement problems.

Liquidity has been defined in multiple ways and presented in Arghyrou and Kontonikos' paper (2010) by the size of government debt. Furthermore, if outstanding bonds are traded in greater quantity, the country's debt would be considered more liquid, and outstanding borrowing rates are reduced, i.e. spreads decrease. In my model, a proxy for liquidity is based on the total outstanding amounts and transactions of euro-denominated debt securities in each country of residence, issued by the Central Government. We were able to obtain this variable from the Bank of Finland online statistics[7].

We include the industrial production growth rate in order to describe business cycles. The variable was reported on a monthly basis and obtained from Haver Analytics. During the crisis period, industrial production deteriorated in all Eurozone countries.

The current account balance is a common measure of a country's external trading position captured by the nature of a country's foreign trade and the net capital outflow. The current account expresses the change in net foreign assets in the accounting sense, or the difference between exports and imports in the economic sense. A current account deficit signifies a reduction in net foreign assets. Hence, the demand for capital inflows increases while the country becomes vulnerable to reversal in flows of funding. Hence, bond yield spreads tend to increase. We could only find quarterly statistics for this variable from Haver Analytics. Hence, the same adjustment as the government debt has been executed for each period of three months.

Furthermore, the Chicago Board Options Exchange Market Volatility Index or VIX is a popular measure of implied volatility of S&P 500 index options. The VIX illustrates the expected volatility in stock markets over the next 30 day period. This index will be incorporated in the model. The VIX is quoted in percentage points. Referred to as the "fear index", a high VIX does not necessarily project a pessimistic trend (or outlook) for a particular stock option. The VIX generally captures the dynamism behind trading activities inside financial markets. During

[7] The variables are available to download on the Bank of Finland website: http://www.suomenpankki.fi/en/tilastot/euroalueen_tilastoja/Pages/default.aspx

periods of booms or busts, a high VIX measures an anticipated sudden move in either direction, as a result of risky behavior. Only in periods of no significant potential downside or upside risk, does the VIX exhibit low values. Option buyers expecting higher prices, will be willing to pay a risk premium to option sellers, which inflates the VIX even more. Hence, periods of high volatility tend to work in a "revolving" feedback mechanism. These effects will be modeled in the T-GARCH model presented in the next section. Monthly averages of the VIX are calculated from daily observations; the data has been obtained from the FRED (Federal Reserve Economic Data). The VIX will be used as a gauge for global financial risk.

### 3.4- The GARCH models:

Testing for ARCH effects:

Recent financial literature has introduced a technique to model the behavior of investors in periods of uncertainty and decision-making under risk. The GARCH model was first introduced by Bollerslev and Taylor (1986). Robert F. Engle's seminal paper 'Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation' (1982) represents another critical contribution to the literature. These ARCH/GARCH models have introduced a variance equation in addition to the regular mean equation, in order to display effects on the variance or the volatility of the series. Verbeek (2004) argues that GARCH models have a more parsimonious representation and perform better than ARCH models due to the low level of parameters involved.

Large movements in spreads are followed by movements of larger magnitude. In other words, volatility tends to exhibit clustering over a period of time. The idea of changing magnitude from one period to another is defined by the conditional variance. While the variance of the series with respect to time, in the presence of fluctuations, is defined as the unconditional variance. The GARCH model incorporates both kinds of variance, focusing on the conditional variance which allows for the variance to depend on its history. Moreover, the model is popular due to its effectiveness in measuring the riskiness of an asset over a certain period of time. The GARCH model is presented with the following specification:

The mean equation takes the following form:

$Y_t = a + \beta' X_t + u_t$

Where $u_t|\Omega_t \sim iid\ N(0, \sigma_t)$.

In other words, error terms $u_t$ are mutually independent and identically distributed, following a normal distribution with zero mean and constant variance $\sigma_t$.

The variance equation is specified below:

$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + u$

The variance depends on both past values of shocks, captured by the lagged squared residual terms, and on its own past values, which are captured by lagged variance terms. The $\beta_1$term represents the coefficient on the past variance terms $\sigma_{t-1}^2$ and the $\alpha_1$ term represents the coefficient on the lagged residuals $u_{t-1}$.

The T-GARCH model was introduced in the works of Zakoian (1990) and Glosten et al. (1993). TGARCH models capture asymmetric behavior in terms of negative or positive shocks. The T-GARCH model captures an asymmetric increase in volatility: it increases more following a market move in one direction than it does following a market move of the same size in the opposite direction. When volatility is very high, investors may decide to close out positions, inducing more stock prices to fall. The asymmetric shock of bad news on the stock market compared to good news will be tested using this model. The mean equation is identical to the GARCH(p,q) model.

The variance equation of the T-GARCH(1,1) is introduced below:

$$\sigma_t^2 = \alpha_0 + u_{t-1}^2(\alpha_1 + \alpha_2 d_{t-1}) + \beta_1 \sigma_{t-1}^2 + u$$

Where $d_t$ is a dummy variable which takes the value of 1 for $u_t < 0$, and 0 otherwise. So good news has an impact of $\alpha_1$ while bad news has an impact of $\alpha_1 + \alpha_2$.

The final model would be the EGARCH model introduced by Nelson (1991). It also captures asymmetrical behavior in the stock variables in response to shocks. The EGARCH highlights persistent effects in the volatility of the series.

The variance equation is given by:

$$\log(\sigma_t^2) = \alpha_0 + \alpha_1 |\varepsilon_{t-1}/\sigma_{t-1}| + \alpha_2(\varepsilon_{t-1}/\sigma_{t-1}) + \alpha_3 \log(\sigma_{t-1}^2) + u$$

The conditional variance will be always positive, since we have been taking the logarithmic form of the variance. The "leverage effect" or the asymmetrical character of the model is captured by $\alpha_2$. A negative value on $\alpha_2$ implies that negative shocks ("bad news") generate more volatility relative to positive shocks ("good news"). The exponential GARCH has a larger explanatory power since it incorporates an exponential impact with larger slopes. We'll apply the EGARCH model to estimate financial volatility of the Athens Stock Exchange General Index.

The data attached to the model consists of Athens Stock Exchange General Index and the L-DAX Index.

The Athens Stock Exchange General Index is a capitalization-weighted index of Greek stocks listed on the Athens Stock Exchange. The index was established on the base value of 100 as of December 31, 1980. The data extends over the period from 1/1/2007 to 3/6/2012, which includes 1352 daily observations.

The L-DAX Index is an indicator of the German benchmark DAX index's performance after the Xetra electronic-trading system closes at the Frankfurt Stock Exchange. The index had a base value of 1,000 when it was first traded on the 30th of December 1987. The data extends over the period from 1/1/2007 to 5/31/2011, which includes 1152 daily observations.

Performing an Augmented Dickey Fuller test on the raw stock market data, we find that they exhibit unit root. Each non-stationary series can be rendered stationary by calculating the first difference of the series. Hence, we considered the first difference of the logarithmic form of each series. A second ADF test was run to confirm stationarity of the variables. Therefore, our GARCH model will feature differences in the percentage change of stock prices in Athens, and Germany.

Further, we were able to generate the graphs of conditional variance which illustrates volatility clustering in Athens Stock Index. By running a simple mean return equation, we store the values of the residual and graph the squared residuals to obtain a plot of volatility. The simple mean return equation takes the form of:

$$\Delta \ln(s_t) = \alpha + \beta \Delta \ln(s_{t-1}) + \mu_t$$

Where $\Delta \ln(s_t)$ represents the percentage change in stock prices and $\mu_t$ is the error term. The graph obtained for Athens stock index accounts for high volatility clustering, while the graph of the L-DAX reveals indistinct volatility. Both series present a sudden spike in response to events in December 2009. Hence, since volatility clustering has been verified in Athens Stock Index, GARCH models would be most suitable.

The bench line equation for the benchline model is presented in the following format:

$$\Delta \ln(athens_t) = \alpha + \beta \Delta \ln(athens_{t-1}) + \mu_t$$

We also introduced the DAX variable in GARCH regressions:

$$\Delta \ln(athens_t) = \alpha + \beta_1 \Delta \ln(athens_{t-1}) + \beta_2 \Delta \ln(dax_t) + \mu_t$$

We also modeled the effect of news on the variance or volatility of the stock market in order to assess the impact of positive or negative shocks. Using the TGARCH model, the first dummy takes into the downgrade of Greece's long-term credit rating from A- to BBB+ on December 8, 2009, by Fitch ratings agency. Greece’s credit rating reaches the lowest level in the Eurozone. Heavy selling of Greek and stock and bonds takes place as fear mounts over the country deteriorating financials and economic outlook. The second dummy in TGARCH marks the 5-year austerity plan approved by the Greek Parliament, including spending cuts and tax increases. This event occurs on June 30th, 2011. It also prompted a high volatility in Athens stocks and bonds.

Using the EGARCH model, we introduced lagged effects using dummy variables specific to a whole month period. The first dummy indicates the first bailout package on March 5th, 2010. The second dummy embodies the second rescue package on July 21, 201. This date marked the acceptance of a support package by Greece to pursue debt stabilization. It also marks the date of a fourth round of austerity measures called "Μεσοπρόθεσμο" or the Midterm, passed on June 29th and enacted on July 21st, 2011. The second dummy variable in the EGARCH model will assess the impact of these measures and its usefulness. Simultaneously, European leaders announce the €109bn ($146bn) bail-out of Greece under which private bondholders will be called on to participate for the first time, contributing a target of a further €37bn.

GARCH models can be used for forecasting purposes. The ability of our model to predict shocks in terms of policy measures and key events will be tested in the next section of this study.

