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# IMPLIED PROBABILITY OF DEFAULT AND THE EUROPEAN SOVEREIGN DEBT CRISIS

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## Abstract

Although the integration of European nations to create the European Union is the result of years of progress, the establishment of the Eurozone, the group of nations using the euro as a single currency, is a fairly new event in European history. While many economies enjoyed relatively prosperous years in the early existence of the euro, the global financial crisis in late 2008 and subsequent sovereign debt crises in several member nations has the future of the Eurozone, and the continuing existence of the euro as a currency, in doubt.

With investors concerned over several Eurozone nations' levels of debt, the market for government securities remains volatile. In several cases, external funding from the European Central Bank and International Monetary Fund has been necessary to avoid default in the face of rising yields on government securities. Greece, Ireland, and Portugal have all received bailouts, and many believe that these are not the last countries to require funding. Italy, Spain, France, and Belgium all have high levels of debt, and the market clearly shows investors' lack of confidence about their futures.

This study applies a reduced form model to the debt of these countries to derive an implied probability of default for various durations of time, ranging from one to five years. The results show high probabilities of default for Greece, Portugal, Ireland, Italy, and Spain, although in most cases probabilities have decreased since late 2011.

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**Acknowledgements**

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## Part I: History of the European Debt Crisis

### Chapter 1: The Integration of Europe

The idea of integrating the European States into a union was born not out of diplomacy, but rather out of war.

From 1939 to 1945, World War II ravaged the political, social, and economic foundations of the European continent. When the dust settled it was the Allies who stood victorious, but the cost for all of Europe was enormous. Determined never to let that destruction happen again, calls for the unification of Europe grew louder and louder in the few years following the fall of the Nazi army.

In his famous speech in Zurich, 1946, Winston Churchill called for the creation of a single European Entity:

> "Yet all the while there is a remedy which, if it were generally and spontaneously adopted, would as if by a miracle transform the whole scene, and would in a few years make all Europe, or the greater part of it, as free and as happy as Switzerland is today. What is this sovereign remedy? It is to re-create the European Family, or as much of it as we can, and provide it with a structure under which it can dwell in peace, in safety and in freedom. We must build a kind of United States of Europe."

This idea, however, was easier said than done. The War had ravaged European industries and created bitter rivalries between countries. As the Cold War settled in, the continent became divided into Eastern and Western Europe. How, then, could unity prevail in a

continent filled with different countries ruled by different leaders, with unique economies and vastly dissimilar cultures?

## European Coal and Steel Community

The answer came through the one thing that the Western European countries had in common: coal and steel. The European Coal and Steel Community was created in April 1951 when West Germany, France, Italy, The Netherlands, Belgium, and Luxembourg signed an agreement that would place these heavy industries under common management. The idea was to promote open trade and transparency between the member countries. Heavy industry was not just a common economic resource, however; it was also the fuel of war. By agreeing to put these industries under common management; France, West Germany, and the other four countries had essentially signed a peace treaty.

The European Coal and Steel Community would prove to be a great success. Through the economic prosperity and social change of the 1960s, the ECSC would hold strong, and even expand into agricultural policy. While the integration had not yet reached the political level as some leaders would have liked, the economic cooperation between the six countries worked well, and the future of European cooperation seemed bright.[1]

The next two decades would see a great expansion in the community, now called the European Economic Community (EEC). Ireland, Denmark, and the United Kingdom joined in 1973. Greece would become the tenth member of the EEC in 1981. Spain and Portugal, each a new democracy following the fall of right wing dictatorships, became

[1] Source: Europa.eu "The EU at a Glance"

members in 1986. By the time the 1980s ended, the EEC had a total of 12 members, and its influence covered a majority of Western Europe.

## Maastricht Treaty and Birth of the Euro

Despite the expansion of members and influence of the EEC, some leaders were still unsatisfied with the level of integration of the European states. Among these leaders was Jacques Delors, a French economist who would become the President of the EEC in 1985. Throughout his career in European Politics, including positions in the European Commission and in the Department of Economics and Finance, Delors had always pushed for a complete political and monetary union whose influence extended well beyond the current economic agreement. His efforts would finally pay off in February 1992 with the signing of the Maastricht Treaty.

The Maastricht Treaty, upon its establishment in 1993, officially created the European Union (EU) that we know today. It initiated two major changes to further integrate the European State. First, it established a three pillar policy structure which defined the powers and influences of the Union. These three pillars; the European Community, Common Foreign and Security Policy, and Justice and Home Affairs, outline the duties and responsibilities of the EU and are coordinated between the national governments and the EU's supra-national bodies; the European Commission, Parliament, and Court of Justice. Some duties, such as competition policy, are handled entirely by the Commission, Parliament, and Court of Justice of the EU, while other policies like education and healthcare are entirely the responsibility of the national governments.

The Maastricht Treaty also officially established a timeline for the creation of a single European currency, to be called the euro. Before the single currency could be introduced, however, it was necessary to ensure that all participating members were in suitable economic standing. For this reason, the Maastricht Treaty set 1999 as the target date for the adoption of the euro and laid out the "convergence criteria" necessary to become a participating nation. The criteria, consisting of five requirements, were designed to ensure price stability within the Eurozone[2] once the currency was released. Despite heavy disagreement between the countries about the strictness of the requirements, the following criteria were eventually agreed upon by the member states:

1. The annual budget deficit must not exceed 3% of the country's GDP.
2. The cumulative public debt must not exceed 60% of GDP.
3. Annual inflation must be no more than 1.5% higher than the average of the three best performing (lowest inflation) member states.
4. Nominal long term interest rates must be no more than 2% higher than that of the three lowest inflation countries.
5. The country's currency must have joined the Exchange Rate Mechanism for at least two consecutive years, and must not have devalued its currency at any point during that time.[3]

With these criteria set, the next step was to create a central bank to control the monetary policy of the European Union. The Maastricht Treaty laid the path for the creation of the

[2] The Eurozone is the set of countries whose national currency is the euro.
[3] The Exchange Rate Mechanism was created in 1979 as a way of maintaining stable interest rates among varied European Currencies. Member currencies originally must not have fluctuated more than +- 2.25% against a central rate, although the limit was later expanded to as much as 15%.

European Monetary Institute (EMI), whose primary responsibilities was ensuring a safe and smooth transition to the euro. The EMI was officially created in 1994, and was eventually replaced in 1998 by the European Central Bank (ECB). The ECB was to be headquartered in Frankfurt, Germany, and would be led by Wim Duisenberg, a Dutch economist. As the central banking institution of the Eurozone, the ECB is an independent body and is responsible for conducting the monetary policy of the euro. This includes maintaining price stability, managing reserves, conducting foreign exchange operations, and printing euro bills and coins.[4]

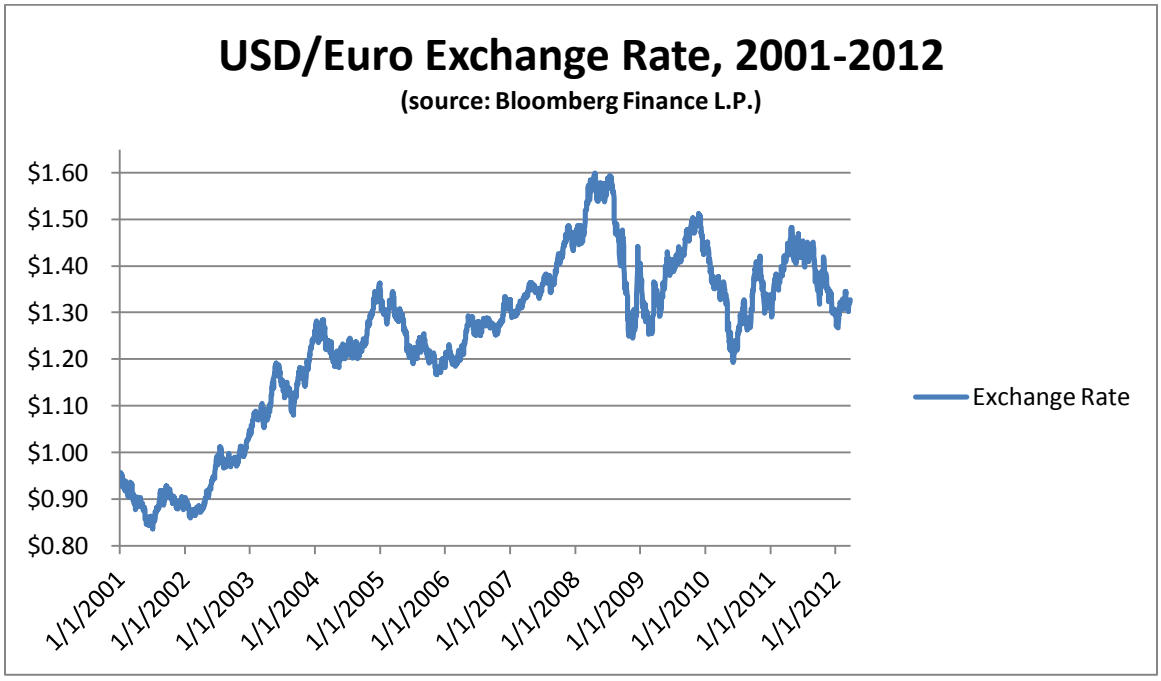
With the criteria defined and the central banking institution established, the time had come to officially introduce the euro as the currency in the EU. With the exception of the United Kingdom and Denmark, who had secured opt-out agreements to maintain their national currencies, each member state presented their case to the European Central Bank, proving they had fulfilled the criteria for membership. Of the applying countries, only Greece was denied entry into the Eurozone in 1999. Greece would later be admitted in 2001, having convinced the ECB that their economy was suitable for membership. Today, the euro is the official currency of 17 of the 27 members of the EU, with several member nations seeking entry into the Eurozone.

For the next seven years, the euro would run smoothly. The global economy was strong, and membership in the EU continued to expand. The ECB in Frankfurt worked hard to maintain a strong currency and limit inflation, mirroring the monetary policies that had made the German Deutschmark a leading global currency. However, the global financial

[4] As a comparison, the mandate of the Federal Reserve of the United States, as set out in the Federal Reserve Act, are maximum employment, stable prices, and moderate long term interest rates (source:federalreserve.gov)

crisis would hit in late 2008, shaking the foundations of the global financial foundation. Figure 1 below shows the euro/USD exchange rate from 2001-2012.

**Figure 1: Euro vs. USD Exchange Rate, 2001-2012**




Though the euro would survive the crisis and remain a powerful currency, the fiscal policies of a small Mediterranean nation would soon threaten the very existence of the Eurozone.

## Chapter 2: The Greece Problem

On April 27 2010, the Standard and Poors (S&P) credit rating agency downgraded 10 year and two year Greek bonds from BBB- to BB+, officially placing the country's debt in the "junk" or "non-investment grade" category.[5] This put Greek debt at the same rating as that of Latvia, Romania, and Uruguay.[6] S&P analysts cited concerns over

[5] See Appendix E for an overview of credit ratings by S&P, Moody's, and Fitch
[6] Source: Bloomberg

Greece's debt structuring and cautioned that investors were likely to only receive 30-50% of their original investment should the country default or undergo a debt restructuring. The news sent shockwaves across Europe and the world. Greek two year note yields soared to 15%, and five year note yields rose to 10.6%, worse than countries like Ecuador (10.5%) and Ukraine (7.1%).[7] 10 year yields increased to over 9%. The spread Greek bonds between German bonds, often considered the "risk-free" investment of Europe, grew to 6.7%, the highest it had been in over five years.[8] Indexes across Europe fell with the news. The UK's FTSE 100 dropped 2.6% and Germany's DAX index slid 2.7% during the trading day.

Just four days earlier, on April 23, the EU and the IMF, an international monetary reserve with funds pooled from 187 member countries, agreed to a €45 billion bailout for the Greek government in an attempt to ease the tension caused by the country's substantial debt burden. When the debt markets failed to react, it became clear that the small nation would require much more money to avoid default. Eight days later, on May 1, the EU and IMF agreed to increase the bailout to €110 billion ($146 billion), contingent upon the enactment of several harsh austerity measures for the country. With his hands tied, Greek Finance Minister George Papandreou passed the measures, which included public sector wage cuts, tax increases, and a four year increase in the pension retirement age. The bill was submitted to Parliament on May 4.

Needless to say, the Greek public was not pleased with the news. On May 5, as televisions and newspapers brought details of the proposed cuts, tens of thousands of

[7] Source: BBC News
[8] Source: Bloomberg Finance L.P.

Greek protesters took to the streets of Athens, the country's capital and largest city. The rioters combatted police officers and hurled explosives. A city bank erupted in flames after a petrol bomb was thrown inside, killing three workers and injuring many more. The rioters stormed to Syntagma Square, the location of the Parliament building, calling the country's leaders "thieves" and demanding they come out. At the end of the day, three citizens lay dead, with dozens more injured. 107 arrests were made in total.

It was now quite apparent that the consequences of this debt crisis extended well beyond the borders of the small nation in southwest Europe. But how could the little country of Greece, the 32nd largest economy in the world by nominal GDP[9], threaten to tear down an entire continent's financial system?

## The Causes of the Greek Debt Crisis

The Greek debt crisis is the result of years of deficit spending fueled by cheap debt. However, the economy was not always in poor shape. In fact, after joining the Eurozone in 2001 Greece was one of the fastest growing economies in the EU. Between 2001 and 2007, Greece's economy grew at an average of 4.1% annually, while the Eurozone average was just 1.97% per year[10]

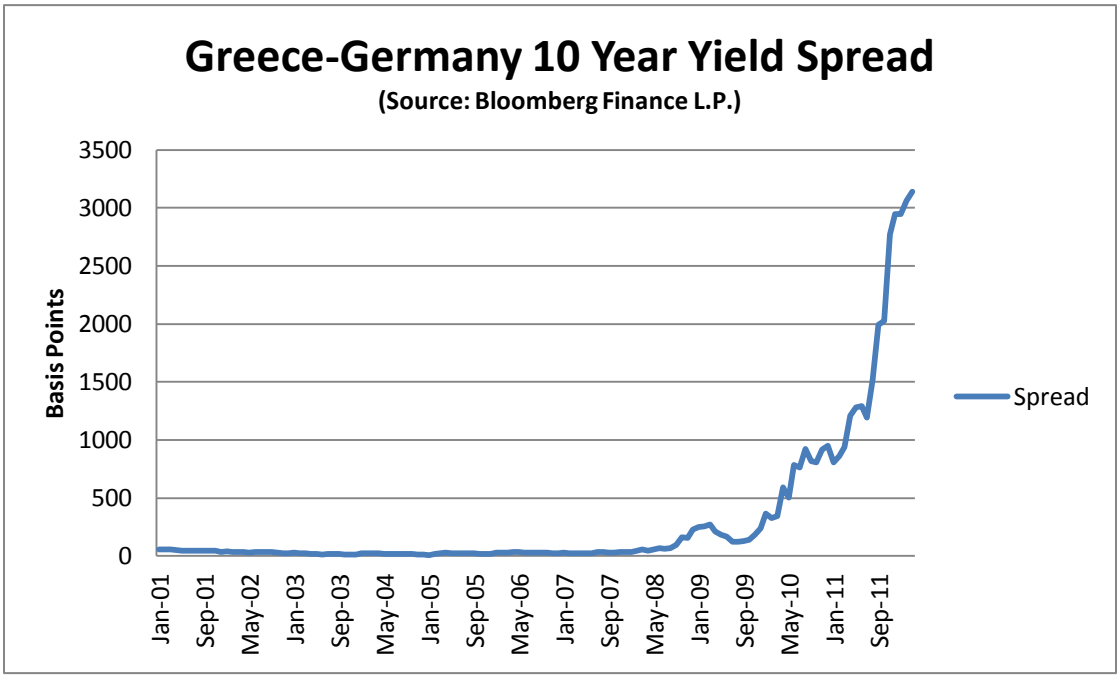
In order to fuel its growth, Greece decided to enact massive public spending. This included funding pensions, social benefits, and federal salaries and benefits. The public sector became the largest component of the Greek economy, with its output totaling 40%

[9] Source: World Bank
[10] See Appendix C for Eurozone GDP growth rates

of the country's GDP.[11] Greece was also host to the 2004 Summer Olympics in Athens, which required further public sector expenditures. In a country whose two largest industries are shipping and tourism, governmental tax revenues were not able to fund this high level of public spending. Compounding this problem was a lack a tax revenues. Greece ranks among the worst countries in the world for tax evasion, with an estimated €15 billion lost annually in uncollected or evaded taxes.[12]

With revenues not sufficient to fuel their spending, the country turned to the debt markets. Greece benefitted from relatively low interest rates over this period, a result of investor confidence in the Eurozone. Between 1999 and 2009, the average spread between Greek and German 10 year bonds was just 50 basis points. Table 2 below shows the yield spread between Greek and German 10 year bonds.