# 4. Empirical Findings

### 4.1.: OLS regressions:

By running the OLS-HAC procedure, we resolved any potential heteroskedasticity or serial correlation in the model. Hence, our estimations are more robust and consistent. The rationale behind these step-wise regressions is to individualize the impact of different factors on bond pricing. The model aims at understanding how spreads have responded to the nature of risk in each period.

#### 4.1.1. Pre-crisis period:

In the period from January 2000 to July 2007, the accession of Greece and other peripheral economies to the EMU was considered a strong move towards market consolidation. Since the creation of the Eurozone, factors such as exchange rate stability and market openness attracted abundant flows of capital into their economies. International trade enhanced prospects for growth and international competitiveness. However, once an asset bubble burst and debt problems emerged, stock prices became highly volatile and the economy regressed.

I investigate the disturbances caused by credit risk, liquidity risk, and country-specific factors on sovereign yield spreads in the pre-crisis period. Models will be based on 90 monthly observations.

In the baseline regression (Appendix, Tables A1), the coefficients on past spread values were positive and significant, causing a rise in spreads. Further, exchange rates held the right positive sign, on the premise that an appreciation leads to lower global competitiveness. Hence, the exchange rate premium was driving bond yields dynamics.

Global risk aversion maintained an important role in explaining spreads. The VIX was in all cases highly relevant in explaining spread movements over time. A rationale for this finding resides in the fact that multilateral trading generally increases the likelihood of external shocks.

Yield spreads were sensitive to liquidity risk, with the exception of Greece. When the liquidity of debt securities held by the government is higher (in terms of trading activity), bond spreads tend to shrink. The results of the model when macroeconomic variables such as the current account balance, government debt, and growth in industrial production are introduced are shown in the Appendix, Tables A3 and A4. The coefficients were insignificant which indicates that macroeconomic risk factors were not associated with bond pricing schemes. Hence, before the eruption of the Euro sovereign crisis, global risk aversion, real exchange risk premium and liquidity premium were the main determinants of government bond yields. Further, inflation in each economy was the main indicator of a price bubble caused by excessive borrowing and unsustainable fiscal spending. Lane has argued along these lines, by referring to common nominal interest rates on credit borrowing: "it also generated rapid growth in lending and local housing booms in the favored countries, with the sharp increase in demand contributing to inflationary pressures."[8] He also argues that the presence of common nominal interest rates across countries with different inflation rates would result in divergent real interest rates and asymmetrical responses to shocks.

4.1.2. Crisis period:

However, when the crisis became widespread in developed world markets, there was a change in the way international risk aversion affected government bond yields. Capital flight to liquid

[8] Philip Lane, *The effects of the European Monetary Union*, Journal of Economic Perspectives, 2006.

markets was also an important development in this period. German government bonds were sold in excess because peripheral economies faced a risk of default. Contagion from the Greek debt crisis was identified as a transmission channel inside the EMU.

OLS Regressions covered the period from July 2007 to January 2012, including 54 monthly observations. The results are presented in tables B1, B2, B3 and B4 of the Appendix.

Past spread values were highly significant for all member countries. In Greece, a rise in previous spreads led to higher current spreads, which is consistent with the spread growth observed. The real exchange rate was not significant in explaining spreads during the crisis episode; the coefficients were no longer significant or exhibited the opposite (negative) sign. In the crisis period, we assumed that markets started evaluating country-specific risk and default probabilities. Inflation levels were no longer a legitimate risk measure.

In the extended models, we included macro-economic variables and analyzed any development from the pre-crisis period.

First, the coefficient on the Greek spread variable had a significant effect on bond spreads, except for few countries not marked by contagion such as Finland, Ireland and Netherlands.

The liquidity proxy contributed to lowering spread values, except for Greece, Ireland and Portugal. As the outstanding amounts and transactions of euro-denominated debt securities increased in each economy by 1 million Euros, spreads increased by 100 basis points in Netherlands, and by 350 basis points in Belgium (according to table B2). The credit quality and liquidity variables were correlated. In other words, the probability of default depended on access to liquidity in credit markets.

The current account balance and growth in industrial production variables were relatively insignificant. The sign on the current account balance is significant and holds the right sign in the case of Belgium and Spain. Thus, a negative current account balance position implied that the country's external trading position fell and demand for capital inflows increased. On the other hand industrial production does not influence yields in general, while consolidated government debt exhibits the opposite sign for Finland and Italy. Controversially, it shows a reduction of spreads when the amount of loans increased in each country.

The crisis was fuelled by shifting expectations in terms of risk factors and uncertainty. Hence, idiosyncratic factors (such as liquidity risk and contagion risk) played an important role in equity markets during the crisis.

The last regression performs an event study featuring four dummy variables. These variables will explain movements in spreads on specific dates. I would like to explain the impact of key events in Greece on other markets, in order to identify sources of financial contagion. The first dummy represents the new shift in regime from a fully credible commitment to a Monetary Union to loss of that commitment. This shift occurs on the eve of the announcement of Greece's revised budget deficit by the Greek PM George Papandreou in November 2009. Greece was criticized for not introducing credible restructuring policies, and thus endangering the stability of the euro. The coefficient on the first dummy is significant for all euro area members, except Portugal. This news had a sudden and significant effect on most equity markets.

The second dummy variable also contributes to increasing yield spreads. The dummy highlights general disagreement between European leaders on the necessity of providing funds for Greece in January 2010. This triggers a region-wide loss of financial guarantees on fiscal liabilities in the future. Thus, bonds spreads increased on average, by 92 basis points in Greece, 27.7 basis points in Spain, and 12.34 basis points in France.

The third dummy variable had a significant impact on the "PIIGS" countries. A rescue loan of €110 billion was accorded to Greece by the ECB and IMF in May 2010. Moreover, leaders in the Union formed an emergency fund amounting to €750bn to support tight markets and thwart any contagion[9]. Hence, this aid benefited EMU members which were mostly exposed to the danger of a debt crisis. Ireland's spreads fell down by 58.43 basis points. However, spreads in Portugal and Spain have increased following this decision. Hence, the ECB failed to boost market confidence. Concerns over contagion from Greece and default risk gained in importance. Alternatively, informed investors usually experience a reduced effect compared to uninformed investors.

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The coefficient on the Greek bond spread was positive and significant at the 1% level for most countries, except the Netherlands and Spain. The risk of contagion has been affecting investors' decisions to trade in European markets. The interactive dummy measures the additional impact generated by Greek spreads on EMU member countries in June 2011. On that date, the government announced a new package of strict austerity austerity and the ECB encouraged the private sector to participate in the "soft restructuring" of Greek debt. In Austria, France and Italy, spreads have decreased significantly at the 1% level. According to the official statistics published

[9] EU ministers offer 750bn-euro plan to support currency; BBC, May 2010.

by Barclays Capital on the top 40 major holders of Greek government bonds and Greek debt on July 2011[10], France and Germany were the biggest external holders of Greek debt (which was also held in form of European Union loans, Eurosystem SMP or Greek banks[11]). Belgium and Italy followed in the ranking. Hence, France and Italy were placed in a politically dangerous position. Austerity measures were beneficial to debt holders assuming that Greece was committed to meet its debt obligations. The solution in the form of a "soft" restructuring entails that Greece extends the maturities of its debt while still promising to repay the full amount. This is the option favored by Germany. Rescheduling would reduce the net present value of debt. However, accounting rules are in favor of banks since they have different possible ways to calculate the net present value of the bonds, which reduces the hit they would bear from this deal.[12]

#### 4.1.3. Crisis contagion:

[10] *Top 40 holders of Greek Government Bonds and Greek Debt*, Barclays Capital, July 2011: http://www.leimonis.com/2011/07/main-holders-of-greek-government-bonds-and-greek-debt/

[11] Euro system SMP or Securities Market Program is the bond buying program conducted by the European Central Bank and its member banks, which held 13% of Greek debt in July 2011. European Union Loans accounted for 10% of Greek debt. Greek public sector funding reached 8% of Greek debt, funds from world's government reached 7%, while the IMF held 5% of Greek debt. Source: Barclays.

[12] *The first causalities*. The economist magazine, June 16th 2011.

In the last period of analysis, from January 2009 to January 2012, we tested the effects of lagged spread values, exchange rates, global volatility index (VIX), and Greek spreads on government bond spreads. The model includes 37 monthly observations and results are presented in table C1 of the Appendix. An exchange rate appreciation seems to have a significant effect on bond spreads in Austria, Finland, France, and the Netherlands. A loss of international competitiveness in these economies has put upward pressure on their bonds. Greek bonds continue to drive bond yield spreads upwards in most countries, except Ireland and Spain. The VIX measure of international volatility has regained importance in the second crisis episode for all regressions except Ireland, Portugal, Greece and Spain. International factors had a negligible impact on the periphery members as opposed to the pre-crisis period.

#### 4.1.4. Summary:

"Greece sneezed, and now most of Europe has a cold"; Quoted from the Washington Post in an article on Europe's financial contagion. Contagion is generally determined by economic links and financial links among countries, which under certain conditions initiates the "fast and the furious" spread of the crisis. In the presence of contagion, investors raise doubts about a country's ability to pay off interest on its debt. Hence, they demand higher interest rates in order to offset the risk of loaning money to countries with exposure to Greece. Thus, the rise in borrowing costs generated a debt cycle.

Bond trading is the transmission channel for Greek contagion was proved to spread and operate. Short-run dynamics have proved that bond spreads respond to extemporaneous or unpredicted factors, such as international risk and contagion risk.

In their paper, Kodres and Pritsker (2002) explain that financial contagion occurs on the basis of rational expectations. They argue that: “contagion occurs when “informed” investors respond to private information on a country-specific factor, by optimally rebalancing their portfolio’s exposure to the shared macroeconomic risk factors in other countries’ markets”[13]. When less informed investors are not expecting or pricing macroeconomic risk from Greece (“investors cannot identify the source of change in asset demand”), they respond by rebalancing their portfolio to suit the information on their own country. Hence, an unusual shock creates excessive co-movement in spreads across equity markets due to the information shock in the market. Hence, the first and second dummy were very significant in the last regression which means that both types of investors have become more aware and responsive to the sources of contagion, by assessing risk factors and changing their demand for assets accordingly.

[13] Graciela L. Kaminsky, Carmen Reinhart, Carlos A. Vegh. *The unholy trinity of financial contagion.* NBER, 2003.

### 4.2. GARCH models:

Before estimating ARCH models for a financial time series, we tested for the presence of unit roots in the residuals. We first differenced the log of the raw data and ran an Augmented Dickey-Fuller Test on the Athens and DAX series. The ADF test rejects the null hypothesis of unit root, hence both variables are stationary (Appendix, section D1). We also tested for the presence of ARCH effects in the benchmark GARCH model by using the ARCH-LM test. The test consists of running the squared residuals on their lagged values and considering the p-value on each lagged residual.

$$\hat{u}_t^2 = \beta_0 + \beta_1 \hat{u}_{t-1}^2 + \cdots + \beta_q \hat{u}_{t-q}^2 + w_t$$

If the F-statistic is close to 0, then the test would inform us of the presence of heteroskedasticity or ARCH effects. We generated the test with 5 lagged residuals. Further, we found that the first four lags were strongly significant at the 1% level, which evidently allowed us to reject the null hypothesis of homoscedasticity.

#### 4.2.1. TGARCH(1,1) model:

We examined the volatility of the Athens stock market index by using the TGARCH(1,1) model. In the baseline model presented in table D3, the ARCH and GARCH effects are highly positive and significant, which showed that the level of volatility was high during the crisis period beginning in April 2007. Leverage effects were also present, since the coefficient on the dummy variable associated with the squared residuals is positive and significant. Therefore, negative shocks ("bad news") have a stronger impact than positive shocks ("good news"), which implies asymmetric behavior in terms of stocks. Hence, this finding confirmed our previous assumption that “bad news” has a bigger effect on the intensity of volatility, than “good news”. However, the coefficient on the lagged percentage change in the value of the Athens stock index is insignificant.

In the second TGARCH model, the ARCH and GARCH coefficients were significant at the 1% level, while the leverage effect was also highly significant. The percentage change in the L-DAX index was added to the model.  Our results revealed the importance of the effect of the DAX performance on the Athens’ stock market. The estimates suggest that that percentage change in the L-DAX stock index had a positive significant effect on the percentage change in the Athens Stock Index. Therefore, any shock in Germany was immediately reflected in trading activities in Athens.

### 4.2.2. EGARCH(1,1) model:

We ran another model to assess the volatility of the Athens stock market index: the EGARCH model. This extended GARCH model was critical in testing for asymmetries in shocks, similar to previously estimated TGARCH model. However, the coefficient on the leverage effect is exponential rather than quadratic. In the baseline model, presented in table D5, the coefficient on C(5) was negative and significant at the 10% level, which indicates the presence of leverage effects. Moreover, the C(6) coefficient signaled the presence of persistence effects. Negative shocks generated a higher volatility than positive shocks. All other parameters in the variance equation were highly significant at the 1% level. A change in previous percentage changes in stock prices led to higher percentage change in current stock prices.

Furthermore, we were able to identify a leverage effect in the EGARCH model incorporating the DAX series. The negative significant coefficient C(5) implies that "bad news" had a stronger impact on the stock market than good news. The DAX had a strong positive effect on the Athens stock index, which corresponds with our previous results in the TGARCH model.

4.2.3. GARCH models with dummy variables:

We also modeled the effect of news on the variance or volatility of the stock market in order to assess the impact of positive or negative shocks. All our results are available to the reader in the Appendix, sections D7, D8, D9 and D10. Using the TGARCH model, we introduced a dummy variable D1 in the variance equation. Its value was fixed at 1 on December 8, 2009 and zero otherwise. The coefficient on the dummy variable was positive and significant, which implies that news of Greece's downgrade increased volatility in Greek stocks. The leverage effect in the TGARCH model was identified and the coefficient was significant.

Similarly, the second dummy was introduced on June 30th, 2011. The t-statistic of the dummy variable was positive and significant at the 1% level. This variable focused on the 5-year austerity plan approved by the Greek Parliament, including spending cuts and tax increases. This austerity package decreased volatility as observed in the negative and significant value of the coefficient on the dummy variable. However, this plan brought only short-term relief, since the government voted on new austerity cuts on February 13$^{th}$, 2012. We conclude that Greece's financial lifeline is dependent on growth and productivity at the moment. Hence, austerity measures have raised controversy and paralyzed the economy in the past. Moreover, the government debt crisis has only been delayed for future generations to bear the costs of redemption.

In the EGARCH model, we introduced lagged effects using dummy variables specific to a whole month period. The first dummy indicates the first bailout package; it takes on the value of 1 over the month following on March 5, 2010, and 0 otherwise. The second dummy embodies the second rescue package on July 21, 201. This date marked the acceptance of a support package by Greece to pursue debt stabilization. The package included three main components:

i) A financial commitment to the Eurozone by the IMF and ECB.

ii) A "voluntary" private sector contribution to the package in order to avert a credit event. The PSI (private sector involvement) comes in the form of a bond swap for new ones with extended maturities.

iii) An effort by Greece to implement fiscal and structural reforms.

It is assigned the value of 1 over the following thirty days, and 0 otherwise. As shown in table D9, the first dummy is not significant, neither is the leverage effect coefficient. Hence, the first bailout did not cause higher market volatility. However, the second bailout amplified the volatility in the percentage change of the Athens Stock Exchange General Index, since the coefficient C(7) is significant and positive at the 1% significance level. However, this news has not generated any leverage effect, since the coefficient C(5) is insignificant at any level.

The coefficient on the dummy variable indicated that Greek markets have exhibited higher volatility after the announcement of the second restructuring package. Hence, this news was perceived as not credible and did not reassure markets as intended. Uncertainty fuelled these stock market fluctuations. Therefore, Greek public opinion objected the austerity package and the higher debt burden and restricted social benefits it represents.

4.2.4. Forecasting volatility in the Athens Stock Exchange:

We selected the EGARCH benchmark model and the EGARCH model with the DAX to run forecasts for the Athens General Stock Exchange Index. The results of our dynamic and static forecasts are displayed in the Appendix parts F1 and F2, for the EGARCH benchmark model. The results for the differenced data are not strong enough to forecast stock prices in Athens. The Theil Inequality coefficient is 0.953 in the Static Forecast signaling that this model does not do a very good job of forecasting future stock prices and variances in Greece.

On the other hand, the static and dynamic forecasts are accessible in the Appendix, sections F3 and F4, for the EGARCH model with the DAX. The Theil Inequality coefficient improved to 0.84 in the Static Forecast. The Bias Proportion and the Variance proportion inform us about the accuracy of the forecast. The small bias observed (0.002682) indicates a good forecasting in the mean and variance equation. However, the Variance proportion is high, which indicates that the variance of the forecast is far from the actual. The covariance proportion is a measure of remaining unsystematic forecasting error. In our sample, it exhibits a low value of 0.36557. Hence, the second forecast model seems to perform better in general than the first model. Finally, we obtained the graph of the actual vs. the forecasted value in the percentage change of the Athens Stock Index. The actual data ends on May 31st, 2011, which allows us to observe the forecasted values more clearly at the end.

# 5. Conclusion and policy implications

This thesis has undertaken an empirical analysis of the European sovereign bond crisis. The regressions of monthly ten-year government bond yield spreads against Germany determined risk factors during the pre-crisis and crisis periods, respectively in January 2000-July 2007 and August 2007-September 2011. Arghyrou and Kontonikos (2010) [14] previously generated these regressions for ten countries in the Eurozone. They described the sovereign debt crisis as "a currency crisis in disguise"; in other words, the impact of the crisis is shifted to equity markets since exchange rates are not independently administered by each country.

After extending their econometric estimations, this study reached the conclusion that macroeconomic fundamentals have been relatively important in explaining fluctuations in spreads over time. Liquidity risk, real exchange rate risk, and international risk were determining factors in the pre-crisis period; whereas liquidity factors and contagion were significant during the crisis period. The real exchange rate premium was priced in sovereign bond yields: inflation was driven by profligate lending. Contagion has also fed into European financial markets, starting with the Greek government debt crisis.

Finally, this study estimated an EGARCH model which addressed asymmetric behavior in Athens' General Stock Index volatility. The estimates for the variance equation showed that there were persistence effects and volatility clustering in the presence of negative shocks. The estimates for the GARCH, TGARCH and EGARCH models supported Greek public opinion

[14] *The EMU sovereign debt crisis: Fundamentals, expectations and contagion*. Arghyrou and Kontonikos (2010), European Economy, Economic papers.

regarding the negative impact of austerity measures, viz., these measures have had the effect of generating more volatility and instability in the country's stock market index.

Our research has cast light on the regime switching mechanism in Greece. This regime shifting model served to represent the potential costs of staying or exiting the euro zone under different regimes or stages of bond pricing. We added a fourth regime which assumes realistically that excessive austerity is likely to increase the costs of default for Greece. Economic policies and conditions that might improve the economy in the long-term run the risk of disrupting growth in the short-term period which, in turn, leads to the likely failure of meeting debt obligations today. Greece is now in a predicament where each bailout and austerity package gives rise to expectations of default and potential exit from the euro zone.