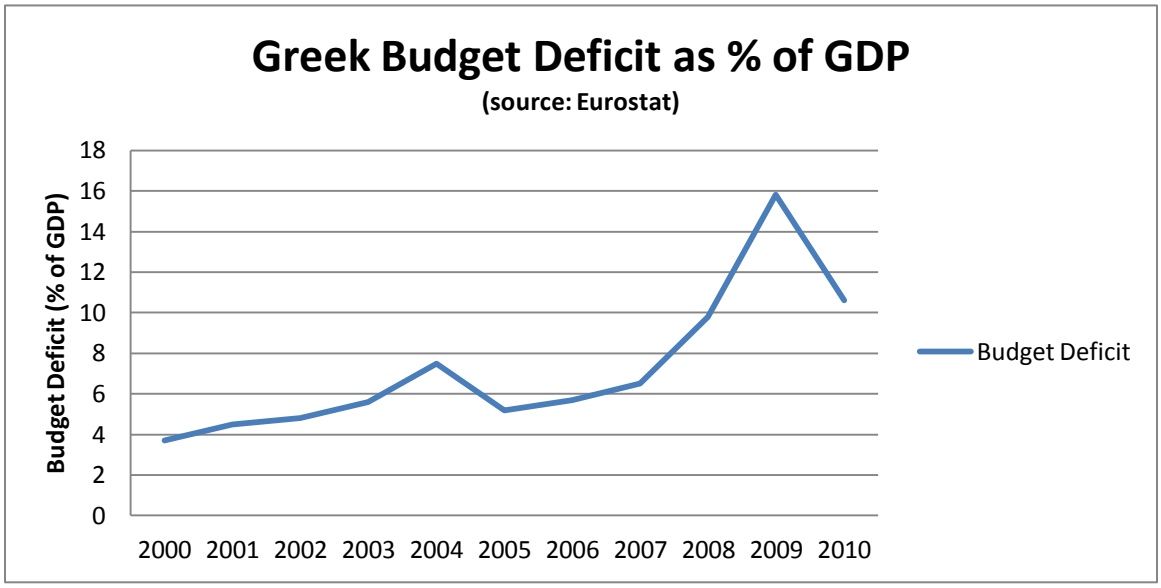
**Figure 2: Greece-Germany Spread, 10 Year Bonds**




[11] Source: CIA World Factbook
[12] Source: The Telegraph

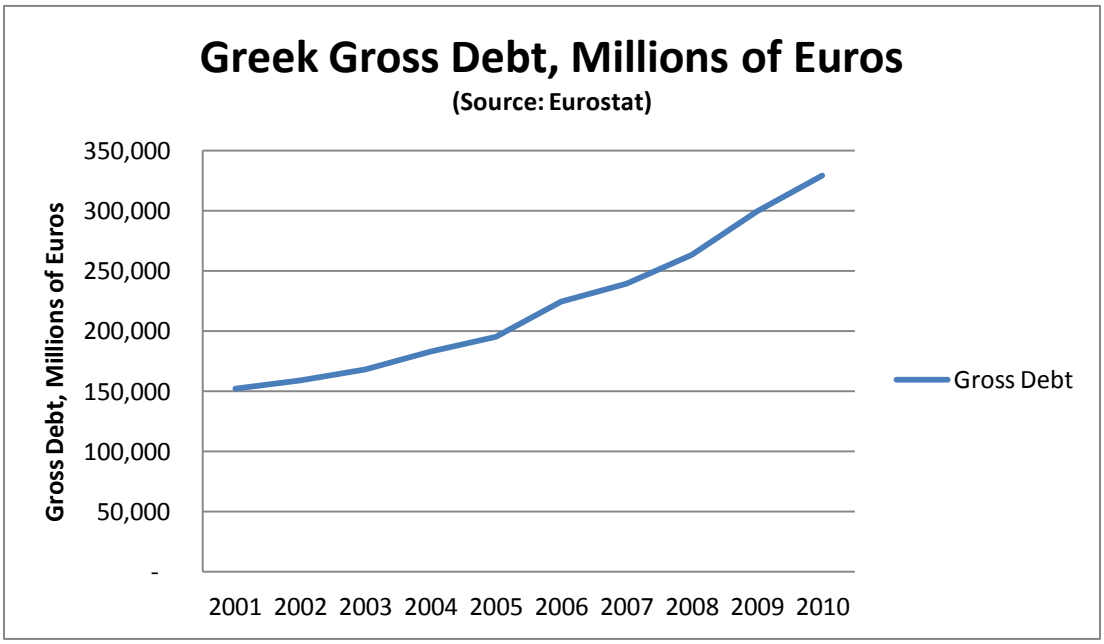
With the ability to raise capital at a fairly cheap price, the Greek government fueled its expanding economy and large public sector expenditures with heavy doses of debt. Between 2001 and 2007, the Greek government ran an annual budget deficit of 5.69% of GDP.[13] This was still over the EU required level of 3% of GDP, but it was far from critical levels. However, in 2008 the deficit jumped to 9.8% of GDP, and increased to 15.8% of GDP in 2009. Over this time, gross government debt increased from €151 billion to almost €300 billion, a 100% increase.[14]

**Figure 3: Greek Budget Deficit**




[13] See Appendix B for budget deficit figures.
[14] See Appendix D for gross government debt figures.

**Figure 4: Greek Gross Debt, Millions of Euros**

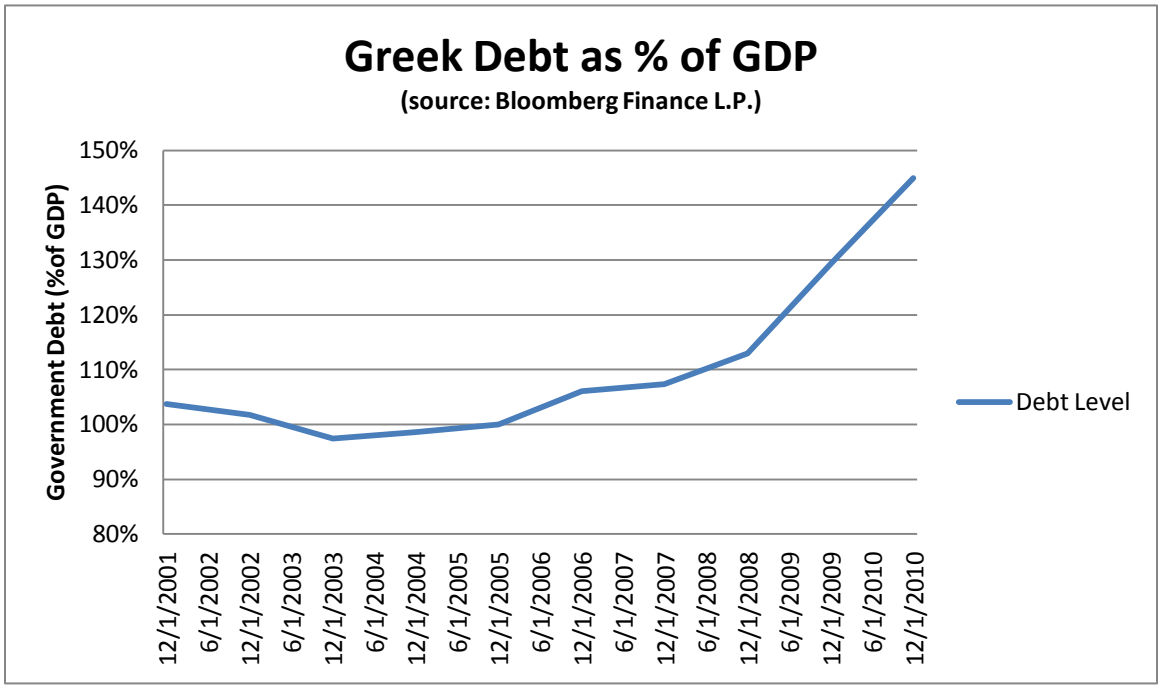



While Greece continued to pile on debt and run large deficits, the EU took no action. This wasn't because of indifference, however; it was because the EU didn't know the truth behind Greece's situation.

In early 2010, rumors surfaced that Greece had lied about its economic standing in order to maintain its standing into the Eurozone. According to the criteria laid out in the Maastricht Treaty, each member of the Eurozone is required to maintain a budget deficit less than 3% GDP and government debt less than 60% GDP. Under intense public scrutiny, Papandreou released revised statistics for 2009, revealing that Greece had run a budget deficit of 12.7% of GDP, more than double the originally reported 6%. Later reports have the final total increased to 15.8% of GDP, the worst in the Eurozone during 2009. The new figures also showed Greece's government to have held about €300 billion

in debt, roughly 129% of GDP. Both of these figures were not just among the highest in the Eurozone, but also among the worst in the world.

**Figure 5: Greek Debt as % of GDP**




In February 2010 it was revealed that American investment banks Goldman Sachs and JP Morgan, among several other American and international banks, received hundreds of millions of dollars in payments to help Greece hide its debt from the EU.

By the middle of 2010, it had become clear that everyone's worst fears had come true: Greece was buried under a debt burden it couldn't possibly hope to repay.

## Preventing Contagion: the European Financial Stability Facility

In late April 2010, the leaders of the ECB and the EU were becoming increasingly aware of Greece's mounting debt problems. At that time, Greece had roughly €300 billion in

outstanding debt, and a default or even bankruptcy was starting to look like a realistic possibility, especially after the S&P downgrade of Greek bonds to junk status.

The concern was not just about the well-being of Greece, however. Holding Greece's toxic debt were primarily European banks. Of the €300 billion in outstanding debt, Greek banks held only €40 billion. 58% of the remaining €240 was held by financial institutions within the Eurozone, including 24.9% by French banks and 14.3% by German banks.[15]

A Greek default, or even worse bankruptcy, would be devastating for the economies of the EU. With so much exposure to Greek debt, Eurozone banks would be forced to write off massive losses. As we have seen with the global crisis of 2008, banks often tighten their credit policies during rough periods, drying up lending and grinding economic activity to a halt. In a year of fragile economic recovery, the last thing the EU could afford was for its banks to take another major hit. GDP growth of the Eurozone was 1.9% for 2010 after a -4.3% growth in 2009.[16]

Knowing this, the EU had very little time to assemble a rescue package. On May 1, the EU and IMF had increased their bailout to the Greek government from €45 billion to €110 billion with hopes of calming the market and preventing Greek contagion. While this prevented an immediate default, it did little to ease the worries of the markets. When yields continued to soar and stocks around the world plummeted, it became clear that something much more drastic was needed.

[15] Source: The Economist
[16] See Appendix C for real GDP growth rate figures.

On Friday May 7, leaders from across Europe gathered in Brussels for an emergency meeting. A rescue package had to be assembled, and it had to be done that weekend before the markets opened on Monday. Over the course of the weekend, the committee, led by ECB president Jean Claude-Trichet, negotiated behind closed doors the terms of the package. With mere minutes to spare on Sunday, the European Financial Stability Facility (EFSF) was created to shore up confidence in the Eurozone. The package included a total of €750 billion in available funds for countries in distress. Of the €750 billion, €440 was guaranteed from the 27 member states of the EU, while €60 was raised by the EU itself.[17] The remaining €250 billion was guaranteed by the IMF.

The goal of the EFSF was to restore investor confidence in the Eurozone. Although Greece was certainly the center of attention at this time, the funds could be accessed by any country who applied. It was essentially a massive safety net; a way for funds to be transferred immediately for any future emergencies. While some stood firmly behind the Maastricht Treaty's "no-bailout" clause, most leaders recognized that future defaults simply had to be avoided.

Although the markets were initially calmed by the news of the creation of the EFSF, the effect would not last. Yields on Greek 10 year bonds fell to 7.6% (down from over 12%) in the week following the announcement of the EFSF, but the trend would soon be reversed. In the following months, the price of Greek debt fell lower and lower, with 10

[17] Source: European Voice

year bonds reaching a yield of 12.01% in December, 910 basis points above that of 10 year German bonds.[18]

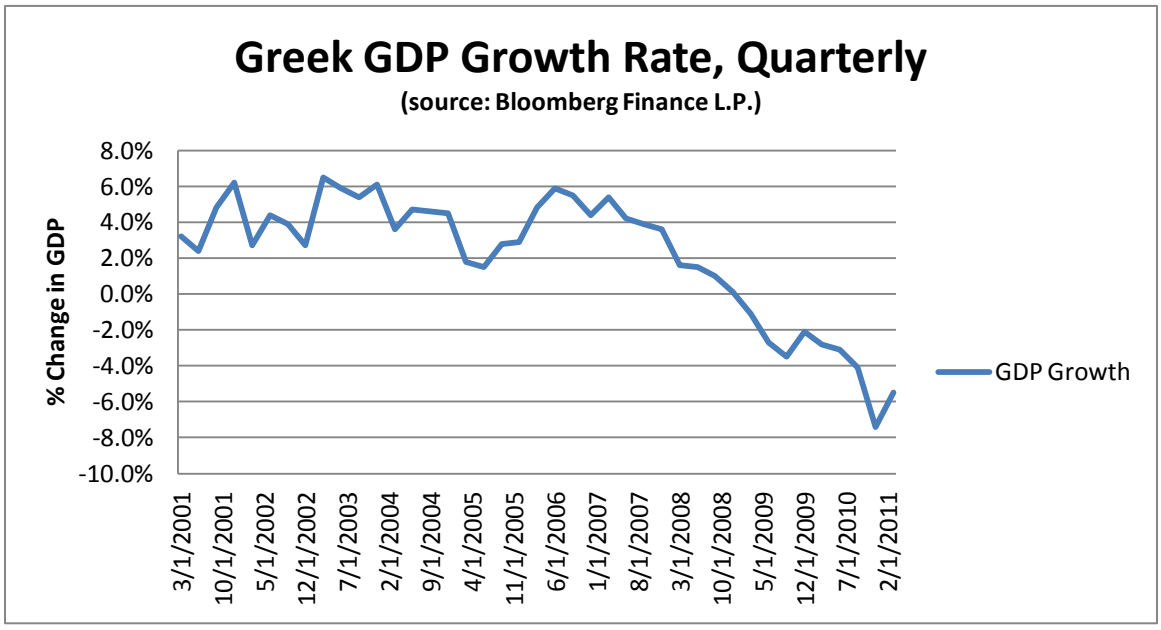
In a combined EU/IMF audit in June, a second series of austerity measures were recommended for the country. In order for Greece to receive the next €12 billion of its bailout package, which it needed to avoid default, the government would have to adjust its budget to cut a proposed €28 billion in public spending over five years. These austerity measures were also received poorly by the public, as trade unions across the country organized a 48-hour labor strike to protest the proposed bill. Despite the resistance, the measures passed in Parliament two days later.

## Greek Write Off

Over the next 12 months, Greece's economy saw little improvement. 10 year Greek bond yields continued to soar, reaching 16% in July 2011. GDP contraction accelerated, with the economy shrinking 5.5% in 2011 compared to 3.5% in 2010. There clearly was no easy way out of this crisis for Greece or the ECB.

[18] Source: Bloomberg Finance L.P.

**Figure 6: Greek GDP Growth Rate**




In July 2011, the EU came upon an agreement that forced private (non-government) investors to write off 50% losses of their Greek debt. The agreement eased Greece's debt burden an estimated €100 billion and will save the country €5 billion in annual interest payments. Adjusted figures now estimate Greece's debt to be roughly 120% of GDP in 2020, similar levels to 2009. This is in stark contrast to the present, where some projections for 2012 have debt as high as 170% of GDP.[19] Also part of the negotiations was an agreement to raise the EFSF total to €1 trillion, growing the size of the EU's "safety net."

Seven months later in February 2012, Greece received its second bailout from the EU/IMF to stall a default. A €130 billion bailout was agreed upon just days before the government was due to default on its maturing debts. In addition, write off levels were

[19] Source: Bloomberg.com

increased to 53.5%, up from 50% that was agreed to in July. Once again, the bailout was contingent upon several budget cuts and other measures.

Today, many analysts question whether or not the Greek economy will be able to stay afloat. Although the country has received billions in bailouts to avoid default and bankruptcy, these funds are merely bandages, treating the symptoms of the crisis but not addressing the root causes. Even with the strict budget cuts, the Greek economy remains sluggish, and many analysts agree that only an economic upturn can prevent Greece from continuing default, or worse, removal from the euro in the future.[20]

## Debt Default vs. Debt Restructuring

The February 2012 agreement between private investors and the Greek government was an example of debt restructuring. Debt restructuring occurs when creditors agree that their money is not likely to be repaid, and are willing to make concessions to allow the debtor a more practical arrangement for paying back their investments. This could include increasing the maturity, lowering the coupon rate, or simply decreasing the principal of securities by a certain percentage. This is in contrast to a default, in which case the debtor simply refuses (or is unable) to pay back the investment. There is no negotiation in a default, and creditors have no say in how much of their investment they will receive.

In this case, a debt restructuring was the more beneficial option for all parties. For investors, the impending restructuring was no surprise, and the ability to negotiate the terms of the default is preferred to letting Greece decide how much to repay. For the EU,

[20] Source: Time.com

the restructuring avoids widespread contagion. By only forcing private investors to "take a haircut," the EU avoided big losses by other sovereign nations, which could have initiated a domino effect. For Greece, a total default would have almost certainly resulted in an exit from the euro.[21]

By negotiating a restructuring of debt, investors are taking big losses. However, these negotiations avoid the worst case scenario, where huge losses spread across Europe and the world, potentially triggering a much more serious and widespread crisis.

## Current State of the Greek Economy

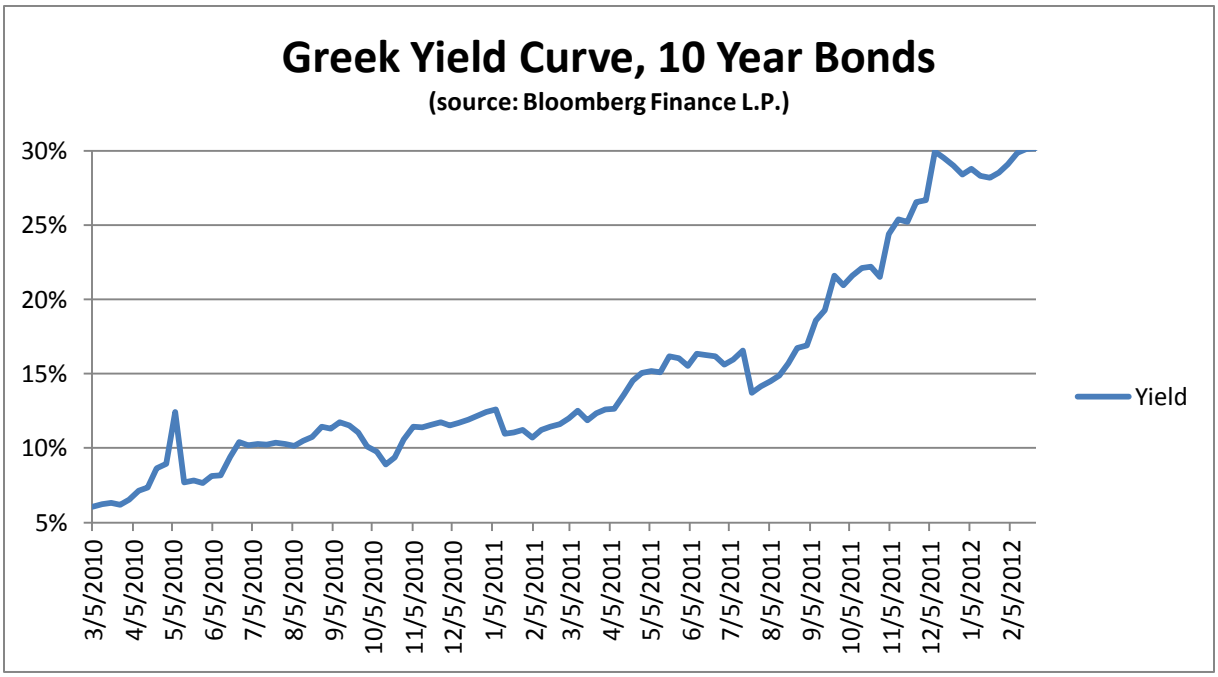
With the risk of understatement, it is safe to say that the Greek economy is in serious distress. Greece again posted negative GDP growth in 2011, this time an estimated 6.05% decline. The budget deficit in 2011 remained at 10.60% of GDP, the same level as 2010. Unemployment figures are not yet available for 2011, but most analysts agree the figure has increased from the 12.55% unemployment posted in 2010.[22]

In the face of extremely uncertain conditions, the bond market has continued its bearish trend on Greek debt. The yield curve on 10 year Greek debt climbed throughout 2011, finally reaching above 30% in November. Compounding this problem is the structure of Greek debt. Of the €354 billion in outstanding debt, €148 billion matures in the next five years. In addition, €53 billion of loan repayments is due in 2017, part of the terms of the EU/IMF bailout. In total, Greece owes its creditors €224.8 billion by the end of 2017,

[21] Source: George Irvin, CNN.com
[22] Estimates are taken from the Economic Forecasting Function of Bloomberg Finance L.P. They represent an average value of estimates given from Bloomberg's contributors.

roughly 63% of its current debt.[23] With yields currently in the neighborhood of 30%[24], it is becoming incredibly expensive for Greece to raise funds on the debt markets, which will continue to make paying off its debt very difficult to manage. Below is a graph of the Greek yield curve on 10 year bonds for the past 24 months.