The lack of an independent central bank has created an untenable situation for policymakers trying to manage insolvent economies. Exchange rate policy such as devaluation, the ability to set domestic interest rates, and the use of short-term capital controls are not available to the monetary authorities. Dominant players in the EMU such as France and Germany have imposed excessive austerity measures on countries such as Greece and Spain that failed to meet their debt obligations. Economic restructuring packages have stifled growth and developed a seemingly never-ending cycle of recessions and painful adjustments. In this connection, this thesis has tried to indirectly estimate how these measures have affected spreads and stock market volatility for selected euro zone countries such as Greece, Spain, and Portugal.

The article by Weisbrot and Montecino[15] (2012) argues that bailouts are just another form of debt transfer from the balance sheet of private banks to the public sector. Further, funds are based on strict conditionality that has added to worsening unemployment levels and economic growth figures--not to mention human and social costs.

Policymakers should aim at balancing economic austerity and growth strategies. Weisbrot and Montecino highlight an alternative solution to the current programs implemented in Greece and elsewhere based on Argentina's experience with default in 2001 on its $80bn debt. The economy initially fell into a steep recession but was, subsequently, able to exceed its pre-crisis growth trend starting in 2007 by first devaluing the peso and then allowing it to float; this experience is contrary to the common belief that a banking crisis coupled with a debt default will lead to a slow and lackluster recovery.

Unlike Greece, Argentina abandoned pro-cyclical policies of the "internal devaluation" variety. These policies of internal devaluation in the Greek case have consisted of lowering wage costs and increasing unemployment. However, the real exchange rate is still increasing and there are no signs of higher international competitiveness and a rising demand for the country's exports; clearly, internal devaluation has yet to occur, if ever. The possibility of defaulting on its European debt valued at $500bn is a risky alternative, but in the wake of the Argentine experience and the alternative of endless years of anemic growth and painful austerity, it should not be entirely dismissed by Greek politicians.

It is unrealistic to expect Greece to stay in the EMU if it defaults on its debt. When Greece defaults, creditors will face losses on their Greek debt holdings_ a necessary step to put Greek

[15]Weisbrot&Montecino.*More Pain, No gain for Greece: Is the Euro worth the costs of pro-cyclical fiscal policy and internal devaluation?*CEPR, 2012.

debt on sustainable footing_ but will unlikely keep supporting the country until it starts running a budget surplus.[16] Upon exit from the EMU, Greece will attempt to devalue the drachma to improve exports competitiveness.

However, policymakers, bankers, and the citizens of the euro zone should be duly concerned about the potential aftermath and contagion arising from a Greek default and should plan an orderly default and restructuring of Greek debt. Europe should pledge to erect a financial firewall and save the banks. A financial firewall implies averting any domino effects or contagion. Any new bonds issued by Portugal, Ireland, Italy or Spain should be guaranteed by the ECB, which creates another burden on Germany. The ECB should implement short-term capital controls in several countries to avoid bank runs. Saving the banks will also require recapitalizing bank holdings of Greek and other sovereign debt. According a Bloomberg article, "once Greece defaults, its bonds and those of a half-dozen euro-area countries suddenly will be worth a fraction of the value at which they are carried on banks' books. The amount of bank capital needed -- estimates range from the IMF's $410 billion to Merrill Lynch's $550 billion -- must be based on realistic stress tests that take sovereign defaults into account."[17]

On the other hand, the governments should secure private capital which could be substituted for banks' equity, similar to the Troubled Asset Relief Program in the US economy.

The European-TARP could be funded by the EFSF (the European Financial Stability Facility). The facility could build a leverage capacity of 2 or 3 trillion euro ($2.6168 or $3.9252 trillion). This is conditional on European taxpayers' guaranteed participation. But Germany, with

[16] *Nothing to fear but the lack of fear itself*;Economist, February 2012:http://www.economist.com/node/21548533.
[17] *A roadmap to a pre-packaged orderly default*; Bloomberg, September 2011: http://www.bloomberg.com/news/2011-09-28/road-map-to-prepackaged-orderly-default-that-keeps-greece-in-euro-view.html

relatively few cards to play, has to fulfill the pledge: if Germany leaves the Eurozone, its exchange rate could appreciate, since its highly accomplished manufacturing and industrial sectors demonstrate larger capacity and developed technology; when compared with European counterparts. Hence, export revenues could drop and the economy could contract at a high rate. However, Germany's advanced economy might attract an inflow of foreign capital investment and restore its world standing in exports. Thus, the decision of Germany regarding the Euro is hardly predictable or pre-determined. Also, some policymakers and economists appear in favor of revising the Maastricht and Lisbon treaties: that is, enforcing a fiscal union and monitoring bond issuance and lending facilities.

A default has been commonly accepted as an inevitable end to Europe's dilemma. The fallout from a default will have world-wide repercussions. However, it should be guided and controlled. Some expected problems to be faced are: Will Greece's exports, growth, foreign direct investment soar or plummet upon default? Will it be able to find creditors for long-term investment?

Spain and Italy are also asking for a financial lifeline, as they grapple with economic austerity and lackluster growth. The connection between sovereign risk and bank risk has risen over the crisis. Recapitalizations of Europe's banks will prove to be costly. This study prescribes careful management of the fiscal budget and supervision of the banking sector. In addition, this study focused mainly on instantaneous shocks and lagged effects of the Greek Stock Market. Further research is needed in order to reach conclusive results on the long-term impact of ECB policies on Greek Stock Market volatility. Indices from peripheral countries could improve the precision of the volatility forecast. Without this added information it is not possible to prescribe viable policies and determine optimal asset allocation strategies for equity markets in the Euro Area.

# Appendix

A1. Pre-crisis time series coefficient estimates, OLS-HAC, baseline:

| | AUS | BEL | FIN | FRA | GRE | IRE | ITA | NEL | POR | SPA |
|---|---|---|---|---|---|---|---|---|---|---|
| $spread_{t-1}$ | 0.48** | 0.54*** | 0.36** | 0.50*** | 0.56*** | -0.39*** | 0.47*** | 0.49*** | 0.45*** | 0.57*** |
| $exch_t$ | 339.26** | 169.65** | 303.95*** | 251.16*** | 18.38 | 52.19 | 167.27*** | 148.15*** | 170.75 | 76.03* |
| $vix_t$ | 18.77*** | 22.42*** | 17.36*** | 21.38*** | 12.83*** | 18.49*** | 17.80*** | 19.35*** | 19.19*** | 18.41*** |
| | | | | | | | | | | |
| $Adj - R^2$ | 0.45 | 0.43 | 0.52 | 0.51 | 0.41 | 0.22 | 0.41 | 0.49 | 0.29 | 0.40 |

A2. Pre-crisis time series coefficient estimates, OLS-HAC, controlling for liquidity:

| | AUS | BEL | FIN | FRA | GRE | IRE | ITA | NEL | POR | SPA |
|---|---|---|---|---|---|---|---|---|---|---|
| $spread_{t-1}$ | 0.25 | 0.36** | 0.35** | 0.20** | 0.39** | 0.24** | 0.31*** | 0.19 | 0.27** | 0.30* |
| $exch_t$ | 416.72*** | 108.37** | 236.06** | 138.60*** | 223.83** | 33.05 | 52.67 | -23.87 | 174.66 | 112.17** |
| $vix_t$ | -0.92 | 3.89 | 17.33*** | -0.80 | -73.21** | 0.69 | 2.27 | -3.36 | 9.02** | -0.25 |
| $liq_t$ | -0.0002*** | -0.0002*** | -0.0004 | -0.00037*** | -0.21 | -0.0005 | -0.00005*** | -0.00009*** | -0.0005*** | -0.00009*** |
| | | | | | | | | | | |
| $Adj - R^2$ | 0.53 | 0.48 | 0.52 | 0.59 | 0.45 | 0.27 | 0.45 | 0.58 | 0.36 | 0.48 |

A3. Pre-crisis time series coefficient estimates, OLS-HAC, controlling for liquidity, current account balance and industrial growth:

| | AUS | BEL | FIN | FRA | GRE | IRE | ITA | NEL | POR | SPA |
|---|---|---|---|---|---|---|---|---|---|---|
| $spread_{t-1}$ | 0.24 | 0.35** | 0.35** | 0.17 | 0.44*** | 0.21* | 0.27** | 0.2 | 0.22* | 0.31* |
| $exch_t$ | 404.28*** | 116.4** | 246.86** | 191.96*** | 69.23* | 52.65 | 117.37 | -74.01 | 107.70 | 119.32** |
| $vix_t$ | -1.20 | 2.28 | 14.06*** | -3.26 | 11.24** | -6.58 | 0.058 | 2.48 | -0.64 | -0.27 |
| $liq_t$ | -0.0002*** | -0.0002*** | -0.00036 | -0.000035*** | 0.00009 | -0.00016 | -0.00005*** | -0.0001*** | -0.0005*** | -0.00008 |
| $cab_t$ | 0.40 | 1.38 | 0.67 | 3.2 | 2.86** | 5.98** | 3.41 | 1.65 | 2.42*** | 0.69 |
| $gind_t$ | -0.66 | 13.10 | -89.87 | 30.04 | 2.15 | 26.3 | 0.78 | 42.93** | -22.69 | 25.00 |
| | | | | | | | | | | |
| $Adj-R^2$ | 0.53 | 0.48 | 0.52 | 0.59 | 0.45 | 0.34 | 0.44 | 0.59 | 0.36 | 0.47 |

A4. Pre-crisis time series coefficient estimates, OLS-HAC, controlling for government debt:

| | AUS | BEL | FIN | FRA | GRE | IRE | ITA | NEL | POR | SPA |
|---|---|---|---|---|---|---|---|---|---|---|
| $spread_{t-1}$ | 0.44** | 0.53*** | 0.36** | 0.43** | 0.42*** | 0.38*** | 0.42** | 0.49*** | 0.26*** | 0.57*** |
| $exch_t$ | 398.26*** | 179.09** | 290.34*** | 377.81** | 128.64*** | 89.05*** | 223.52*** | 163.1*** | 359.86*** | 87.32 |
| $vix_t$ | 13.57*** | 22.19*** | 18.31*** | 13.54** | 0.27 | 15.5* | 11.88** | 16.33*** | 5.54 | 18.36*** |
| $debt_t$ | -47.83 | -45.36 | 14.15 | -50.40 | -68.52*** | -77.37 | -66.04 | -30.63 | -70.36*** | -29.82 |
| | | | | | | | | | | |
| $Adj-R^2$ | 0.47 | 0.43 | 0.51 | 0.54 | 0.45 | 0.20 | 0.41 | 0.49 | 0.35 | 0.39 |

B1. Crisis time series coefficient estimates, OLS-HAC, baseline:

| | AUS | BEL | FIN | FRA | GRE | IRE | ITA | NEL | POR | SPA |
|---|---|---|---|---|---|---|---|---|---|---|
| $spread_{t-1}$ | 0.55*** | 0.41*** | 0.36*** | 0.27** | 1.12*** | 0.90*** | 0.20* | 0.41*** | 0.88*** | 0.79*** |
| $exch_t$ | 45.2 | 153.36 | 125.78* | 63.3 | 718.6 | -498** | 47.85 | -17.2 | -300.65 | -555.84* |
| $vix_t$ | 31.85*** | 35.35*** | 32.09*** | 28.07*** | 78.48 | -26.29 | 61.06*** | 26.74*** | -16.6 | 10.02 |
| $GRspread_t$ | 0.02*** | 0.05*** | 0.008** | 0.027*** | | -0.004 | 0.1*** | 0.005 | 0.07** | 0.022 |
| | | | | | | | | | | |
| $Adj-R^2$ | 0.82 | 0.94 | 0.62 | 0.82 | 0.98 | 0.94 | 0.97 | 0.53 | 0.98 | 0.95 |

B2. Crisis time series coefficient estimates, OLS-HAC, controlling for liquidity:

| | AUS | BEL | FIN | FRA | GRE | IRE | ITA | NEL | POR | SPA |
|---|---|---|---|---|---|---|---|---|---|---|
| $spread_{t-1}$ | 0.19* | 0.12 | 0.02 | -0.07 | 1.18*** | 0.88*** | 0.20* | 0.06 | 0.86*** | 0.57*** |
| $exch_t$ | 321.71** | 140.4 | 47.17 | 123.02 | 616.7 | -571.12* | 205.65 | 66.01 | 14.10 | -601.26** |
| $vix_t$ | 26.07*** | 21.19*** | 30.98*** | 17.12** | 90.13 | -52.9 | 53.68*** | 22.56*** | -31.85 | -6.95 |
| $liq_t$ | -0.0004*** | -0.00035*** | -0.00029*** | -0.000048*** | 0.0005 | -0.0003 | -0.00008*** | -0.0001*** | -0.0005 | -0.00012*** |
| $GRspread_t$ | 0.02*** | 0.067*** | 0.002 | 0.03*** | | 0.024 | 0.12*** | 0.007** | 0.08*** | 0.045** |
| | | | | | | | | | | |
| $Adj-R^2$ | 0.84 | 0.95 | 0.71 | 0.85 | 0.98 | 0.94 | 0.97 | 0.64 | | 0.96 |

B4. Crisis time series coefficient estimates, OLS-HAC, controlling for liquidity, current account balance, growth in industrial production and government debt:

| | AUS | BEL | FIN | FRA | GRE | IRE | ITA | NEL | POR | SPA |
|---|---|---|---|---|---|---|---|---|---|---|
| $spread_{t-1}$ | 0.18** | -0.02 | -0.03 | -0.007 | 0.86*** | 0.75*** | 0.27** | 0.058 | 0.64*** | 0.36*** |
| $exch_t$ | 315.63** | 257.28 | -31.21 | 46.63 | -2228.3** | -174.28 | -17.45 | 146.53 | 1413** | -362.17** |
| $vix_t$ | 22.91** | 29.09** | 24.05** | 18.12 | -61.5 | -51.16 | 20.02 | 19.73* | 5.96 | -12.03 |
| $GRspread_t$ | 0.01** | 20.48 | 0.015** | 0.03*** | | 0.10 | 0.14*** | 0.02** | 0.22*** | 0.11*** |
| $liq_t$ | -0.0043*** | -0.00025* | -0.00038*** | -0.00005*** | -0.001* | -0.0002 | -0.0002*** | -0.00008** | 0.0003 | -0.0002*** |
| $cab_t$ | 3.69 | -2.27*** | --1.14 | 0.43 | 5.25 | -1.67 | 6.02 | -2.89 | -6.68 | -5.23* |
| $gind_t$ | -158.27 | 70.26 | 6.29 | 291** | -282.46 | -237.14 | 138.2 | 58.34 | -127.75 | 181.36 |
| $debt_t$ | 54.71 | 0.09*** | -75.86*** | -32.2 | 40.71 | 49.74 | -524.47** | -6.61 | 178.89 | -8.67 |
| | | | | | | | | | | |
| $Adj-R^2$ | 0.81 | 0.93 | 0.77 | 0.75 | 0.96 | 0.94 | 0.96 | 0.68 | 0.98 | 0.97 |

B4. Crisis time series coefficient estimates, OLS-HAC, events study:

| | AUS | BEL | FIN | FRA | GRE | IRE | ITA | NEL | POR | SPA |
|---|---|---|---|---|---|---|---|---|---|---|
| $spread_{t-1}$ | 0.55*** | 0.42*** | 0.38*** | 0.27** | 1.20*** | 0.87*** | 0.31*** | 0.41*** | 0.86*** | 0.92*** |
| $exch_t$ | 6.48 | 110 | 90.27 | 27.33 | 561.6 | -635.64** | 13.29 | -39.10 | -184.07 | -474.18 |
| $vix_t$ | 32.67*** | 35.74*** | 32.69*** | 28.98*** | 93.5 | -14.20 | 62.86*** | 27.56*** | -14.06 | 10.41 |
| $GRspread_t$ | 0.02*** | 0.047*** | 0.008** | 0.027*** | | -0.005 | 0.10*** | 0.004 | 0.078*** | 0.020 |
| $GRspread_t * D4$ | -0.006*** | -0.004 | 0.04* | -0.005*** | | 0.071*** | -0.02*** | 0.002 | 0.065*** | 0.016** |
| $D1$ | 14.80*** | 11.63** | 14.98** | 22.38*** | 77.05* | 30.26*** | 22.00*** | 20.90*** | 2.37 | 24.51*** |
| $D2$ | 26.43*** | 14.87*** | 11.44** | 12.34*** | 92.50*** | -20.04 | 15.4*** | 13.20*** | 11.82* | 27.7*** |
| $D3$ | 1.37 | -6.55 | 4.49 | 1.32 | 29.17 | -58.43*** | -1.9 | 4.022 | 37.83*** | 38.58*** |
| $D4$ | | | | | -94.58*** | | | | | |
| $liq_t$ | | | | | 0.0006 | | | | | |
| | | | | | | | | | | |
| $Adj-R^2$ | 0.84 | 0.93 | 0.60 | 0.83 | 0.98 | 0.94 | 0.97 | 0.51 | 0.98 | 0.95 |

C1. Contagion period, time series coefficient estimates, OLS-HAC, baseline:

| | AUS | BEL | FIN | FRA | GRE | IRE | ITA | NEL | POR | SPA |
|---|---|---|---|---|---|---|---|---|---|---|
| $spread_{t-1}$ | 0.42** | 0.17 | 0.0004 | 0.007 | 1.14*** | 0.88*** | 0.09 | 0.034 | 0.89*** | 0.69*** |
| $exch_t$ | 239.34* | 180.4 | 172.33** | 251.15** | 3501.2 | -262.55 | 130.89 | 175.55* | 4.79 | 6.85 |
| $vix_t$ | 30.6** | 44*** | 42.65*** | 28.66*** | 123.32 | -82.14 | 81.04*** | 31.76** | -45.73 | 0.026 |
| $GRspread_t$ | 0.02*** | 0.06*** | 0.008** | 0.035*** | | 0.006 | 0.13*** | 0.007** | 0.07** | |
| | | | | | | | | | | |
| $Adj-R^2$ | 0.75 | 0.93 | 0.49 | 0.84 | 0.97 | 0.90 | 0.97 | 0.36 | 0.98 | 0.93 |

### D1. Unit Roots: Augmented-Dickey Fuller Test.

Null Hypothesis: D_ATHENS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=23)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -38.41162 | 0.0000 |
| Test critical values: | 1% level | -3.434984 | |
| | 5% level | -2.863474 | |
| | 10% level | -2.567849 | |

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D_DAX has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on SIC, maxlag=22)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -19.97164 | 0.0000 |
| Test critical values: | 1% level | -3.435851 | |
| | 5% level | -2.863857 | |
| | 10% level | -2.568054 | |

*MacKinnon (1996) one-sided p-values.