**Figure 7: Greek 10 Year Yield Curve**




Source: Bloomberg Finance L.P.

But the European debt crisis would be much less serious if the story ended there. Indeed, Greece is not an isolated problem. As it turns out, several economies across Europe are suffering from their own distinct, yet very serious, problems, and each threaten the continuity of the Eurozone.

[23] Source: Debt Distribution Function, Bloomberg Finance L.P.
[24] At the time this paper was completed, yields had dropped below 20% on news that Greece would be receiving additional funds from the EFSF.

## Chapter 3: Ireland and Portugal

### The End of the Celtic Tiger

In 2007, Ireland was on top of the world. After decades as one of the poorest economies in Europe, the hardworking Irish finally had their day in the sun. Ireland joined the EU, at the time called the EEC, in 1979. Following the signing of the Maastricht Treaty and the creation of the Euro the Irish economy exploded, giving birth to the "Celtic Tiger" period which saw average annual GDP growth of 7% between 1996 and 2007, including growth of 11.2% and 10.9% in 1996 and 1997, respectively.[25]

The Celtic Tiger was fueled by several factors: First, Irish banks were able to raise funds cheaply, benefitting from low ECB interest rates. With this, lending increased, and consumer spending rose dramatically. At the same time, Ireland saw an influx of international business activity, a result of both time zone and language similarities to the UK as well as extremely low corporate tax rates, averaging between 10 and 12.5%. The increased economic activity saw the creation of a housing bubble, as consumers and business snatched up cheap properties in the mid-1990s and saw them nearly triple in value over the next decade. Between 1995 and 2007, Irish property values increased 192%, second highest in the world over that period behind only South Africa.[26]

Much like in the United States, the property bubble would burst in 2007, bringing the Celtic Tiger years to a violent end and ushering in a devastating recession. When the bubble burst, Irish banks were forced to write off huge losses, estimated around €100

[25] See Appendix C for GDP growth rates.
[26] Source: The Economist

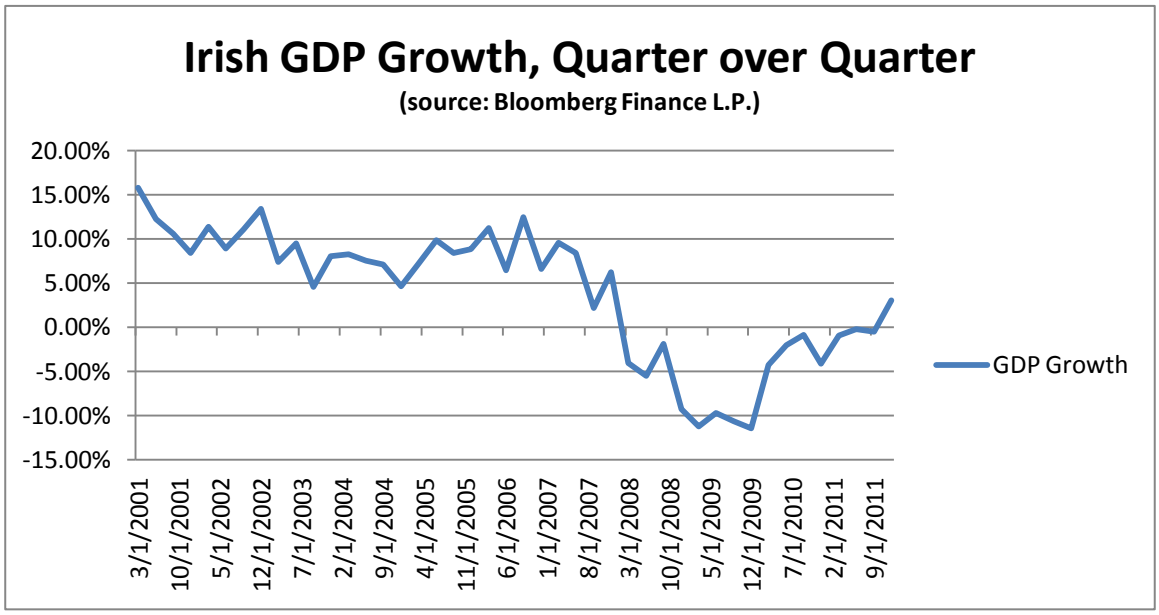
billion.[27] In September 2008, the Irish government passed a bill that would allow the government to guarantee to debts and deposits of six of its largest banks, Allied Irish Bank, Bank of Ireland, Anglo Irish Bank, Irish Life and Permanent, Irish Nationwide Building Society, and the Educational Building Society. The guarantee was for an unlimited amount of funds, and would continue for two years, though it would later be extended for a third year.

In late 2009, the Irish government revealed its plans to create the National Asset Management Agency (NAMA), essentially a "bad bank" that would serve to eat up the bad loans of Irish banks in an effort to free up credit. NAMA bought the "bad" loans from the banks, valued at €77 billion, for just €54 billion.[28]

During this same period, the Irish economy was experiencing the wrath of the global financial crisis. In 2009, GDP shrunk 7% and unemployment nearly doubled, rising from 6.1% to 11.8%.

[27] Source: Irish Times
[28] Source: The Irish Times

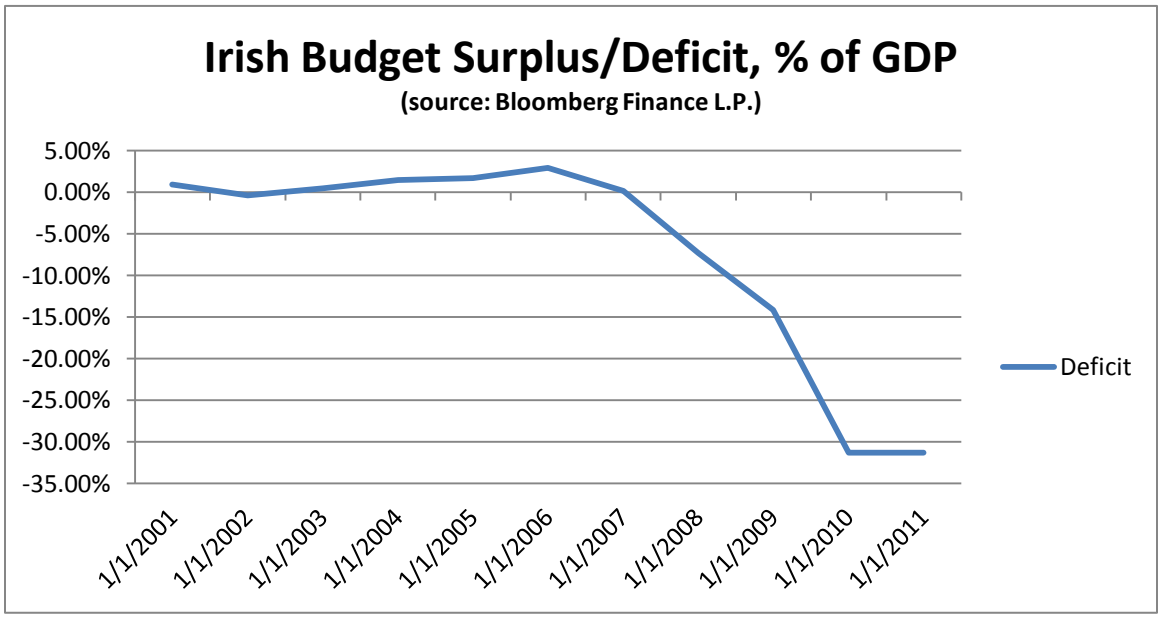
**Figure 8: Irish GDP Growth**




Government expenditures were skyrocketing from NAMA and the bank guarantees while the economy came screeching to a halt, limiting tax revenues. The result was a massive increase in the budget deficit. From 2000-2007, the Irish government averaged a 1.5% budget surplus annually. In 2008, immediately following the collapse of the real estate bubble, the government ran a budget deficit of 7.3% of GDP. In 2009 the deficit jumped to 14.2% GDP, second highest in the Eurozone only to Greece. By 2010, government support for Irish banks was 32% of GDP, and the government was running a budget deficit of 31.3% GDP.[29]

[29] See Appendix B for budget deficit figures

**Figure 9: Irish Budget Deficit**




With the staggering increases in government deficits came a surge in public debt. In 2007, Irish public debt levels were 24.8% of GDP. By 2010, government debt had increased to 92.5% of GDP. In the span of just 3 years, gross government debt had grown from €47 billion to €144 billion, a 206% increase.

**Figure 10: Irish Debt as % of GDP**

## Irish Junk

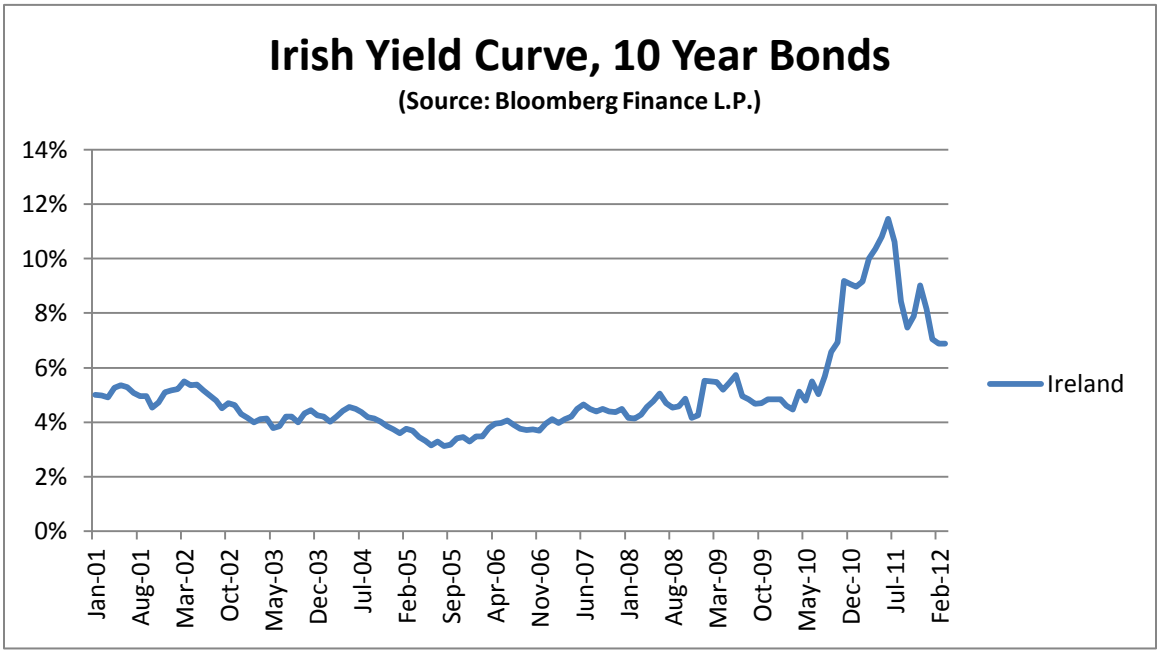
Naturally, the debt markets were not happy with Ireland's situation. Yields on long term debt had stayed relatively low through most of 2010, despite negative economic conditions. However, the yield on 10 year bonds jumped over 8% in October and continued increasing to 9% in November.[30] Suddenly the deficit looked unstable, and the EU began to worry if the Irish government might soon go bust.

In November 2010 the EU/IMF agreed to its second bailout of an EU member state, this time an €85 billion agreement. This was the first time the EFSF would be activated, with €22.5 billion of the bailout coming from the pool. €22.5 billion would come from the IMF, €17.5 from Irish pension funds, and the remainder from the EU and its member states in the form of a loan. According the Jean Claude Junker, chairman of the Eurogroup, €10 billion of the bailout would be used for bank recapitalization, €25 billion for "banking contingencies," and €50 billion for financing the budget.

Following the bailout, the yield on Irish 10 year bonds reduced to roughly 8%, but the effect would not last. Yields continued to increase throughout early 2011, reaching an all-time high of 13.8% following Moody's fifth downgrade of Irish debt since 2009, this time to Ba1, officially "junk" status.[31] Although S&P never downgraded Irish bonds to junk status, it did downgrade the bonds five times since 2009 to a rating of BBB+. Yields would only stay above 10% until early August, and have since dropped below 8% amid improving investor confidence in the country's austerity measures and budget cuts.

[30] Source: Bloomberg Finance L.P.
[31] Source: Bloomberg Finance L.P.

**Figure 11: Irish Yield Curve 10 Year Bonds**




## Portugal: The Third Victim

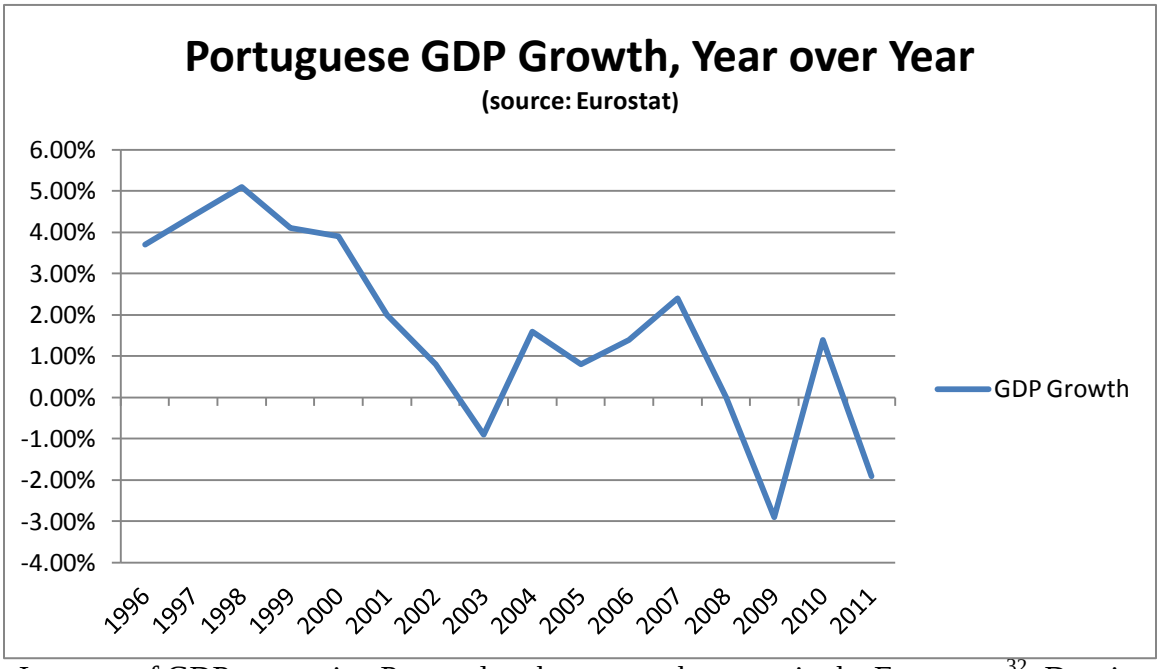
On May 16 2011, Portugal officially became the third victim of the European sovereign debt crisis when the EU and IMF agreed to a €78 billion bailout package to keep the country out of default. In the course of one year, three countries had now received bailout funds from the Eurozone. The crisis was spreading like a wildfire.

Portugal's declining economic situation is different from that of the crisis' previous victims, however. Whereas the decline of Greece and Ireland can be attributed to specific instances of economic mismanagement, Portugal's situation is much more clouded. In Greece's case, the debt crisis was spawned by a decade of fiscal irresponsibility and an ensuing scandal to cover it up. For Ireland, the crisis is the result of a shocking and sudden end to 15 years of prosperity, compounded by the government's promises to bailout the banks that were hit worst by the crisis. In each case, the government simply

spent much more than they could ever hope to pay, and when this was realized by the markets and the price of debt increased, a bailout was the only way to keep the government from defaulting or going broke. With Portugal, however, there is no one event or person to point the finger at. Portugal simply became a victim of bond speculation, and its weak economy was soon unable to sustain the rising prices of debt.

Portugal's economy has been sluggish for the better part of the past decade. Since 2001, the country's GDP growth has underperformed the rest of the Eurozone every year. Portugal's GDP growth has only exceeded 2% in one of these years, and has shrunk or remained stagnant in 5 of the 11 years.

**Figure 12: Portuguese GDP Growth**

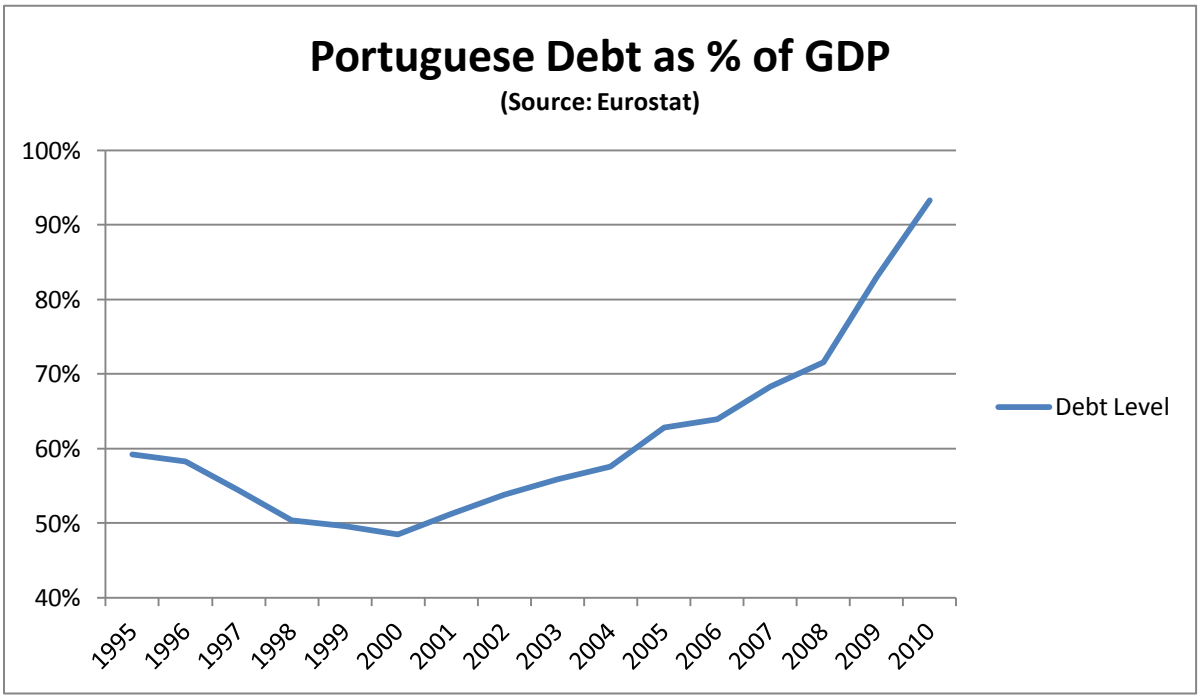



In terms of GDP per capita, Portugal ranks among the worst in the Eurozone.[32] Despite this, the country managed to keep its debt and budget deficits relatively under control.