## D2. Test for autoregressive conditional heteroskedasticity (ARCH-LM test).

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 98.90298 | Prob. F(5,1339) | 0.0000 |
| Obs*R-squared | 362.7582 | Prob. Chi-Square(5) | 0.0000 |

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 04/12/12 Time: 10:46
Sample (adjusted): 1/11/2007 3/07/2012
Included observations: 1345 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000312 | 6.88E-05 | 4.532928 | 0.0000 |
| RESID^2(-1) | 0.606285 | 0.027303 | 22.20588 | 0.0000 |
| RESID^2(-2) | -0.355589 | 0.031814 | -11.17708 | 0.0000 |
| RESID^2(-3) | 0.218277 | 0.032726 | 6.669807 | 0.0000 |
| RESID^2(-4) | -0.102538 | 0.031814 | -3.223012 | 0.0013 |
| RESID^2(-5) | 0.043435 | 0.027303 | 1.590867 | 0.1119 |

| | | | |
|---|---|---|---|
| R-squared | 0.269709 | Mean dependent var | 0.000529 |
| Adjusted R-squared | 0.266982 | S.D. dependent var | 0.002805 |
| S.E. of regression | 0.002402 | Akaike info criterion | -9.220976 |
| Sum squared resid | 0.007722 | Schwarz criterion | -9.197760 |
| Log likelihood | 6207.106 | Hannan-Quinn criter. | -9.212280 |
| F-statistic | 98.90298 | Durbin-Watson stat | 1.998138 |
| Prob(F-statistic) | 0.000000 | | |

### D3. T-GARCH baseline model.

Dependent Variable: D_ATHENS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/05/12 Time: 12:32
Sample (adjusted): 1/04/2007 3/07/2012
Included observations: 1350 after adjustments
Convergence achieved after 93 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1)

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -4.49E-05 | 0.000464 | -0.096728 | 0.9229 |
| D_ATHENS(-1) | 0.030767 | 0.028333 | 1.085924 | 0.2775 |
| | | Variance Equation | | |
| C | 1.42E-06 | 8.39E-07 | 1.687100 | 0.0916 |
| RESID(-1)^2 | 0.087228 | 0.012854 | 6.785931 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | 0.029253 | 0.013793 | 2.120802 | 0.0339 |
| GARCH(-1) | 0.912524 | 0.007423 | 122.9390 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | -0.006661 | Mean dependent var | -0.001331 |
| Adjusted R-squared | -0.007408 | S.D. dependent var | 0.022999 |
| S.E. of regression | 0.023084 | Akaike info criterion | -4.986046 |
| Sum squared resid | 0.718286 | Schwarz criterion | -4.962900 |
| Log likelihood | 3371.581 | Hannan-Quinn criter. | -4.977378 |
| Durbin-Watson stat | 2.141046 | | |

**D4: T-GARCH model including the DAX index.**

Dependent Variable: D_ATHENS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/05/12 Time: 12:31
Sample (adjusted): 1/04/2007 5/31/2011
Included observations: 1149 after adjustments
Convergence achieved after 58 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*RESID(-1)^2*(RESID(-1)<0) + C(7)*GARCH(-1)

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.000140 | 0.000447 | -0.313072 | 0.7542 |
| D_ATHENS(-1) | 0.035775 | 0.031958 | 1.119454 | 0.2629 |
| D_DAX | 0.051272 | 0.002628 | 19.50769 | 0.0000 |
| | | Variance Equation | | |
| C | 3.47E-06 | 1.32E-06 | 2.623351 | 0.0087 |
| RESID(-1)^2 | 0.082267 | 0.014166 | 5.807166 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | 0.093241 | 0.025606 | 3.641415 | 0.0003 |
| GARCH(-1) | 0.875984 | 0.012391 | 70.69355 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | -0.021906 | Mean dependent var | -0.001073 |
| Adjusted R-squared | -0.023690 | S.D. dependent var | 0.022411 |
| S.E. of regression | 0.022675 | Akaike info criterion | -5.199498 |
| Sum squared resid | 0.589222 | Schwarz criterion | -5.168752 |
| Log likelihood | 2994.112 | Hannan-Quinn criter. | -5.187892 |
| Durbin-Watson stat | 2.222207 | | |

### D5: EGARCH baseline model:

Dependent Variable: D_ATHENS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/04/12 Time: 21:30
Sample (adjusted): 1/04/2007 3/07/2012
Included observations: 1350 after adjustments
Convergence achieved after 100 iterations
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(5)
*RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1))

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000636 | 0.000467 | 1.363417 | 0.1728 |
| D_ATHENS(-1) | 0.047784 | 0.028101 | 1.700460 | 0.0890 |
| | | Variance Equation | | |
| C(3) | -0.168350 | 0.025388 | -6.631022 | 0.0000 |
| C(4) | 0.177228 | 0.011188 | 15.84148 | 0.0000 |
| C(5) | -0.011573 | 0.006759 | -1.712253 | 0.0869 |
| C(6) | 0.994532 | 0.003342 | 297.5512 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | -0.013462 | Mean dependent var | -0.001331 |
| Adjusted R-squared | -0.014213 | S.D. dependent var | 0.022999 |
| S.E. of regression | 0.023161 | Akaike info criterion | -4.962199 |
| Sum squared resid | 0.723138 | Schwarz criterion | -4.939053 |
| Log likelihood | 3355.484 | Hannan-Quinn criter. | -4.953531 |
| Durbin-Watson stat | 2.163864 | | |

## D6. EGARCH model including the DAX:

Dependent Variable: D_ATHENS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/04/12 Time: 21:31
Sample (adjusted): 1/04/2007 5/31/2011
Included observations: 1149 after adjustments
Convergence achieved after 137 iterations
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(4) + C(5)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(6)
*RESID(-1)/@SQRT(GARCH(-1)) + C(7)*LOG(GARCH(-1))

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000134 | 0.000437 | 0.306157 | 0.7595 |
| D_ATHENS(-1) | 0.036602 | 0.030498 | 1.200144 | 0.2301 |
| D_DAX | 0.044974 | 0.002597 | 17.31428 | 0.0000 |
| | | Variance Equation | | |
| C(4) | -0.342635 | 0.055702 | -6.151235 | 0.0000 |
| C(5) | 0.270550 | 0.021087 | 12.83020 | 0.0000 |
| C(6) | -0.051631 | 0.015901 | -3.247045 | 0.0012 |
| C(7) | 0.982556 | 0.005982 | 164.2552 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | -0.015890 | Mean dependent var | -0.001073 |
| Adjusted R-squared | -0.017663 | S.D. dependent var | 0.022411 |
| S.E. of regression | 0.022608 | Akaike info criterion | -5.185301 |
| Sum squared resid | 0.585753 | Schwarz criterion | -5.154555 |
| Log likelihood | 2985.955 | Hannan-Quinn criter. | -5.173694 |
| Durbin-Watson stat | 2.208753 | | |

## GARCH models with dummies:

**D7.TGARCH model with dummy.**

First Dummy Variable: December 8, 2009.

Dependent Variable: D_ATHENS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/05/12 Time: 15:34
Sample (adjusted): 1/04/2007 3/07/2012
Included observations: 1350 after adjustments
Convergence achieved after 96 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*D1

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.000200 | 0.000439 | -0.456039 | 0.6484 |
| D_ATHENS(-1) | 0.015061 | 0.026234 | 0.574098 | 0.5659 |
| | | Variance Equation | | |
| C | 4.72E-06 | 1.42E-06 | 3.323408 | 0.0009 |
| RESID(-1)^2 | 0.064417 | 0.011428 | 5.636977 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | 0.084651 | 0.018450 | 4.587987 | 0.0000 |
| GARCH(-1) | 0.887291 | 0.010872 | 81.61567 | 0.0000 |
| D1 | 0.035882 | 0.009849 | 3.643328 | 0.0003 |

| | | | |
|---|---|---|---|
| R-squared | -0.003922 | Mean dependent var | -0.001331 |
| Adjusted R-squared | -0.004666 | S.D. dependent var | 0.022999 |
| S.E. of regression | 0.023052 | Akaike info criterion | -5.054583 |
| Sum squared resid | 0.716332 | Schwarz criterion | -5.027580 |
| Log likelihood | 3418.844 | Hannan-Quinn criter. | -5.044470 |
| Durbin-Watson stat | 2.113311 | | |

**D8. TGARCH model with dummy:**

Second Dummy Variable: June 30th , 2011

Dependent Variable: D_ATHENS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/12/12 Time: 12:09
Sample (adjusted): 1/04/2007 3/07/2012
Included observations: 1350 after adjustments
Convergence achieved after 4 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*RESID(-1)^2*(RESID(-1)<0) +
C(6)*GARCH(-1) + C(7)*D3

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.001139 | 0.001532 | -0.743358 | 0.4573 |
| D_ATHENS(-1) | -0.002431 | 0.060724 | -0.040028 | 0.9681 |
| | | Variance Equation | | |
| C | 0.000457 | 0.000217 | 2.105068 | 0.0353 |
| RESID(-1)^2 | 0.131621 | 0.038716 | 3.399664 | 0.0007 |
| RESID(-1)^2*(RESID(-1)<0) | -0.039150 | 0.083524 | -0.468725 | 0.6393 |
| GARCH(-1) | 0.547186 | 0.207840 | 2.632729 | 0.0085 |
| D3 | -0.001079 | 5.38E-05 | -20.04916 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.000142 | Mean dependent var | -0.001331 |
| Adjusted R-squared | -0.000600 | S.D. dependent var | 0.022999 |
| S.E. of regression | 0.023005 | Akaike info criterion | -4.461721 |
| Sum squared resid | 0.713432 | Schwarz criterion | -4.434717 |
| Log likelihood | 3018.662 | Hannan-Quinn criter. | -4.451608 |
| Durbin-Watson stat | 2.085567 | | |

**D9. EGARCH model: the first Greek bailout.**

Third Dummy variable: the month following March 5th, 2010.