[32] Source: World Bank

From 2001-2008, Portugal's average budget deficit was 3.8% of GDP[33], still worse than the Eurozone average of 2.1% of GDP but far from critical levels. Public debt was also kept manageable, staying below 70% of GDP until 2008.

**Figure 13: Portuguese Debt as % of GDP**




As with most countries, Portugal was hit hard by the global financial crisis starting in late 2008. In 2009, Portugal's economy shrank 2.9%. The economy rebounded in 2010, albeit less than the Eurozone average, growing 1.4% compared to the average of 2%. As a result of the economic losses, Portugal's debt grew 30% between 2008 and 2010, rising to 93% of GDP.[34] While these numbers are not strong, they are in stark contrast to Greece and Ireland, who were both clearly in the midst of serious debt crises by 2010.

[33] See Appendix B for budget deficit figures.
[34] See Appendix A for Debt/GDP figures.

Despite this fact, Portugal soon fell victim to the bond markets. From 2001-2009, the average yield of a 10 year Portuguese note was 4.3%, compared with an average yield of 4.03% on German 10 year note, a mere 27 point spread. However, when the markets reacted to the crises in Greece and Ireland, the spillover affected Portugal. Yields rose above 5% in May 2010, and by September stood above 6%. Over the course of the next seven months yields rose above 9%. The spread between Portuguese and German bonds was now 5.85%.[35]

The cause for this market reaction is not entirely clear, although there has been much speculation. Robert Fishman of the New York Times wrote in an April 2011 column,

> "…In Greece and Ireland the verdict of the markets reflected deep and easily identifiable economic problems. Portugal's crisis is thoroughly different; there was not a genuine underlying crisis… Its accumulated debt is well below the level of nations like Italy that have not been subject to such devastating assessments. Its budget deficit is lower than that of several other European countries and has been falling quickly as a result of government efforts."

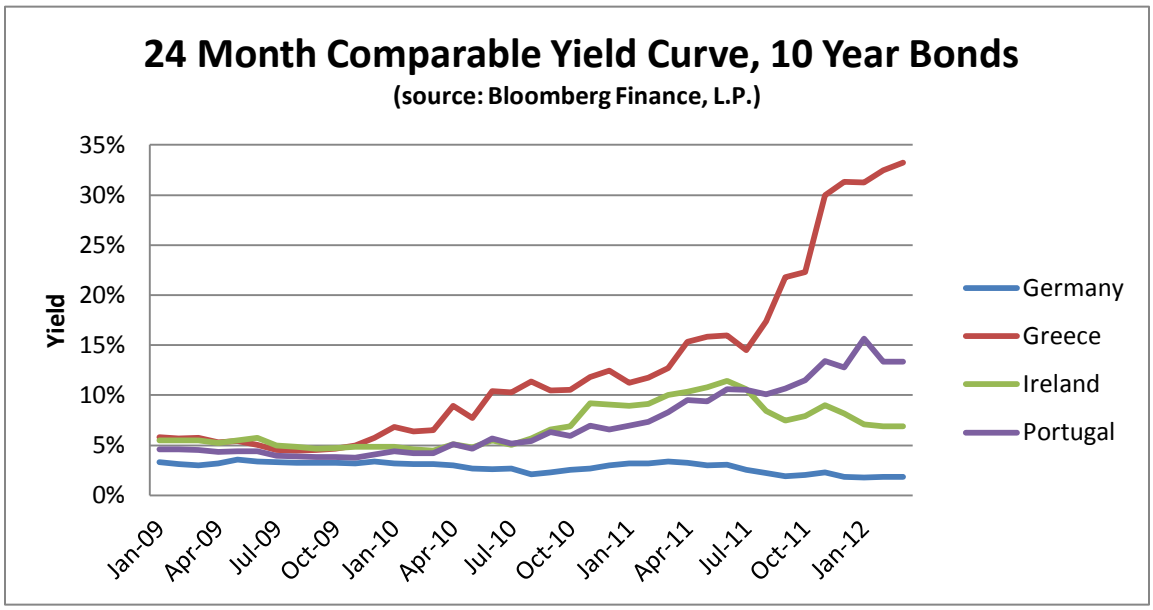
The markets had indeed been shaken by the debt crisis in Europe, and fear of contagion was high. With an underperforming economy and rising levels of debt, confidence in Portugal sank, and yields shot skyward, following the rising levels of Greece and Ireland.

By May 2011, yields hovered around 10%, and it became clear the Portugal could not sustain its high borrowing cost. Worried about a Portuguese default, the EU/IMF agreed to a €78 billion bailout. Fishman believes the bailout was a result of the credit rating

[35] See Appendix F for long term interest rates.

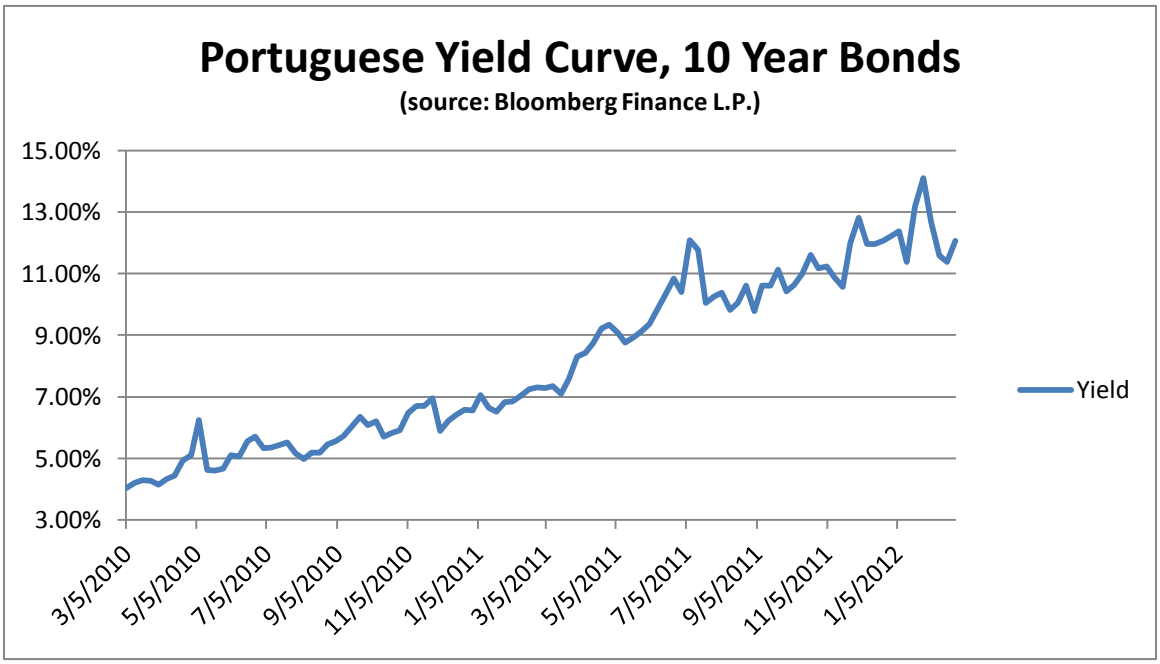
agencies response to Europe's problems. "Market contagion and rating downgrades, starting when the magnitude of Greece's difficulties surfaced in early 2010, have become a self-fulfilling prophecy: by raising Portugal's borrowing costs to unsustainable levels, the rating agencies forced it to seek a bailout."

**Figure 14: 24 Month Comparable Yield Curve**




Following Portugal's bailout, the markets continued to lose confidence in the country's ability to pay its creditors. Moody's downgraded Portuguese bonds to junk status in July, causing yields to soar above 12%. Yields fluctuated around 12% for the remainder of 2011 until S&P downgraded Portuguese debt to junk status in January 2012. The markets reacted strongly, pushing yields above 16% by the end of the month. All three ratings agencies currently hold a "negative" economic outlook for the country.

**Figure 15: Portuguese 10 Year Yield Curve**




The Portuguese bailout and rising cost of debt is a frightening sign for the economy of the Eurozone. The crisis had now claimed three victims, and it is becoming evident that the damage may not yet be completely done. The market has reacted harshly to countries with high levels of debt, prompting four separate bailouts to avoid government defaults. With Greece, Ireland, and now Portugal all falling victim to this debt crisis, who will be the next domino to fall?

## Chapter 4: Who Else is at Risk?

When considering the European Sovereign Debt Crisis, analysts typically refer to the problem area as "PIIGS": Portugal, Italy, Ireland, Greece, and Spain. Although the economies of these countries are vastly different, each government is center stage in the crisis, and each is a threat for future default on its debt. While Greece, Ireland, and Portugal have all received bailouts from the EU/IMF, many believe that Italy and Spain

could be next. For the purpose of this thesis, we will also include France and Belgium as potential problem countries, for reasons to be explained in the following paragraphs.

## Italy[36]

In terms of net government debt, Italy is the most indebted country in the Eurozone, with the country holding €1.64 trillion in debt. Italy's debt currently stands at 120% of GDP, the second highest in the Eurozone behind only Greece. In addition, GDP growth for the country has been small, growing just 0.4% in 2011, including -0.5% growth in the fourth quarter of 2011. These are compared to the Eurozone average GDP growth of 1.90% in 2011, including 0.7% growth in the fourth quarter. Italy has been successful in maintaining stable deficit figures, however, as the government ran a deficit of 4.6% in both 2010 and 2011. Analysts expect the deficit to decrease to 2.2% of GDP in 2012, most likely due to harsh spending cuts enacted by the government.

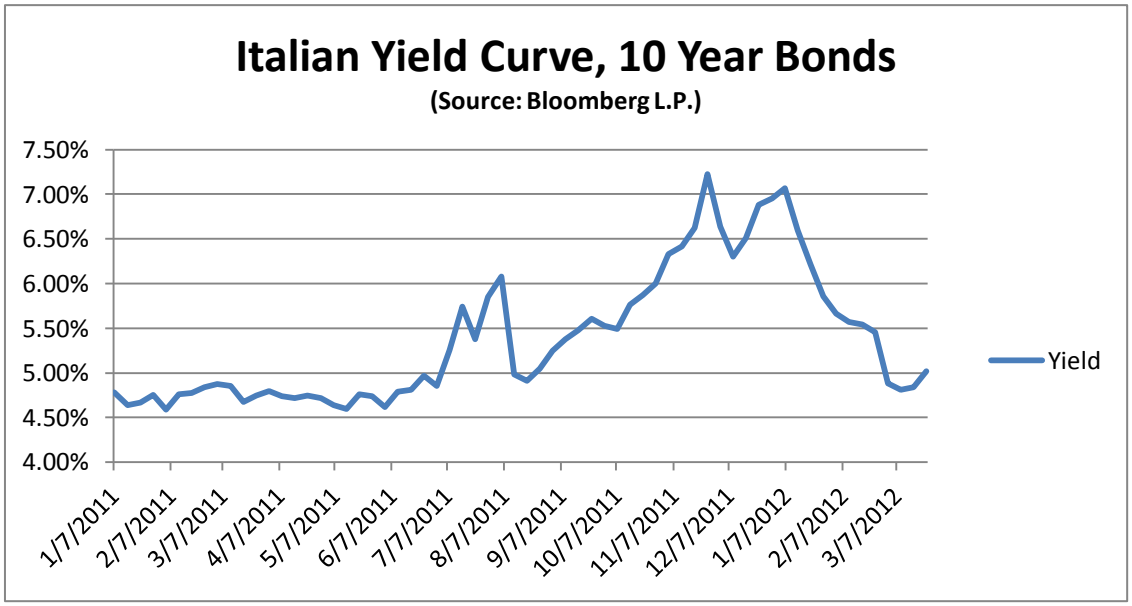
Citing concerns over high levels of debt, S&P has downgraded Italian bonds 7 times since 2008, including three separate downgrades in 2011. The debt currently stands at a BBB+ rating, or medium investment grade. Likewise, Moody's has also downgraded Italian debt 7 times since 2009, including two downgrades in 2011. Moody's, S&P, and Fitch all currently hold a "negative" economic outlook for the country.

The downgrades and concerns over high levels of debt have caused yields on Italian debt to soar. In late 2010, the average yield stood around 4%. Yields on 10 year Italian bonds first started to increase in late 2010 amid fears of contagion. The yields continued to hike

[36] Statistics in this section are taken from Bloomberg Finance, L.P.

throughout 2011, reaching above 7% in November 2011. However, markets have since calmed, and the current yield on Italian 10 year bonds is 4.91%[37].

**Figure 16: Italian 10 Year Bond Yield Curve**

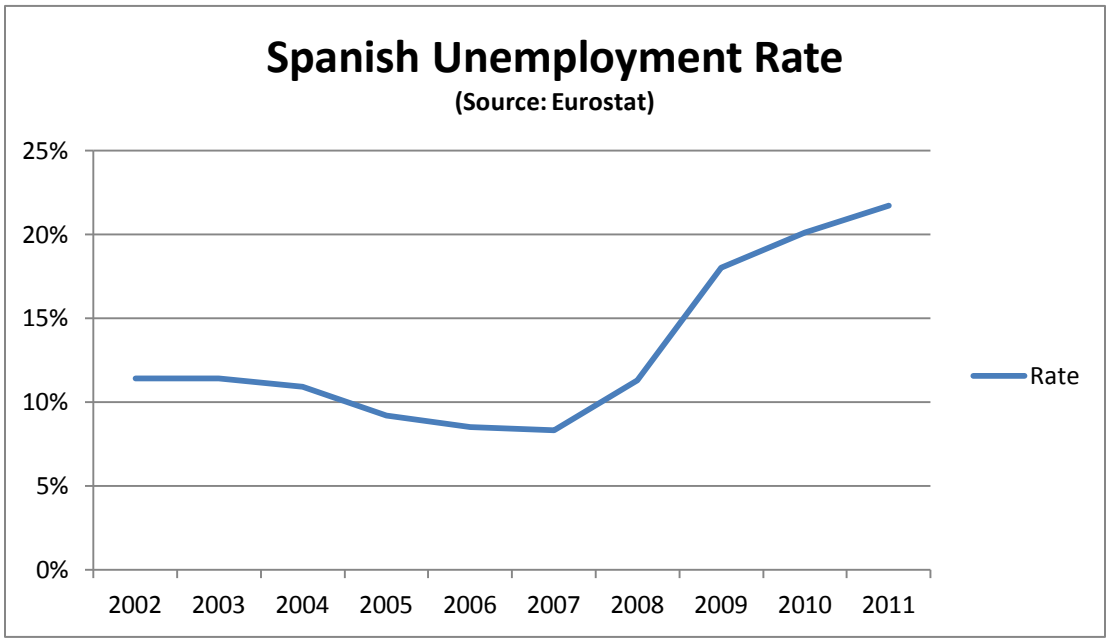



## Spain[38]

Spain is a unique case among the problem countries of this crisis. For Spain, overwhelming debt is not an exceptional concern; the country's debt is currently just 61% of GDP, among the best in the Eurozone. The other indicators of Spain's economy are far worse, however. Spain has been in the midst of an employment crisis since 2008, when unemployment jumped to 11.38%, the worst in the Eurozone. Since then, unemployment has increased to a staggering 21.65%, and Bloomberg projections have the figure increasing to 23.75% by the end of 2012.

[37] As of March 12th. Source: Bloomberg
[38] Statistics in this section are taken from Bloomberg Finance, L.P.

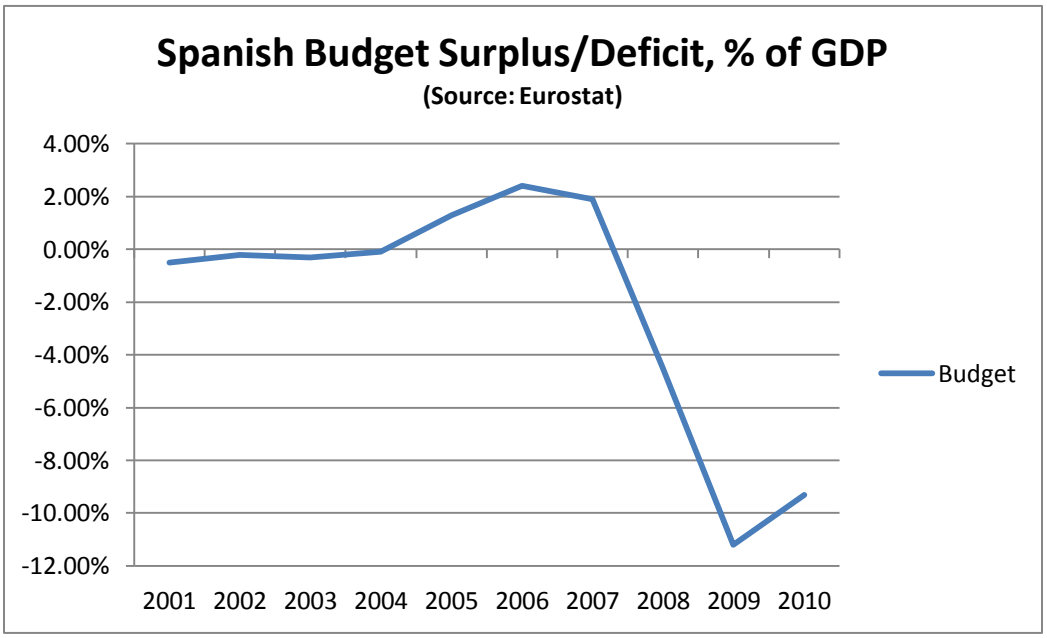
**Figure 17: Spanish Unemployment Rate**




As a result of this unemployment, GDP growth has been stagnant, slowing to .9% in 2008, and then growing at -3.7% in 2009. The economy has been slow to recover from the global crisis, growing just 0.7% in 2011 compared to the EU average of 1.9%. In addition, forecasts have the economy growing -1% in 2012 amidst rising unemployment.

Government spending has also been out of control since 2009. In 2008 the government ran a deficit of 4.5% of GDP. The figure jumped to 11.20% of GDP 2009, the third worst in the Eurozone behind Greece and Ireland. This figure dropped slightly to 9.30% in 2010 and remained steady in 2011, still among the worst in the Eurozone and only slightly better than that of Portugal.

**Figure 18: Spanish Budget Surplus/Deficit, % of GDP**

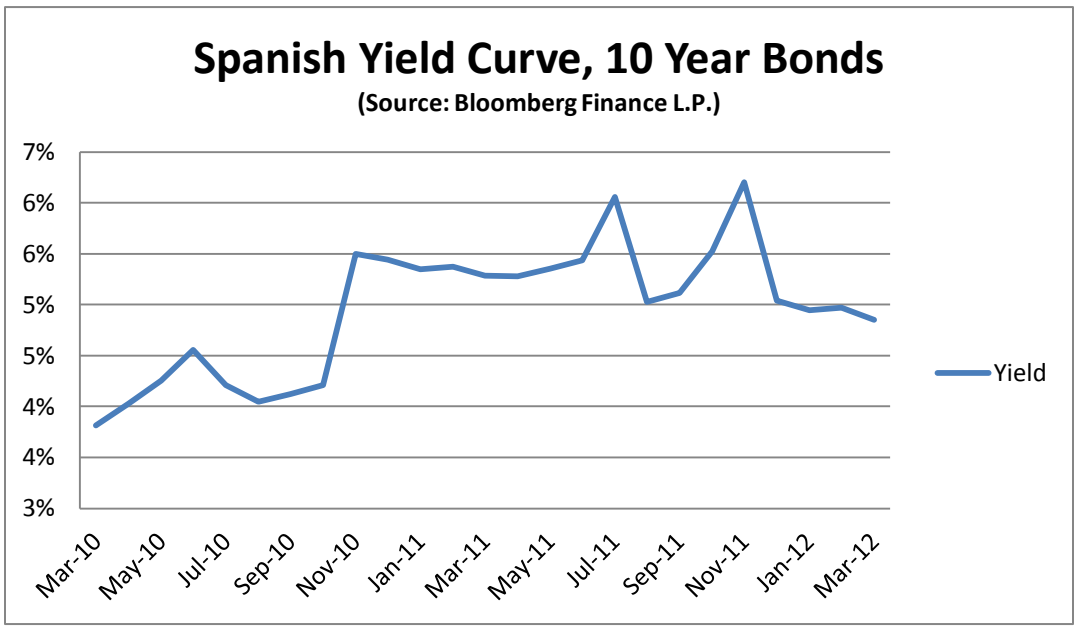



Although Spanish debt is only 61% of GDP, some analysts are concerned about the maturity of the debt. The Spanish government owes a majority of its obligations within the next five years, a troubling fact given the high levels of unemployment and the stagnant or negative GDP growth in recent years.

As a result, Spain has seen its debt downgraded several times in the past two years. Moody's downgraded Spanish debt three times in 2011 and again in February 2012 to a rating of A3, the lowest possible A rating. S&P has downgraded Spanish debt four times since 2010, including its latest downgrade in January 2012. The current rating is A, or upper medium grade. All three credit agencies have issued a "negative" economic outlook for the country.

As a result of the downgrades, yields have increased over the past two years, increasing from around 4% in early 2010 to a high of over 6.5% in November 2011. Yields have since decreased, and the current yield on Spanish 10 year bonds is 5.06%[39].

**Figure 19: Spanish Yield Curve, 10 Year Bonds**



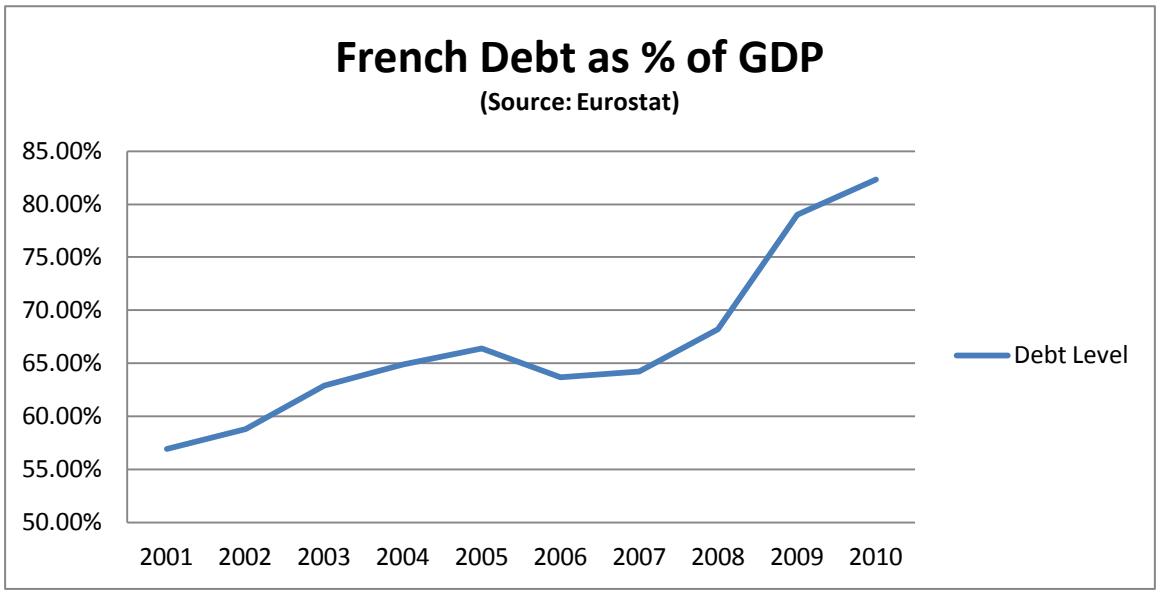

## France[40]

France is not included in the "PIIGS" countries, and for good reason. It is historically one of the biggest, most important economies in Europe, and although it has been affected by the crisis, it is not nearly as large a threat to the Eurozone economy as the "PIIGS" countries. I included France as a possible victim of this crisis, however, because of its relatively large level of debt and potential spillover effects in the debt markets.

[39] As of March 12. Source: Bloomberg
[40] Statistics in this section are taken from Bloomberg Finance, L.P.

France is the second most indebted country in the Eurozone by net government debt. Its €1.3 trillion in net debt trails only Italy. The government debt currently stands at 85.5% of GDP, and although this is half the levels of Greece and 40% lower than the levels of Italy, it is still above the Eurozone average of 85.3% of GDP and is among the worst in the EU.

**Figure 20: French Debt as % of GDP**



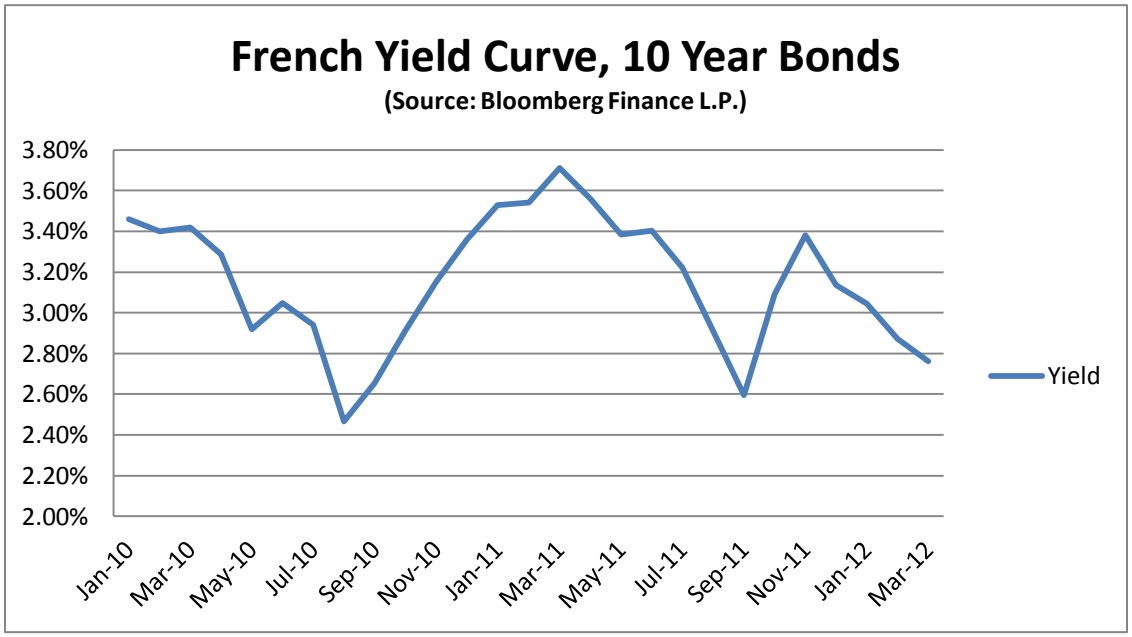

The French economy remains relatively stable despite its high levels of debt. The country's GDP grew 1.50% in 2010 and will grow an estimated 1.70% in 2011. The budget deficit has been fairly high, around 7% of GDP for the past 3 years, although this number is projected to decrease to 4.50% in 2012. Unemployment has also been high but stable, maintaining a level around 9.5% in each of the past 3 years.

Despite its stable economic production, French debt has also been downgraded by S&P. French bonds had been rated AAA By S&P from 1992 until February 2011, when the ratings agency decided to downgraded the debt to AAAu. It was downgraded again in

January 2012 to AA+u. Neither Moody's nor Fitch have downgraded French debt, although all three agencies have issued a "negative" economic outlook for the country.

The yields on 10 year French bonds have yet to see any real increases. Yields rose slightly in the first quarter of 2011 following the S&P downgrade, but it was not a big increase. Yields fell to around 3% by the end of 2011, and currently stand around 2.8% for 10 year bonds.

**Figure 21: French Yield Curve, 10 Year Bonds**




While France has yet to truly feel the wrath of the debt markets, its downgrade by S&P and its consensus negative outlook show that the coast is not completely clear. Much like Spain, France has a majority of its debt due in the next five years, including €255 billion in interest payments due in 2012. With France's high levels of debt, a market shock could raise yields on French debt and cause serious issues for the country in the near future.

## Belgium[41]

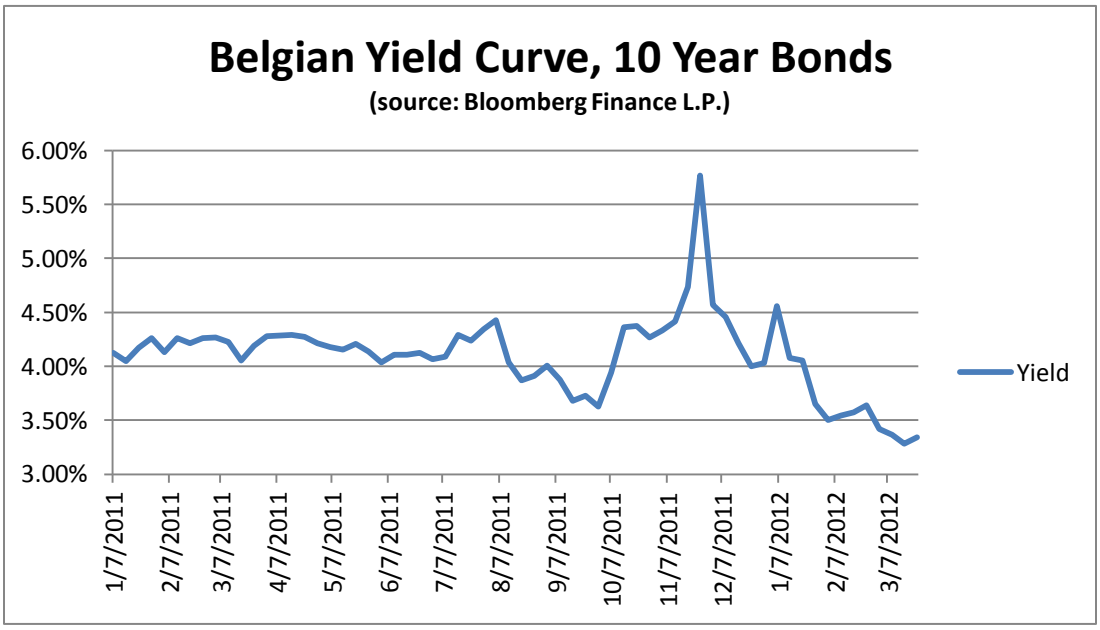
Belgium, much like Portugal, could be a potential peripheral victim of the crisis. Belgium is a small yet productive economy in northern Europe, and area that has thus far been relatively unaffected to the crisis compared to the southern countries. With just €326 billion in net government debt, Belgium is roughly half as indebted as Spain and has less than a quarter the debt of France. However, due to the size of the economy, debt is currently 99.70% of GDP, the fifth highest figure in the Eurozone.

Economic growth was sluggish in 2011, growing just .90%, 1% lower than the Eurozone average of 1.90%. Government spending has been kept relatively low, increasing only slightly to 4.10% of GDP in 2011.

Yields on Belgian 10 year bonds have remained relatively low, averaging 4.15% over the past 12 months. Yields reached a high in late November, soaring above 5.5%, but quickly fell in the weeks following, and currently stand around 3.5%.

[41] Statistics in this section are taken from Bloomberg Finance, L.P.

**Figure 22: Belgian Yield Curve, 10 Year Bonds**




Although all three credit rating agencies have issued a "negative" economic forecast for the country, the debt has only been downgraded once by Moody's (in December 2011) and has not been downgraded by S&P. Both agencies have the bonds at investment grade.

Much like France, Belgium remains far from the crisis levels of the PIIGS countries. However, with high levels of debt maturing in the near future and slow economic growth, a market shock could have serious implications. Should the cost of borrowing increase substantially for the small northern European country, a default would not be out of the realm of possibility.

## Part II: Implied Probability of Default

### Chapter 1: The Economics of Sovereign Debt Markets

For traditional companies, there are several options for raising capital. A company can take out a loan, issue bonds, or issue ownership in the company in the form of shares. Each of these actions increases the right side of the balance sheet and is used to fuel growth in assets or to meet obligations. For governments, these options do not exist. There is no equity for sovereign nations, and it would be impossible for a country to receive a loan from a single source. Instead, governments rely solely on government securities to raise outside capital. These securities are divided into three different categories based on maturity length. Securities that mature in one year or less are called bills. Securities with a maturity between one and ten years from the issue date are called notes, and those with a maturity longer than ten years are called bonds.

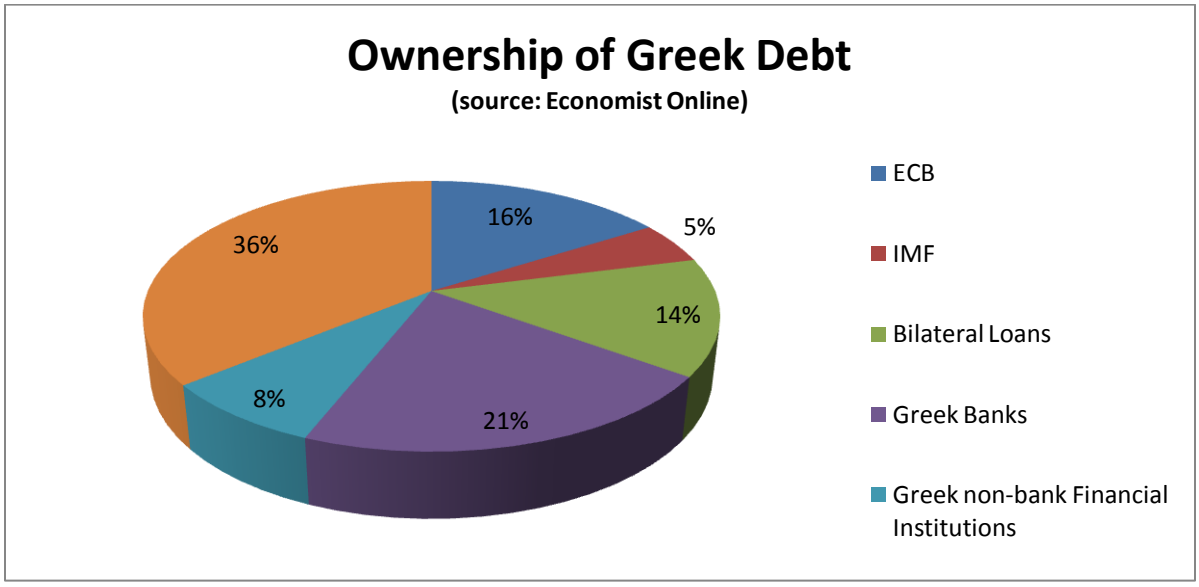
These bills, notes, and bonds are issued by the government through an auction process. The government announces the amount of capital they wish to raise, as well as the details of the security they are issuing; maturity date, coupon rate (for bonds), and purchase limits. On the auction date, investors have two options for purchasing the securities: competitive bidding or a non-competitive bidding. Non-competitive bidders simply place an order for a given number of securities at the listed price. Competitive bidders, however, place a bid for the securities and must "win" the auction to receive them. The government issues the securities through a reverse auction process, where the bids for the highest price (and therefore lowest yield) are given priority. Bids are fulfilled by decreasing price until the amount of needed capital is reached, at which point the auction

ceases. If the total amount of the bids exceeds the value of the securities being auctioned, the auction is said to be "oversubscribed." This is generally positive for the government, as it shows high demand for the securities, pushing prices upwards.

Government auctions are open to all investors, although there are minimum requirements for the amount of securities that must be purchased. Bids can be made by individual investors, although in most cases the majority of the securities are purchased through institutions. These institutions include private banks, insurance companies, funds, and central banks.

Below is a chart showing the ownership of Greek bonds as of May 2011.

**Figure 23: Ownership of Greek Debt**




The ownership of Greek bonds is roughly split into thirds: Greek banks and financial institutions hold roughly 29%; the public holds 35% through the ECB, IMF, and bailout loans; and the market, including individual and international investors hold about 36%.

## Calculating Yield to Maturity

There are several different measures of bond yields. The most inclusive measure, and the one I will be using exclusively in this paper, is "yield to maturity." When I refer to the yield of a security, it is the yield to maturity with which I am referring. The formula for calculating yield to maturity is as follows:

$$P = \sum_{t=1}^{n} \frac{C}{(1+y)^t} + \frac{FV}{(1+y)^n}$$

Where:

P= market price of security
n= number of periods until maturity
C= coupon payment (coupon rate * par value)
FV= face value of security (par value)
y= yield to maturity

Thus, the yield is a product of the market price, par value, coupon rate, and maturity date of the security. The yield is not actually a tangible part of a security. It is an implied figure, a way of measuring the return on that investment, and is completely driven by the market price, coupon, and maturity of the security.

If investors believe that Greece may default on its debt, then the bond will be viewed as riskier, which will drive the market price down. Since the coupon payments and the face value of the bonds are constant, the implied yield on that bond will increase. Thus, there is an inverse relationship between bond prices and yields.

## Expensive Debt vs. Cheap Debt

Since the beginning of the debt crisis in Europe, falling prices of government securities has been an observable phenomenon. As investors lose confidence in certain Eurozone countries, they will demand a higher return on their risky investment. For example, a Greek government bond maturing in April 2016 with a 4.59% coupon was quoted at 94.555 on September 1, 2009. This means that a $100,000 par value bond would sell on the market for $94,555. The yield at that price was 5.62%. Currently, that same bond is quoted at 27.625, with a yield of 51.34%.[42]

Like companies, governments do not raise any capital in the secondary markets. Thus the current market price of a security in the secondary market is not a direct concern for the government. It is, however, a gauge on the market's view of the riskiness of that security. If 10 year Greek bonds are selling at a yield around 18%, then it is safe to assume that any new securities that the Greek government issues will also be sold at a fairly high yield, or a lower price.