Dependent Variable: D_ATHENS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/07/12 Time: 21:19
Sample (adjusted): 1/04/2007 3/07/2012
Included observations: 1350 after adjustments
Convergence achieved after 113 iterations
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(5)
*RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1)) + C(7)*D6

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000613 | 0.000469 | 1.307568 | 0.1910 |
| D_ATHENS(-1) | 0.047790 | 0.027928 | 1.711178 | 0.0870 |
| Variance Equation | | | | |
| C(3) | -0.164050 | 0.025032 | -6.553711 | 0.0000 |
| C(4) | 0.177307 | 0.011145 | 15.90932 | 0.0000 |
| C(5) | -0.012342 | 0.006804 | -1.813924 | 0.0697 |
| C(6) | 0.995040 | 0.003310 | 300.6253 | 0.0000 |
| C(7) | -0.034640 | 0.041769 | -0.829319 | 0.4069 |

| | | | |
|---|---|---|---|
| R-squared | -0.013293 | Mean dependent var | -0.001331 |
| Adjusted R-squared | -0.014045 | S.D. dependent var | 0.022999 |
| S.E. of regression | 0.023160 | Akaike info criterion | -4.961461 |
| Sum squared resid | 0.723018 | Schwarz criterion | -4.934457 |
| Log likelihood | 3355.986 | Hannan-Quinn criter. | -4.951348 |
| Durbin-Watson stat | 2.164237 | | |

*C(7) represents the estimate of the coefficient on the dummy variable.

**D10. EGARCH model: the second Greek rescue package.**

Fourth Dummy variable: the month following July 21st, 2011.

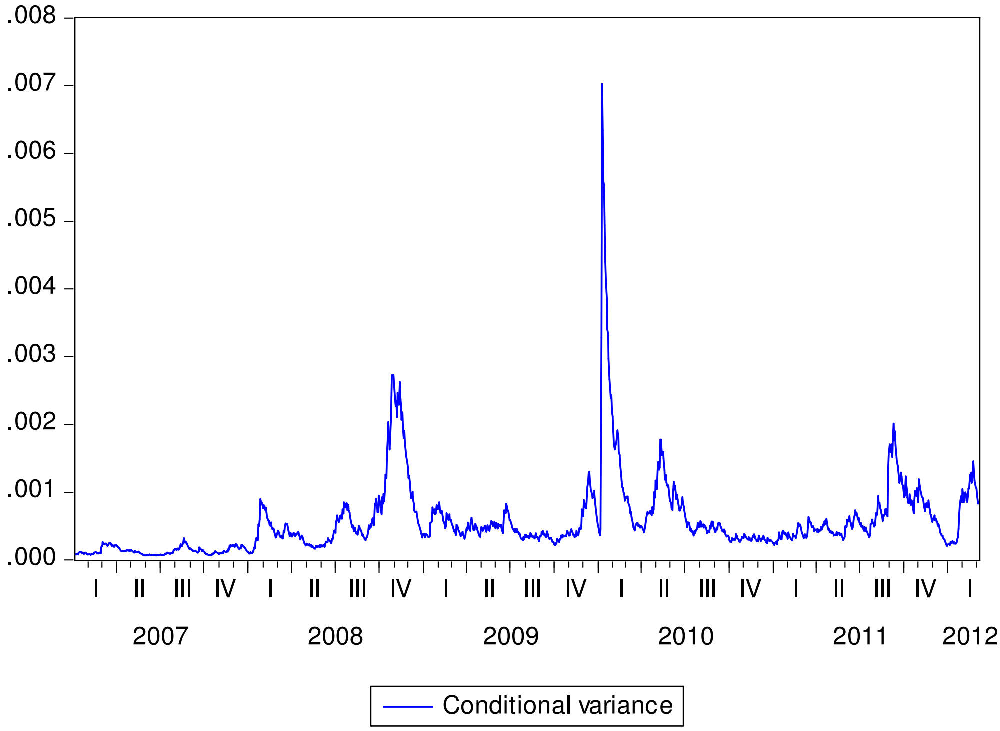
Dependent Variable: D_ATHENS
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 04/07/12 Time: 21:17
Sample (adjusted): 1/04/2007 3/07/2012
Included observations: 1350 after adjustments
Convergence achieved after 92 iterations
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(5)
*RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1)) + C(7)*D5

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.000637 | 0.000461 | 1.381393 | 0.1672 |
| D_ATHENS(-1) | 0.061038 | 0.030000 | 2.034604 | 0.0419 |
| | | Variance Equation | | |
| C(3) | -0.182228 | 0.027650 | -6.590544 | 0.0000 |
| C(4) | 0.175845 | 0.010957 | 16.04828 | 0.0000 |
| C(5) | -0.002388 | 0.007658 | -0.311807 | 0.7552 |
| C(6) | 0.992756 | 0.003643 | 272.5148 | 0.0000 |
| C(7) | 0.082050 | 0.016151 | 5.080211 | 0.0000 |

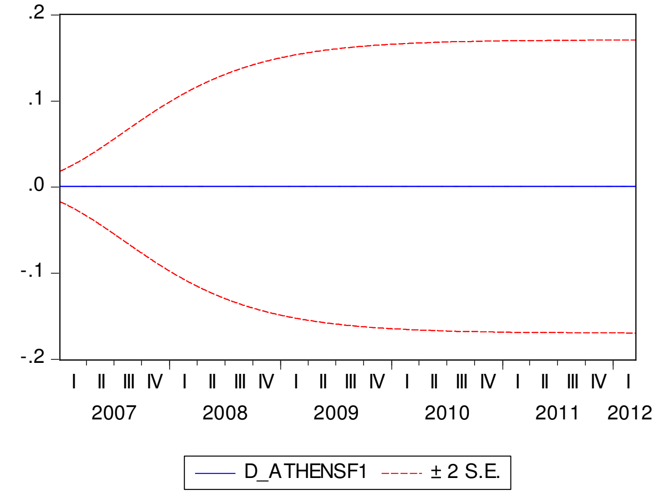
| | | | |
|---|---|---|---|
| R-squared | -0.015982 | Mean dependent var | -0.001331 |
| Adjusted R-squared | -0.016735 | S.D. dependent var | 0.022999 |
| S.E. of regression | 0.023190 | Akaike info criterion | -4.966124 |
| Sum squared resid | 0.724937 | Schwarz criterion | -4.939120 |
| Log likelihood | 3359.134 | Hannan-Quinn criter. | -4.956011 |
| Durbin-Watson stat | 2.188211 | | |

*C(7) represents the estimate of the coefficient on the dummy variable.

**E1. Conditional Variance in the EGARCH baseline model.**

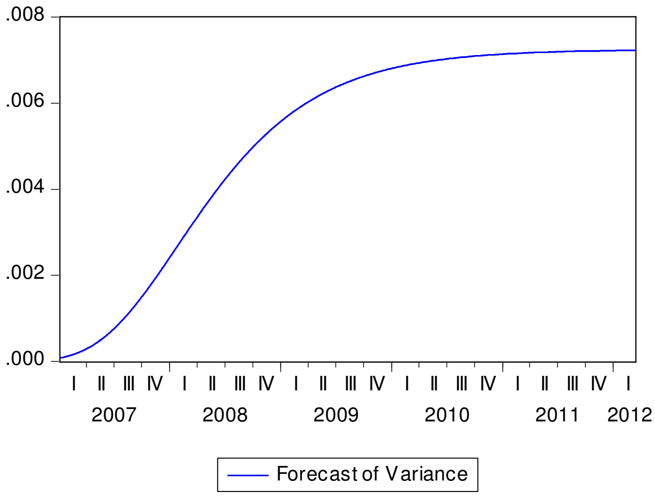


**F1. Dynamic forecast from the EGARCH baseline model.**

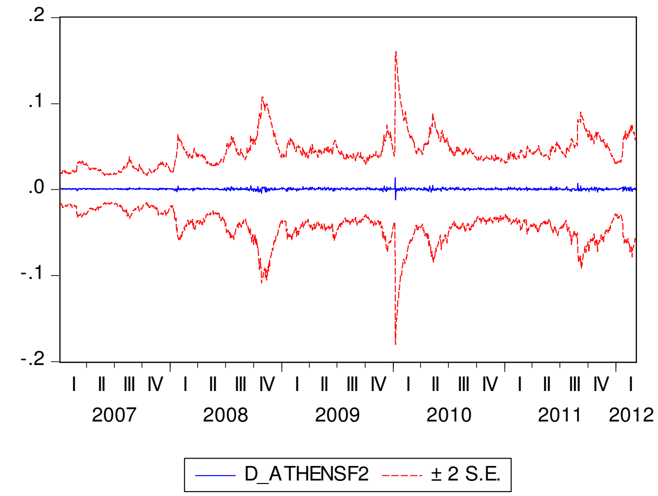



Forecast: D_ATHENSF1
Actual: D_ATHENS
Forecast sample: 1/01/2007 3/14/2012
Adjusted sample: 1/04/2007 3/14/2012
Included observations: 1350