It is here that debt becomes expensive for governments. Suppose the Greek government plans to raise €100 million through the auction of 10 year, 5% coupon bonds with a €10,000 par value. Let's assume the market views Greek bonds as secure, and the price for non-competitive bids is listed at €9,500. If the entire auction is sold through non-competitive bids, the government will need to issue 10,527 bonds to raise the necessary €100 million.

[42] Data as of March 15, 2012

Now let's assume that the market views Greek bonds as risky investments, and the non-competitive price is listed at €5,500. For the Greek government to raise the same €100 million, it will now need to issue 18,182 bonds. This means that the government will be paying interest on 7,655 more bonds, making new debt extremely expensive.

## Chapter 6: Implied Probability of Default Analysis

### Literature Review

Although not widely studied, the implied probability of default is not a new concept. In fact, Saini and Bates (1978) report that following the first oil shock in 1973-1974, the topic received increasing attention from scholars, bankers, and investors alike. Several models were designed and testing to figure out just how likely investments were to be repaid. Many early models focused on discriminate analysis, where economic indicators were tested to determine their relevance to default probability.

This paper, however, focuses on a more quantifiable measurement of default probability. In terms of defining a default probability, there is a large span of models with a range of complexities to determine an exact probability of default for a sovereign nation at a given time. As Karmann and Maltriz (2010) point out, there are typically two main ways default probability is assessed. The most common of these methods is country ratings. While banks and journals often publish ratings, the most widely used are those of credit rating agencies like Standard and Poor's or Moody's. These agencies assign ratings to countries based on how likely they are to default, with lower ratings meaning riskier investments. In his 2004 study, Sy ran a regression of lagged ratings changes to debt

crisis indicators, and found a significant dependency between ratings changes and debt crises.[43]

However, this is not the only way to determine a country's ability to pay its creditors. Investors can monitor market trends to derive default probabilities from bond prices. The market is a natural indicator of default risk; prices of bonds are a direct result of investors' beliefs about their default risk. Riskier bonds have less value. However, just looking at prices does not give us a clear default probability; it simply reflects the markets view of the security. To generate a definable default probability, a model needs to be created.

Karmann and Maltriz focused on the comparison between ratings and market based models to determine a default probability. They created a simple reduced form[44] market model to predict one year default rates based on market prices, and then compared the results of the simple market model to a ratings model.[45] Their findings show that the market model, even in simplified form, significantly outperformed the ratings model in predicting defaults of emerging countries.

More complex market models have also been developed. Xu and Nencioni (2000) describe a model used by JP Morgan to calculate Implied Default Probability using market prices. Their model, though based on a simple reduced form model, describes default probability as a function of the Poisson Distribution. Berd, Marshal, and Wang

[43] Sy's report uses a 3 month lag between ratings changes and crisis indicators. In a previous study, Reinhardt (2002) used longer lag times and found weaker significance between ratings and indicators.
[44] The term "reduced form" involves making assumptions to reduce the model to a more basic form. See next section for explanation.
[45] The ratings model was created using historical default rates by rating category. For example, 41% of bonds rated CCC or below by S&P defaulted between 1975 and 2006, so this was used as the probability of default for countries in that category.

(2003) of Lehman Brothers create a model using a decay factor and a time based hazard rate to calculate default probabilities.

## Default Probability Model

Given the findings of Karmann and Maltriz, I decided to create a simple reduced form model to predict default probabilities. However, in their design, the model testing only one year probability of default rates. My intention is to analyze the prices of securities with maturities ranging between one and five years to determine to probability of default in that given period.

The basic form of a reduced form model, as outlined by Karmann and Maltriz, is as such:

Using a simple zero coupon bond, and under the assumption of risk neutrality[46], the current market price of a bond, $P_m$ , is the expected payment $E_t$ at time t, discounted using the risk free rate.

**Equation 1**

$$P_m = E_t * e^{(-r_f)t}$$

The expected payment value $E_t$ can be defined as sum of two possible scenarios: default or non-default. In a non-default scenario, the bond will pay the promised or contractual payments, $B_T$. This is weighted by the probability of survival, or 1 minus the probability of default (PoD). In default, the bond will pay some percentage of the promised payments, known as the recovery rate (RR), weighted by the probability of default. If the

[46] Risk neutrality, in this case, is not an exceptional assumption. The creation of credit default swaps makes default risk virtually completely diversifiable (Karmann 2010).

recovery rate is 50%, a bond will pay investors 50% of the promised payments in a default scenario. By inserting this new definition of the expected payments, we can combine the two scenarios and create the following:

**Equation 2** $$\boldsymbol{P_m = [(1 - PoD_t) * B_T + PoD_t * RR * B_T] * e^{(-r_f)t}}$$

However, the market price of this same bond could also be defined as the promised or contractual payments of the bond, $B_t$, discounted using the risk adjusted interest rate, or the yield of the bond.

**Equation 3** $$\boldsymbol{P_m = B_T * e^{-(yt)}}$$

By inserting equation 2 into equation 3 and assuming all contractual payments to be 1, we can simplify the formula and solve for the probability of default as shown below:

**Equation 4** $$\boldsymbol{PoD_t = \frac{e^{-(y-r_f)*t} - 1}{RR - 1}}$$

Thus we are left with the probability of default as a function of only the yield of the bond in question, the risk free rate, and the recovery rate. This is, however, one equation with two unknown variables. Recovery rate is not an observable variable until after a default is realized, so the model requires us to estimate its value.

This estimation is no simple task. Some scholars, like Poignant-Eng (1992), set the recovery rate equal to zero. This, however, is an unrealistic assumption, as in almost

every case a default does not mean 100% losses for investors.[47] Lehrbass (2000) used the Moody's historical corporate recovery rate of 40% in his model. This, too, is problematic, as recovery rates for sovereign nations and corporations are likely to be quite different. Vrugt (2010) uses a recovery rate between 40%-60% when applying the model to Greek bonds in 2010. For our purposes, this range of recovery rate seems acceptable.

## Assumptions

As mentioned before, this model operates under the assumption of risk neutrality. For this reason, we are able to discount the expected value of the bond at the risk free rate. The model also assumes that the probability of default is a constant value over the period tested.[48] Lastly, it is assumed that the recovery rate, like probability of default, is time independent and is treated as a constant. The recovery rate is assumed to be 47%, consistent with the 53% write off that was negotiated in the February 2012 debt restructuring for Greece. For the purposes of this model, the yield on German sovereign bonds was used as the risk free rate. While this is a subjective substitution, German bonds are widely considered the gold standard of stability in the Eurozone.[49]

[47] Karmann and Maltriz outline a table of recovery rates for defaulting countries between 1998 and 2005, with the lowest being Argentina in 2001 at a recovery rate of 30%. No other country was below 50%.
[48] Andritzky (2004) reduced form models using both a time dependent probability of default and a simple fixed probability of default to two defaulting countries, Argentina and Russia. His results show that the complex, time dependent hazard rate did not outperform the fixed rate.
[49] Source: CNN Money

## Methodology

The goal of this analysis is to determine market based probabilities of default over different periods of time. To do this, the model was applied to bonds with 1, 2, 3, 4, and 5 year maturities. The predicted probability for a given default period is the probability of default for that country over that same period of time. For example, if the model predicts a 30% probability of default for a country using three year bonds, the market believes there is a 30% chance that country defaults at some point in the next three years.

In doing this, it is possible to be both forward and backward looking when analyzing default probabilities. Using current bond yields, it is possible to look at the present probabilities of default for the countries in questions. However, these numbers are less meaningful without context. For this reason, I also applied the model to average weekly yields for each country, starting on January 1st 2010 and running until week ending March 23rd. In cases where data was not available, the bonds were omitted from analysis.[50] However, since there are currently no bonds offered for Greece between one and five years to maturity, I substituted six month bills and 10 year bonds for short term and long term default probabilities, respectively.

[50] This happened on several instances, where various countries did not offer bonds of a given maturity.

## Data and Analysis

The results of the analysis can be found below:

**Table 1: Current Probabilities of Default Excluding Greece, Recovery Rate=47%**

| Country | Years to Maturity | S&P Rating | Current YTM | Current PoD |
|---|---|---|---|---|
| Germany | 1 | AAA | 0.1410% | |
| Italy | 1 | BBB+ | 1.4616% | 2.4753% |
| Spain | 1 | A | 1.6693% | 2.8617% |
| France | 1 | AA+ | 0.2668% | 0.2372% |
| Belgium | 1 | AA | 0.5880% | 0.8415% |
| Portugal | 1 | BB | 4.0324% | 7.2012% |
| Ireland | 1 | BBB+ | 4.6365% | 8.2942% |
| Germany | 2 | AAA | 0.2628% | |
| Italy | 2 | BBB+ | 2.4707% | 8.1504% |
| Spain | 2 | A | 2.4535% | 8.0883% |
| France | 2 | AA+ | 0.4610% | 0.7464% |
| Belgium | 2 | AA | 1.3119% | 3.9176% |
| Portugal | 2 | BB | 10.5593% | 35.1151% |
| Ireland | 2 | BBB+ | 4.7298% | 16.1256% |
| Germany | 3 | AAA | 0.4230% | |
| Italy | 3 | BBB+ | 3.0284% | 14.1859% |
| Spain | 3 | A | 3.2061% | 15.1137% |
| France | 3 | AA+ | 0.7872% | 2.0503% |
| Belgium | 3 | AA | 1.6373% | 6.7497% |
| Portugal | 3 | BB | 15.2138% | 67.6146% |
| Ireland | 3 | BBB+ | 5.0460% | 24.4344% |
| Germany | 4 | AAA | 0.6558% | |
| Italy | 4 | BBB+ | 3.5439% | 20.5851% |
| Spain | 4 | A | 3.5146% | 20.3879% |
| France | 4 | AA+ | 1.1373% | 3.5992% |
| Belgium | 4 | AA | 1.9765% | 9.7088% |
| Portugal | 4 | BB | 14.5768% | 80.5628% |
| Ireland | 4 | BBB+ | 12.8179% | 72.6821% |
| Germany | 5 | AAA | 0.9531% | |
| Italy | 5 | BBB+ | 4.0944% | 27.4248% |
| Spain | 5 | A | 4.0095% | 26.7388% |
| France | 5 | AA+ | 1.7551% | 7.4163% |
| Belgium | 5 | AA | 2.3540% | 12.7638% |
| Portugal | 5 | BB | 15.1119% | 95.7249% |
| Ireland | 5 | BBB+ | 5.1066% | 35.3828% |

**Table 2: Six Month and 10 Year Probabilities of Default for Greece, Recovery Rate=47%**

| Country | Years to Maturity | S&P Rating | Current YTM | Current PoD |
|---|---|---|---|---|
| Germany | 6 months | AAA | 0.0707% | |
| Greece | 6 months | SD | 5.6980% | 5.2348% |
| Germany | 10 | AAA | 1.7940% | |
| Greece | 10 | SD | 20.2491% | 158.8783% |

As expected, long term probabilities of default are higher than short term probabilities. Logically, this makes sense, as a country is more likely to default over a five year period than it is over just the next year.

The model shows that over a one year period, Ireland is the most likely to default, with a probability calculated to be 8.29%. However, after one year period Portugal becomes the most likely to default, with a 35% probability of default over two years, jumping up to a 95.7% probability of default over five years. Of the countries tested, the market has the most faith in France, which is also consistent with its ratings from S&P, which are the highest of the sample.

In Greece's case, the model predicts a 5.2% probability of default over the next six months; however this number jumps to well over 100% over a 10 year period.

As a comparison, I also ran the model on historical yields, starting in 2010. Black lines indicate major crisis events, while red lines indicate downgrades on long term debt by Standard and Poors[51]. The results can be found below:

[51] Includes downgrades in outlook, such as change from "neutral" to "negative." Source: Bloomberg Finance L.P.

**Figure 24: Italy Probability of Default**

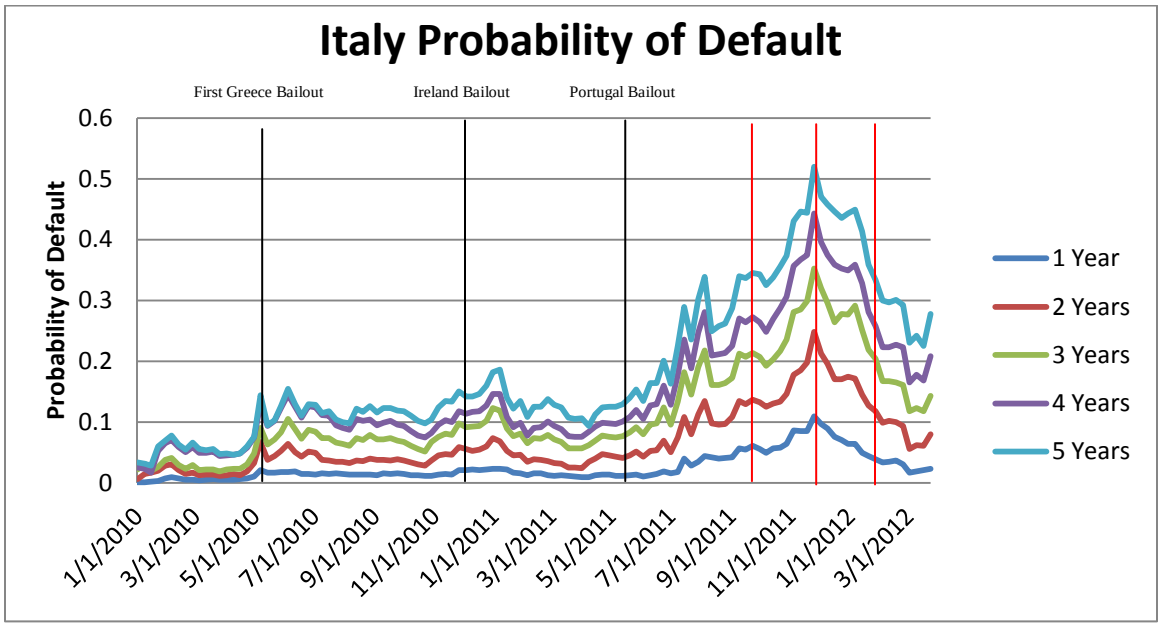



**Figure 25: Spain Probability of Default**

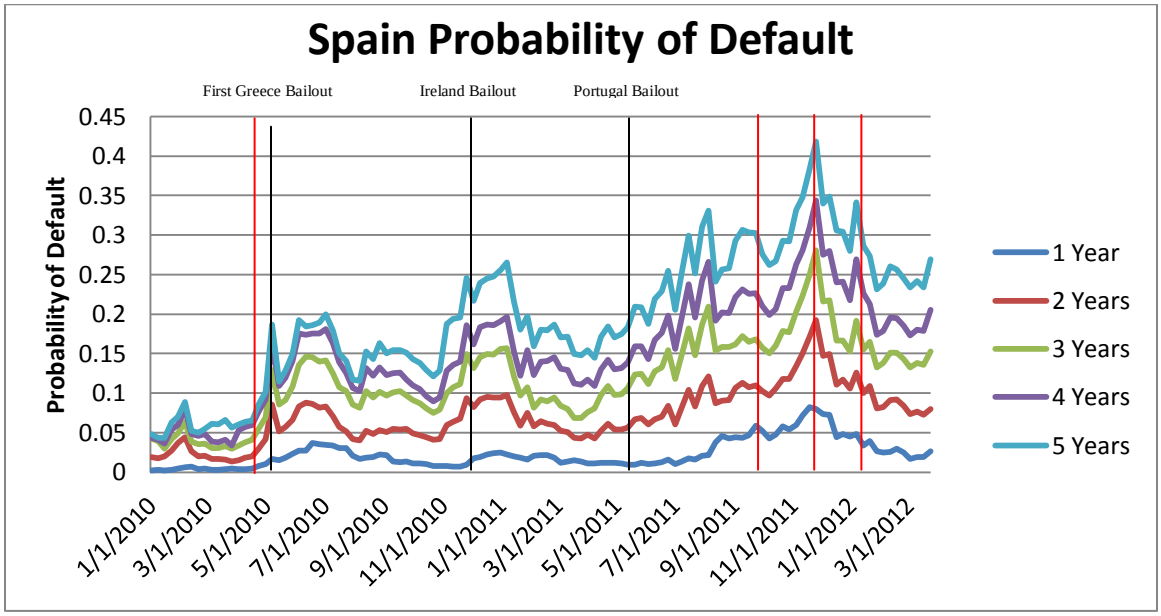


**Figure 26: France Probability of Default**

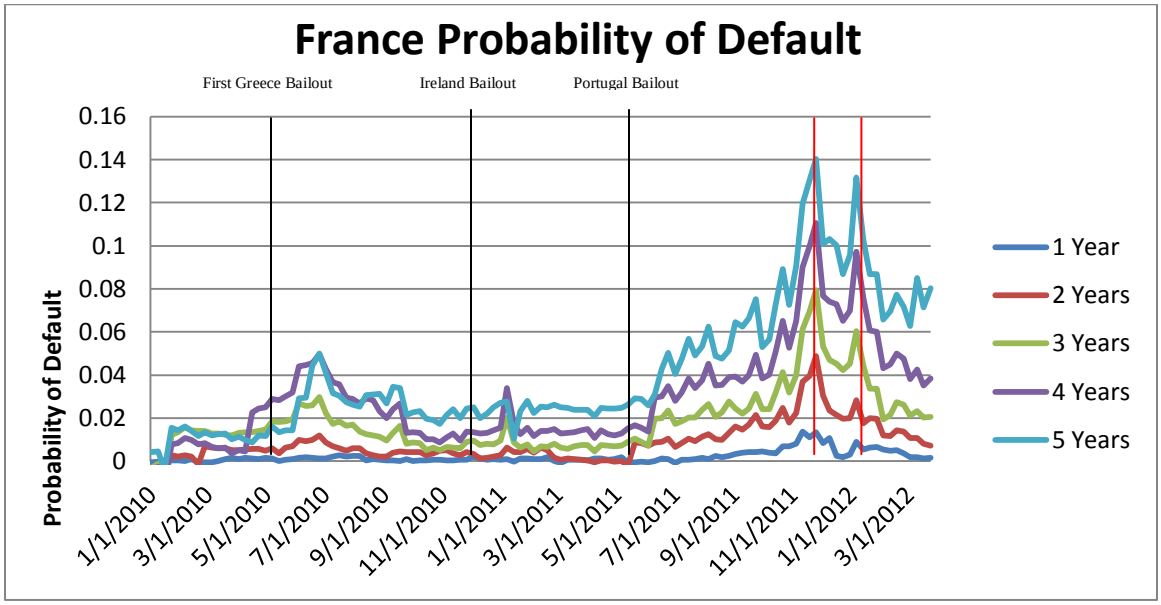
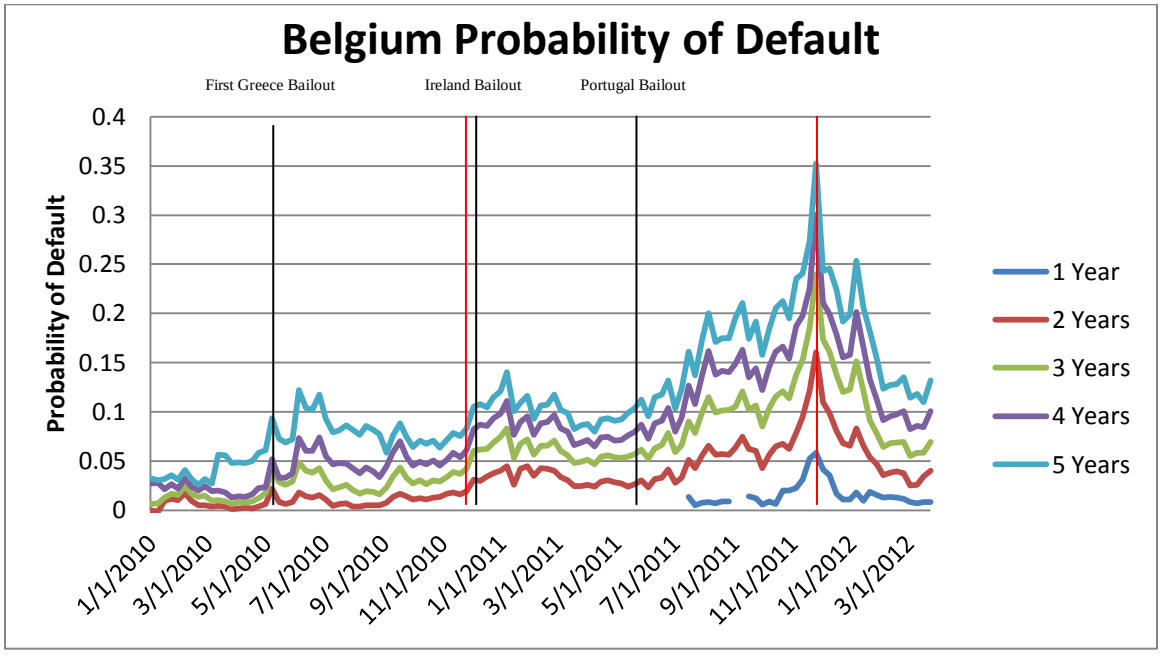



**Figure 27: Belgium Probability of Default**




It can be seen that the probability of default curves for Italy, Spain, France, and Belgium all have similar shapes, albeit with different magnitudes. Each of these countries retains

relatively low probability of default through May 2010, where a sharp increase can be noted in the days leading up to the first Greek bailout. Spain's increase, jumping from around 7% to close to 20% for five year bonds, is larger most likely due to its downgrade by S&P leading up to the bailout. From here, the level remains consistent for the most part until the Portugal bailout in early May, 2011.

Starting around the middle of May, 2011, the probabilities of default for these four countries begins a startling climb. Both Spain and Italy would be downgraded by S&P in September, and all four countries were downgraded in November. Finally, the probability of default reached its peak for all of these countries in the week ending November 25th. For Italy, this was above 50% for 5 year bonds, and for Spain it was over 40%. Belgium reached a peak near 35% for five year bonds, while the market had more confidence in France, whose level reached just 14% at its peak.

Since the end of November, the market has calmed a bit, and default probabilities have lowered from their peak levels. However, they are consistently higher than early 2010, showing there is still concern in the market about these countries.

It is no surprise that the shapes of these default probability curves are similar for these countries. While none of them experienced actual default in this time, the market was clearly worried about their ability to pay. Concerns about crisis contagion drove the yields up on these bonds, and with rising yields came increasing probabilities of default. Whether or not these defaults will be recognized is yet to be seen.

**Figure 28: Portugal Probability of Default**

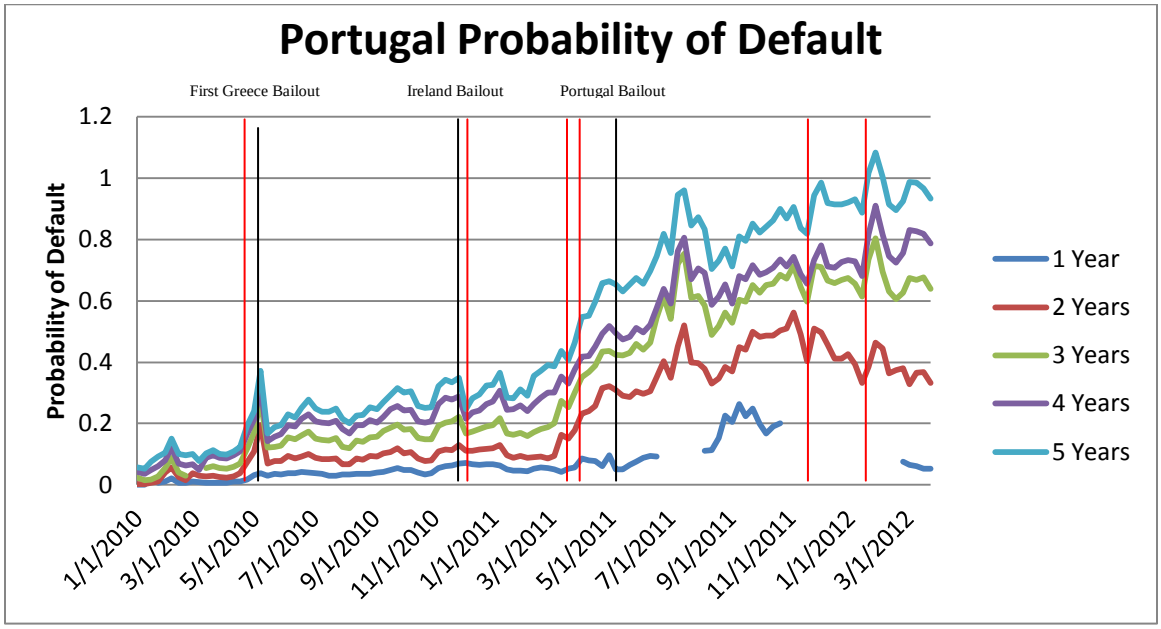



**Figure 29: Ireland Probability of Default**

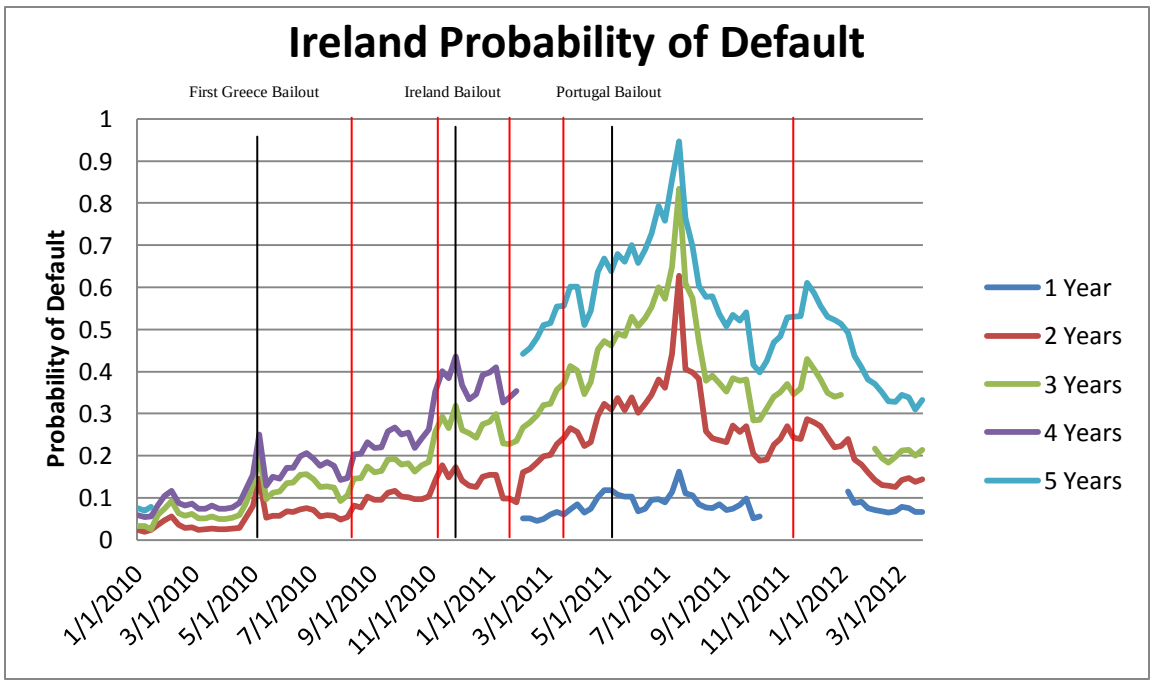
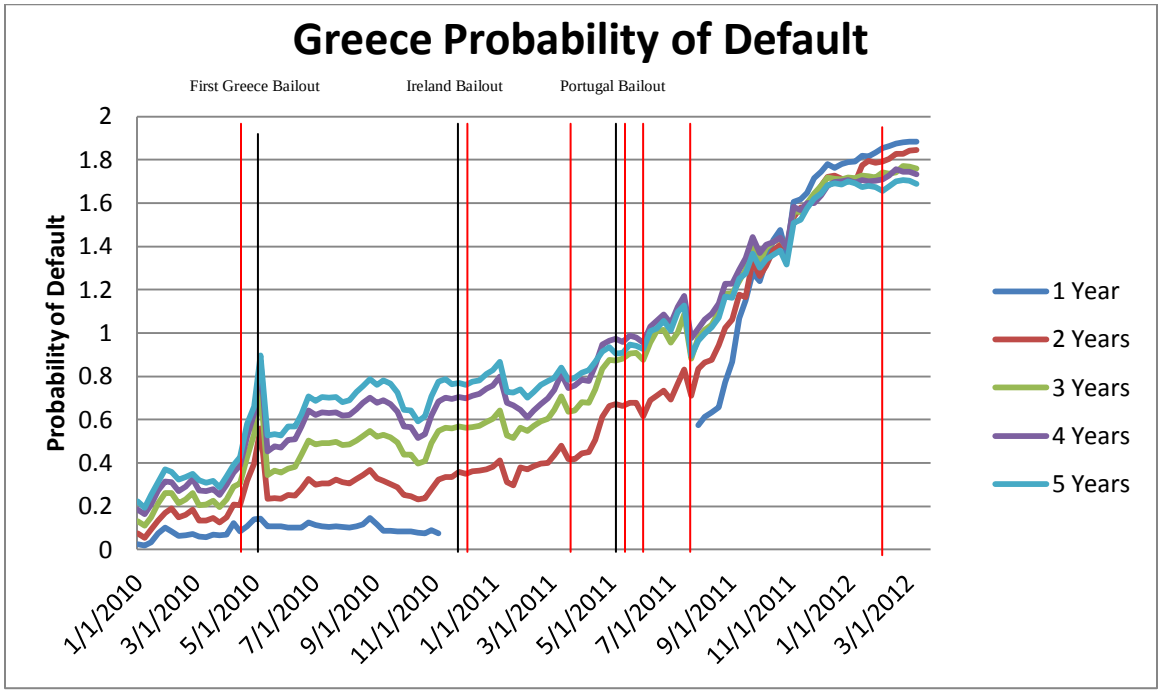


**Figure 30: Greece Probability of Default**




Clearly, the model is less consistent with Portugal, Ireland, and Greece. Portugal saw (comparatively) low probabilities of default through the middle of 2011. However, following its bailout in early May, probabilities skyrocketed and didn't turn back. After two downgrades by S&P at the end of 2011 and beginning of 2012, the probability of default reached its high in late January, amid concerns of a possible second necessary bailout for the struggling country.[52] Current default probabilities have dipped slightly since January, but remain extremely high for maturities over three years.

For Ireland, the probability of default began its steady climb following the November 2010 bailout of the country. S&P downgraded the debt in the days leading up to the bailout, and in the following months the country was downgraded twice more. Default probabilities finally reached a peak of close to 100% for five year bonds in the week

[52] "Fears Mount that Portugal Will Need a Second Bailout"- Wall Street Journal, 1/24/2012

ending July 15th, 2011. This is perhaps a response to a ratings cut from Moody's, who downgraded Irish debt to junk status on July 13th.[53]

Since this time, Ireland has seen its debt downgraded again by S&P in late 2011. However, the market has significantly calmed, and five year probabilities of default are below 35%, much lower than Greece and Portugal and even comparable to Spain and Italy.

Greece is perhaps the most interesting case studied here. Like Ireland and Portugal, a sharp increase can be noted at the time the country was first bailed out (May 2010). However, the market has continued a bearish stance on Greek debt from that point on, with the probability of default continually rising. Currently, the probability of default, even for just one year, is well above 100%, and it seems that the market is certain that Greece will continue its financial difficulties.

## Model Problems and Revisions

While this model does a good job estimating default probabilities, there are several issues that could be revised in the future. First is the estimation of recovery rate. Recovery rate is only an observable variable ex-post facto, and is extremely difficult to estimate. By increasing the recovery rate to 60% from 47%, Italy's five year probability of default increases from 27.4% to 36%. Clearly, this is an extremely important assumption, and future research to better estimate recovery rate could be beneficial for the model.

Second, while the model does an excellent job addressing probabilities of default for non-defaulting countries, it is less effective for countries that are currently in a state of

[53] "Ireland Cut to Junk by Moody's as EU Seeks to Contain Crisis"- Bloomberg.com, 7/13/2011

default. The best example of this is Greece, who has consistently maintained a default probability well over 100% since the middle of 2011. Theoretically, this should be impossible, but the model does not account for prior defaults, which is a potential flaw.

For future analysis, a more robust model may be able to mitigate the effects of these errors. For example, the complex models developed by JP Morgan and Lehman Brothers use time based hazard rates, which can account for countries entering and exiting states of default.

## Conclusion

The European Sovereign Debt Crisis is unlike any event the modern world has seen. While the global crisis of late 2008 shook the foundations of the financial world, this debt crisis has threatened to tear down the economy of an entire continent; taking with it the world's most circulated currency.[54] With three countries already requiring external aid to keep afloat, the Eurozone economy is in extreme distress. Several countries are burdened with high levels of debt and slowing economies, and bond yields remain high. Thus far, the EU has emphasized containing the crisis and avoiding the spread to larger nations like Italy, Spain, and France. However, the long term success of these efforts remains undetermined.

The market has shown that the high levels of debt and slowing economic growth shown by Greece, Ireland, and Portugal is not sustainable in the long run. Even after bailout packages from the EU and IMF, the probability of default for Greece and Portugal are astonishingly high. Other problems countries like Italy and Spain also show high

[54] Source: Market Oracle

probabilities of default, an indication of a lack of confidence in the market. Whether or not these defaults will occur is unknown, but one thing is for certain: governmental economics in the European Union is forever changed.

## Notes

As the crisis continues, this section is devoted to any current updates for the status of the countries in question.

Spain: On March 30, the Spanish government officially announced €27 billion in budget cuts for the 2012 year, with sharp decreases in government ministry spending and an increase in corporate taxes. Protests erupted the day before, with union workers demonstrating on the streets of Madrid. The government hopes the cuts will decrease the budget deficit to 5.3% of GDP for the year.[55]

Greece: On March 15th, the EU/IMF finalized the second Greek bailout, totaling €130 billion. The agreement was sealed when the IMF agreed to contribute €28 billion to the total. Greek Finance Minister Evangelos Venizelos said following the announcement, ""The crisis is not over, we have before us many difficult issues. We must get through 2012, which will be a difficult year; we must get to 2013 which is the year for positive growth. (But) we have different conditions."[56]

Portugal: On March 12, Deutsch Bank chief economist Thomas Mayer told reporters he believes a second Portuguese bailout may occur later in 2012. "With Portuguese bond yields still in the double digits, this summer we will have a discussion about the need for a new Portuguese program." Portugal is still cutting spending to meet the terms of its €78 billion bailout from last year.[57]

[55] "Spain announces €27 billion deficit-cutting plan"- Wall Street Journal, 3/30/2012
[56] "IMF rubber stamps 28 billion euros for Greek bailout"- BBC News, 3/15/2012
[57] "Mayer Says Portugal Bailout Talks May Start Again"- Bloomberg, 3/12/2012

# Appendix A

**Government Debt as % of GDP**

| Year | EU-27 | Eurozone | Belgium | France | Germany | Greece | Ireland | Italy | Portugal | Spain |
|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | - | - | 130.2 | 55.5 | 55.6 | 97.0 | 81.2 | 120.9 | 59.2 | 63.3 |
| 1996 | - | - | 127.2 | 58.0 | 58.5 | 99.4 | 72.7 | 120.2 | 58.3 | 67.4 |
| 1997 | - | - | 122.5 | 59.2 | 59.8 | 96.6 | 63.7 | 117.4 | 54.4 | 66.1 |
| 1998 | - | - | 117.2 | 59.4 | 60.5 | 94.5 | 53.0 | 114.2 | 50.4 | 64.1 |
| 1999 | 65.7 | 71.6 | 113.6 | 58.9 | 61.3 | 94.0 | 48.0 | 113.0 | 49.6 | 62.4 |
| 2000 | 61.9 | 69.2 | 107.8 | 57.3 | 60.2 | 103.4 | 37.5 | 108.5 | 48.5 | 59.4 |
| 2001 | 61.0 | 68.1 | 106.5 | 56.9 | 59.1 | 103.7 | 35.2 | 108.2 | 51.2 | 55.6 |
| 2002 | 60.4 | 67.9 | 103.4 | 58.8 | 60.7 | 101.7 | 31.9 | 105.1 | 53.8 | 52.6 |
| 2003 | 61.9 | 69.1 | 98.4 | 62.9 | 64.4 | 97.4 | 30.7 | 103.9 | 55.9 | 48.8 |
| 2004 | 62.3 | 69.5 | 94.0 | 64.9 | 66.3 | 98.6 | 29.4 | 103.4 | 57.6 | 46.3 |
| 2005 | 62.8 | 70.1 | 92.0 | 66.4 | 68.6 | 100.0 | 27.2 | 105.4 | 62.8 | 43.1 |
| 2006 | 61.5 | 68.5 | 88.0 | 63.7 | 68.1 | 106.1 | 24.7 | 106.1 | 63.9 | 39.6 |
| 2007 | 59.0 | 66.3 | 84.1 | 64.2 | 65.2 | 107.4 | 24.8 | 103.1 | 68.3 | 36.2 |
| 2008 | 62.5 | 70.1 | 89.3 | 68.2 | 66.7 | 113.0 | 44.2 | 105.8 | 71.6 | 40.1 |
| 2009 | 74.7 | 79.8 | 95.9 | 79.0 | 74.4 | 129.3 | 65.2 | 115.5 | 83.0 | 53.8 |
| 2010 | 80.1 | 85.3 | 96.2 | 82.3 | 83.2 | 144.9 | 92.5 | 118.4 | 93.3 | 61.0 |