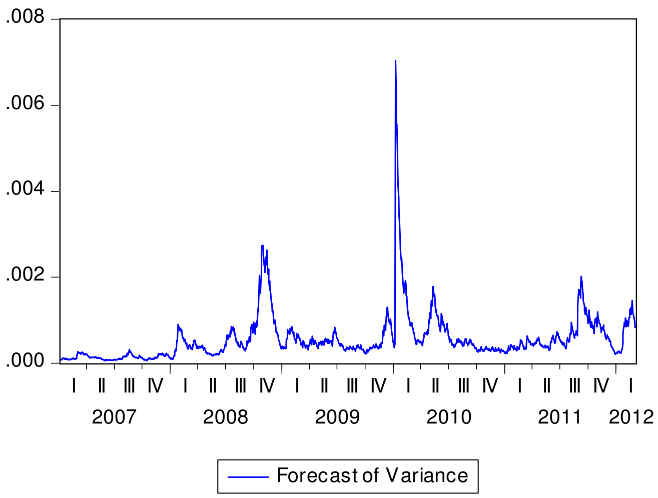
| | |
|---|---|
| Root Mean Squared Error | 0.023077 |
| Mean Absolute Error | 0.015247 |
| Mean Abs. Percent Error | 111.9066 |
| Theil Inequality Coefficient | 0.973824 |
| Bias Proportion | 0.007504 |
| Variance Proportion | 0.991950 |
| Covariance Proportion | 0.000546 |



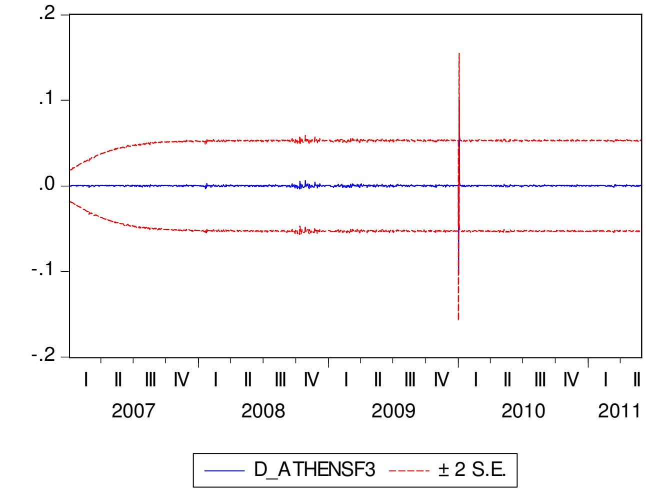
**F2. Static forecast from the EGARCH baseline model.**



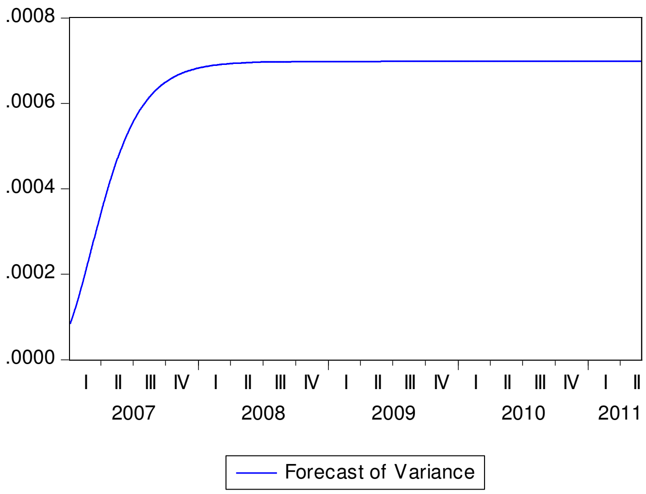

| | |
|---|---|
| Forecast: D_ATHENSF2 | |
| Actual: D_ATHENS | |
| Forecast sample: 1/03/2007 3/07/2012 | |
| Adjusted sample: 1/04/2007 3/07/2012 | |
| Included observations: 1350 | |
| Root Mean Squared Error | 0.023144 |
| Mean Absolute Error | 0.015244 |
| Mean Abs. Percent Error | 123.2205 |
| Theil Inequality Coefficient | 0.953708 |
| Bias Proportion | 0.006768 |
| Variance Proportion | 0.894677 |
| Covariance Proportion | 0.098555 |



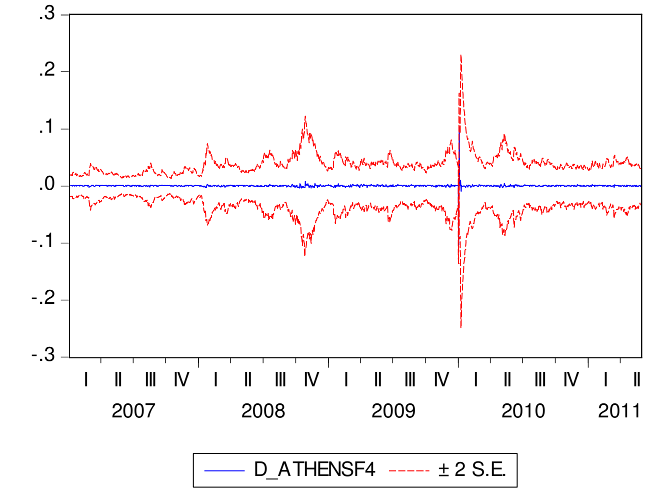
**F3. Dynamic forecast from the EGARCH model with the DAX.**




| | |
|---|---|
| Forecast: D_ATHENSF3 | |
| Actual: D_ATHENS | |
| Forecast sample: 1/04/2007 3/14/2012 | |
| Adjusted sample: 1/04/2007 5/31/2011 | |
| Included observations: 1149 | |
| Root Mean Squared Error | 0.022502 |
| Mean Absolute Error | 0.014438 |
| Mean Abs. Percent Error | 116.9243 |
| Theil Inequality Coefficient | 0.841735 |
| Bias Proportion | 0.002918 |
| Variance Proportion | 0.646811 |
| Covariance Proportion | 0.350271 |

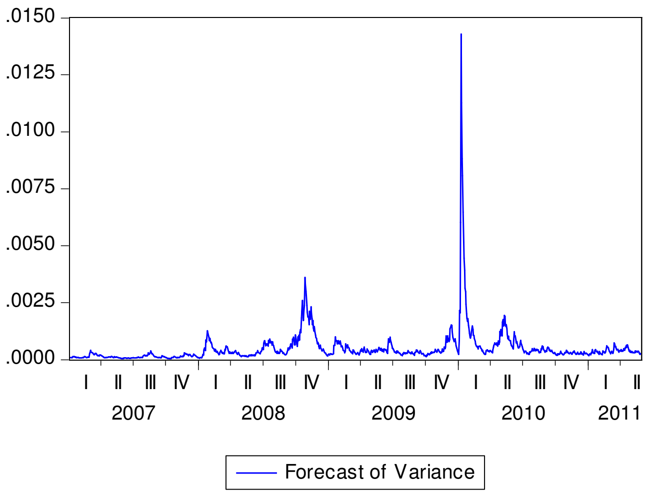


**F4. Static forecast from the EGARCH model with the DAX.**

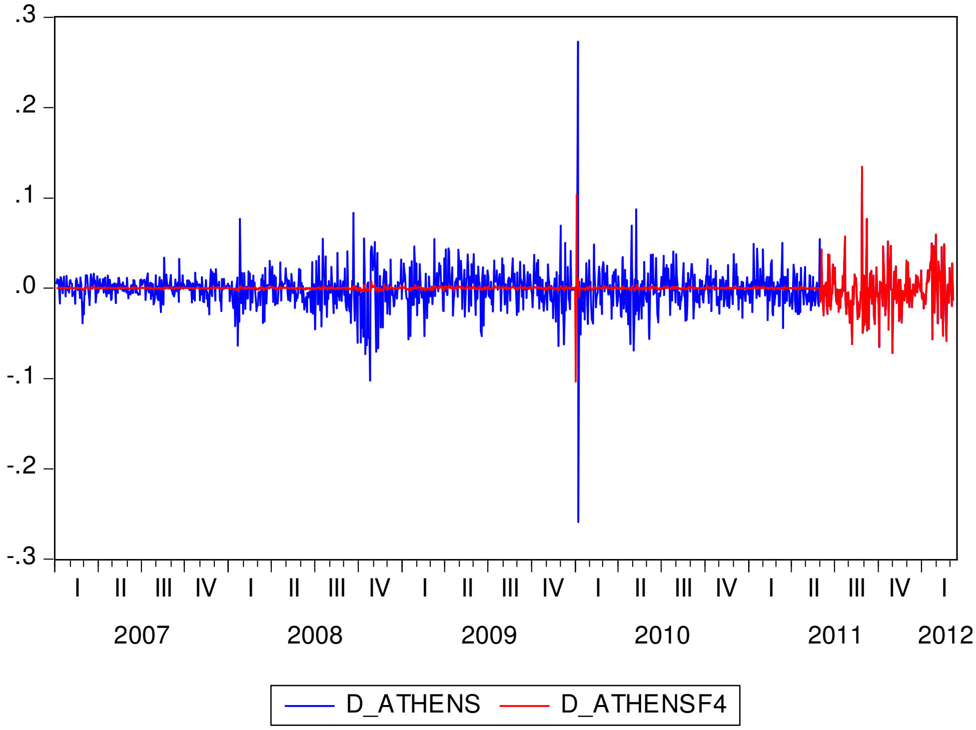



Forecast: D_ATHENSF4
Actual: D_ATHENS
Forecast sample: 1/01/2007 5/31/2011
Adjusted sample: 1/04/2007 5/31/2011
Included observations: 1149

| | |
|---|---|
| Root Mean Squared Error | 0.022579 |
| Mean Absolute Error | 0.014438 |
| Mean Abs. Percent Error | 122.7873 |
| Theil Inequality Coefficient | 0.839874 |
| Bias Proportion | 0.002682 |
| Variance Proportion | 0.631748 |
| Covariance Proportion | 0.365570 |



**F5. Graph of actual vs. forecasted values of the percentage change in Athens' Stock Index.**



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