Source: Eurostat

## Appendix B

**Government Budget Deficit/Surplus as % of GDP**

| Year | EU-27 | Eurozone | Belgium | France | Greece | Ireland | Italy | Portugal | Spain |
|---|---|---|---|---|---|---|---|---|---|
| 2001 | -1.5 | -1.9 | 0.4 | -1.5 | -4.5 | 0.9 | -3.1 | -4.3 | -0.5 |
| 2002 | -2.6 | -2.6 | -0.1 | -3.1 | -4.8 | -0.4 | -3.1 | -2.9 | -0.2 |
| 2003 | -3.2 | -3.1 | -0.1 | -4.1 | -5.6 | 0.4 | -3.6 | -3.0 | -0.3 |
| 2004 | -2.9 | -2.9 | -0.3 | -3.6 | -7.5 | 1.4 | -3.5 | -3.4 | -0.1 |
| 2005 | -2.4 | -2.5 | -2.7 | -2.9 | -5.2 | 1.7 | -4.4 | -5.9 | 1.3 |
| 2006 | -1.5 | -1.3 | 0.1 | -2.3 | -5.7 | 2.9 | -3.4 | -4.1 | 2.4 |
| 2007 | -0.9 | -0.7 | -0.3 | -2.7 | -6.5 | 0.1 | -1.6 | -3.1 | 1.9 |
| 2008 | -2.4 | -2.1 | -1.3 | -3.3 | -9.8 | -7.3 | -2.7 | -3.6 | -4.5 |
| 2009 | -6.9 | -6.4 | -5.8 | -7.5 | -15.8 | -14.2 | -5.4 | -10.1 | -11.2 |
| 2010 | -6.6 | -6.2 | -4.1 | -7.1 | -10.6 | -31.3 | -4.6 | -9.8 | -9.3 |

Source: Eurostat

# Appendix C

**Real GDP Growth, Year over Year**

| Year | EU-27 | Eurozone | Belgium | France | Germany | Greece | Ireland | Italy | Portugal | Spain |
|---|---|---|---|---|---|---|---|---|---|---|
| 1996 | 1.8 | 1.5 | 1.4 | 1.1 | 0.8 | 2.4 | 11.2 | 1.1 | 3.7 | 2.5 |
| 1997 | 2.7 | 2.6 | 3.7 | 2.2 | 1.7 | 3.6 | 10.9 | 1.9 | 4.4 | 3.9 |
| 1998 | 3 | 2.8 | 1.9 | 3.4 | 1.9 | 3.4 | 7.8 | 1.4 | 5.1 | 4.5 |
| 1999 | 3 | 2.9 | 3.5 | 3.3 | 1.9 | 3.4 | 9.9 | 1.5 | 4.1 | 4.7 |
| 2000 | 3.9 | 3.8 | 3.7 | 3.7 | 3.1 | 3.5 | 9.3 | 3.7 | 3.9 | 5 |
| 2001 | 2.2 | 2 | 0.8 | 1.8 | 1.5 | 4.2 | 4.8 | 1.9 | 2 | 3.7 |
| 2002 | 1.3 | 0.9 | 1.4 | 0.9 | 0 | 3.4 | 5.9 | 0.5 | 0.8 | 2.7 |
| 2003 | 1.4 | 0.7 | 0.8 | 0.9 | -0.4 | 5.9 | 4.2 | 0 | -0.9 | 3.1 |
| 2004 | 2.5 | 2.2 | 3.3 | 2.5 | 1.2 | 4.4 | 4.5 | 1.7 | 1.6 | 3.3 |
| 2005 | 2 | 1.7 | 1.7 | 1.8 | 0.7 | 2.3 | 5.3 | 0.9 | 0.8 | 3.6 |
| 2006 | 3.3 | 3.3 | 2.7 | 2.5 | 3.7 | 5.5 | 5.3 | 2.2 | 1.4 | 4.1 |
| 2007 | 3.2 | 3 | 2.9 | 2.3 | 3.3 | 3 | 5.2 | 1.7 | 2.4 | 3.5 |
| 2008 | 0.3 | 0.4 | 1 | -0.1 | 1.1 | -0.2 | -3 | -1.2 | 0 | 0.9 |
| 2009 | -4.3 | -4.3 | -2.8 | -2.7 | -5.1 | -3.3 | -7 | -5.1 | -2.9 | -3.7 |
| 2010 | 2 | 1.9 | 2.3 | 1.5 | 3.7 | -3.5 | -0.4 | 1.5 | 1.4 | -0.1 |
| 2011 | 1.6 | 1.5 | 2.2 | 1.6 | 3 | -5.5 | 1.1 | 0.5 | -1.9 | 0.7 |

Source: Eurostat

# Appendix D

**Gross Government Debt, Millions of Euros**

| Year | EU-27 | Eurozone | Belgium | France | Germany | Greece | Ireland | Italy | Portugal | Spain |
|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | - | - | 282,164 | 675,121 | 1,066,905 | 95,013 | 41,848 | 1,070,525 | 53,013 | 295,206 |
| 1996 | - | - | 270,741 | 711,533 | 1,101,489 | 107,666 | 45,607 | 1,227,808 | 55,508 | 323,920 |
| 1997 | - | - | 268,507 | 745,309 | 1,130,998 | 114,864 | 44,577 | 1,234,499 | 54,514 | 331,204 |
| 1998 | - | - | 269,614 | 786,610 | 1,185,449 | 115,679 | 42,081 | 1,254,388 | 55,489 | 345,968 |
| 1999 | 5,645,461 | 4,618,016 | 271,296 | 804,496 | 1,225,272 | 122,335 | 43,853 | 1,281,550 | 58,657 | 361,775 |
| 2000 | 5,697,149 | 4,694,160 | 272,186 | 826,392 | 1,232,252 | 140,971 | 39,659 | 1,300,269 | 61,569 | 374,033 |
| 2001 | 5,849,114 | 4,828,169 | 276,647 | 851,577 | 1,243,138 | 151,869 | 41,576 | 1,358,351 | 68,672 | 378,247 |
| 2002 | 6,006,169 | 4,983,611 | 277,716 | 910,874 | 1,295,283 | 159,214 | 41,912 | 1,368,897 | 75,456 | 383,435 |
| 2003 | 6,257,284 | 5,218,980 | 271,637 | 1,003,351 | 1,383,997 | 168,025 | 43,322 | 1,394,339 | 79,914 | 382,032 |
| 2004 | 6,607,871 | 5,467,470 | 273,882 | 1,076,932 | 1,455,033 | 183,157 | 44,255 | 1,445,826 | 85,794 | 389,142 |
| 2005 | 6,951,861 | 5,718,546 | 279,014 | 1,145,354 | 1,526,322 | 195,421 | 44,393 | 1,514,408 | 96,469 | 391,745 |
| 2006 | 7,200,497 | 5,871,545 | 280,413 | 1,149,937 | 1,574,709 | 224,204 | 44,059 | 1,584,096 | 102,441 | 390,225 |
| 2007 | 7,315,133 | 5,989,013 | 282,106 | 1,211,563 | 1,582,466 | 239,300 | 47,159 | 1,602,107 | 115,587 | 381,401 |
| 2008 | 7,790,967 | 6,481,057 | 309,191 | 1,318,601 | 1,649,046 | 263,131 | 79,602 | 1,666,584 | 123,108 | 435,822 |
| 2009 | 8,779,319 | 7,125,819 | 326,319 | 1,492,746 | 1,767,744 | 299,537 | 104,648 | 1,763,629 | 139,945 | 563,878 |
| 2010 | 9,812,653 | 7,818,724 | 340,739 | 1,591,169 | 2,061,795 | 329,351 | 144,269 | 1,842,826 | 161,257 | 641,802 |

Source: Eurostat

## Appendix E

| S&P | Moody's | Fitch | Explanation |
|---|---|---|---|
| Investment Grade | | | |
| AAA | Aaa | AAA | Prime |
| AA+ | Aa1 | AA | High grade |
| AA | Aa2 | | |
| AA- | Aa3 | | |
| A+ | A1 | A | Upper medium grade |
| A | A2 | | |
| A- | A3 | | |
| BBB+ | Baa1 | BBB | Medium grade |
| BBB | Baa2 | | |
| BBB- | Baa3 | | |
| Non-Investment Grade | | | |
| BB+ | Ba1 | BB | Speculative |
| BB | Ba2 | | |
| BB- | Ba3 | | |
| B+ | B1 | B | |
| B | B2 | | |
| B- | B3 | | |
| CCC+ | Caa1 | CCC | Highly Speculative |
| CCC | Caa2 | | |
| CCC- | Caa3 | CC | |
| CC | Ca | C | |
| C | | | |
| D | C | D | In default |
| Source: JP Morgan Bond School | | | |

# Appendix F

**Average Yield, 10 Year Government Bond**

| Month/Year | Eurozone | Belgium | France | Germany | Greece | Italy | Ireland | Portugal | Spain |
|---|---|---|---|---|---|---|---|---|---|
| Jan-01 | 4.7931 | 5.1383 | 4.936 | 4.7931 | 5.3403 | 5.1799 | 5.0057 | 5.1527 | 5.1119 |
| Feb-01 | 4.7499 | 5.1258 | 4.893 | 4.7499 | 5.305 | 5.1653 | 4.9688 | 5.1223 | 5.0858 |
| Mar-01 | 4.701 | 5.0893 | 4.847 | 4.701 | 5.2673 | 5.1319 | 4.9188 | 5.1277 | 5.0416 |
| Apr-01 | 5.0282 | 5.3854 | 5.169 | 5.0282 | 5.5192 | 5.4268 | 5.2644 | 5.4346 | 5.3605 |
| May-01 | 5.1661 | 5.4701 | 5.291 | 5.1661 | 5.603 | 5.5432 | 5.3627 | 5.532 | 5.4604 |
| Jun-01 | 5.096 | 5.4202 | 5.233 | 5.096 | 5.5696 | 5.4958 | 5.2897 | 5.4818 | 5.4116 |
| Jul-01 | 4.8758 | 5.1839 | 4.992 | 4.8758 | 5.3546 | 5.268 | 5.065 | 5.2505 | 5.1818 |
| Aug-01 | 4.7843 | 5.084 | 4.903 | 4.7843 | 5.2388 | 5.1458 | 4.9488 | 5.136 | 5.073 |
| Sep-01 | 4.7868 | 5.0807 | 4.897 | 4.7868 | 5.2615 | 5.1522 | 4.9538 | 5.1358 | 5.0707 |
| Oct-01 | 4.3931 | 4.6672 | 4.528 | 4.3931 | 4.839 | 4.7454 | 4.5278 | 4.6958 | 4.6689 |
| Nov-01 | 4.5513 | 4.8272 | 4.673 | 4.5513 | 4.9817 | 4.9146 | 4.7155 | 4.8457 | 4.8308 |
| Dec-01 | 4.994 | 5.1861 | 5.065 | 4.994 | 5.3216 | 5.2669 | 5.0952 | 5.1863 | 5.1767 |
| Jan-02 | 4.9008 | 5.1577 | 4.979 | 4.9008 | 5.2772 | 5.1852 | 5.1771 | 5.1335 | 5.0804 |
| Feb-02 | 4.9601 | 5.1827 | 5.034 | 4.9601 | 5.3245 | 5.2289 | 5.2097 | 5.1928 | 5.1328 |
| Mar-02 | 5.2511 | 5.4613 | 5.325 | 5.2511 | 5.5742 | 5.5012 | 5.4884 | 5.4631 | 5.4205 |
| Apr-02 | 5.1181 | 5.3349 | 5.207 | 5.1181 | 5.4484 | 5.3623 | 5.3569 | 5.3547 | 5.2891 |
| May-02 | 5.1643 | 5.3706 | 5.251 | 5.1643 | 5.4758 | 5.392 | 5.3885 | 5.3923 | 5.3566 |
| Jun-02 | 4.9377 | 5.1692 | 5.026 | 4.9377 | 5.2708 | 5.1858 | 5.1687 | 5.2013 | 5.1484 |
| Jul-02 | 4.7486 | 4.9637 | 4.831 | 4.7486 | 5.0888 | 4.9953 | 4.9798 | 5.0309 | 4.9439 |
| Aug-02 | 4.5646 | 4.7713 | 4.65 | 4.5646 | 4.8933 | 4.795 | 4.8016 | 4.8203 | 4.7446 |
| Sep-02 | 4.268 | 4.4773 | 4.384 | 4.268 | 4.6052 | 4.5752 | 4.5137 | 4.5287 | 4.4543 |
| Oct-02 | 4.5073 | 4.6579 | 4.59 | 4.5073 | 4.7917 | 4.7567 | 4.7066 | 4.6988 | 4.6131 |
| Nov-02 | 4.4869 | 4.6109 | 4.556 | 4.4869 | 4.7224 | 4.6989 | 4.6356 | 4.6286 | 4.5667 |
| Dec-02 | 4.1998 | 4.3152 | 4.259 | 4.1998 | 4.4237 | 4.4246 | 4.2998 | 4.3256 | 4.2789 |
| Jan-03 | 4.0681 | 4.2273 | 4.119 | 4.0681 | 4.3353 | 4.2755 | 4.1664 | 4.1674 | 4.115 |
| Feb-03 | 3.9139 | 4.0485 | 3.949 | 3.9139 | 4.1707 | 4.0794 | 3.9841 | 3.976 | 3.9195 |
| Mar-03 | 4.0405 | 4.1714 | 4.116 | 4.0405 | 4.2759 | 4.2073 | 4.106 | 4.2061 | 4.0449 |
| Apr-03 | 4.0881 | 4.1943 | 4.144 | 4.0881 | 4.2564 | 4.228 | 4.1337 | 4.2289 | 4.169 |
| May-03 | 4.2409 | 3.8271 | 3.772 | 3.7172 | 3.876 | 3.8445 | 3.7722 | 3.8634 | 3.7915 |
| Jun-03 | 4.2380 | 3.8997 | 3.846 | 3.7985 | 3.9454 | 3.8949 | 3.8459 | 3.9353 | 3.87 |
| Jul-03 | 4.0502 | 4.26 | 4.198 | 4.1398 | 4.3169 | 4.336 | 4.1952 | 4.2913 | 4.2301 |
| Aug-03 | 4.2380 | 4.2561 | 4.194 | 4.1366 | 4.3137 | 4.3249 | 4.2027 | 4.2921 | 4.2227 |
| Sep-03 | 4.0502 | 4.0535 | 4.042 | 3.9543 | 4.1314 | 4.1344 | 3.986 | 4.1032 | 4.0052 |
| Oct-03 | 4.3245 | 4.3614 | 4.343 | 4.3245 | 4.4354 | 4.4437 | 4.314 | 4.4652 | 4.326 |
| Nov-03 | 4.4511 | 4.4912 | 4.463 | 4.4511 | 4.5596 | 4.5658 | 4.4374 | 4.5982 | 4.4518 |
| Dec-03 | 4.2855 | 4.3376 | 4.297 | 4.2855 | 4.4187 | 4.4165 | 4.26 | 4.437 | 4.2874 |
| Jan-04 | 4.2363 | 4.3657 | 4.258 | 4.2363 | 4.448 | 4.3683 | 4.2066 | 4.4006 | 4.3016 |

| Month/Year | Eurozone | Belgium | France | Germany | Greece | Italy | Ireland | Portugal | Spain |
|---|---|---|---|---|---|---|---|---|---|
| Feb-04 | 4.0469 | 4.1818 | 4.063 | 4.0469 | 4.2612 | 4.2741 | 4.008 | 4.2058 | 4.1154 |
| Mar-04 | 3.9275 | 4.0818 | 4.002 | 3.9275 | 4.1688 | 4.1717 | 4.2092 | 4.1007 | 4.0107 |
| Apr-04 | 4.1709 | 4.3027 | 4.242 | 4.1709 | 4.3992 | 4.3986 | 4.4127 | 4.3157 | 4.2349 |
| May-04 | 4.3681 | 4.4532 | 4.396 | 4.3681 | 4.5361 | 4.5558 | 4.5593 | 4.4643 | 4.3931 |
| Jun-04 | 4.3119 | 4.3966 | 4.333 | 4.3119 | 4.5026 | 4.496 | 4.4796 | 4.4161 | 4.3349 |
| Jul-04 | 4.2119 | 4.2927 | 4.231 | 4.2119 | 4.3943 | 4.3929 | 4.3734 | 4.3051 | 4.233 |
| Aug-04 | 4.019 | 4.1013 | 4.036 | 4.019 | 4.2015 | 4.198 | 4.1824 | 4.1078 | 4.0376 |
| Sep-04 | 3.9876 | 4.0688 | 4.048 | 3.9876 | 4.184 | 4.1563 | 4.1333 | 4.0659 | 4.0023 |
| Oct-04 | 3.8691 | 3.9431 | 3.926 | 3.8691 | 4.0549 | 4.0289 | 4.019 | 3.9459 | 3.8756 |
| Nov-04 | 3.7869 | 3.7981 | 3.787 | 3.7869 | 3.9071 | 3.8738 | 3.8604 | 3.7802 | 3.7373 |
| Dec-04 | 3.6769 | 3.6856 | 3.673 | 3.6769 | 3.7992 | 3.825 | 3.7428 | 3.6717 | 3.7074 |
| Jan-05 | 3.5431 | 3.5402 | 3.534 | 3.5431 | 3.6334 | 3.6574 | 3.5864 | 3.519 | 3.5582 |
| Feb-05 | 3.7108 | 3.7082 | 3.744 | 3.7108 | 3.8927 | 3.822 | 3.7547 | 3.6863 | 3.7248 |
| Mar-05 | 3.6179 | 3.7081 | 3.652 | 3.6179 | 3.8344 | 3.7522 | 3.6828 | 3.7 | 3.6374 |
| Apr-05 | 3.3923 | 3.5039 | 3.437 | 3.3923 | 3.6665 | 3.5636 | 3.4551 | 3.5 | 3.422 |
| May-05 | 3.2678 | 3.3456 | 3.285 | 3.2678 | 3.5149 | 3.4803 | 3.3018 | 3.4 | 3.2629 |
| Jun-05 | 3.1277 | 3.1924 | 3.128 | 3.1277 | 3.3709 | 3.3424 | 3.1565 | 3.2 | 3.1124 |
| Jul-05 | 3.2392 | 3.3094 | 3.246 | 3.2392 | 3.4587 | 3.4432 | 3.2777 | 3.3826 | 3.2297 |
| Aug-05 | 3.0986 | 3.1593 | 3.101 | 3.0986 | 3.3185 | 3.3024 | 3.1343 | 3.2441 | 3.079 |
| Sep-05 | 3.1448 | 3.1958 | 3.187 | 3.1448 | 3.3593 | 3.3434 | 3.1716 | 3.2849 | 3.1267 |
| Oct-05 | 3.387 | 3.4251 | 3.419 | 3.387 | 3.5931 | 3.5885 | 3.4087 | 3.5094 | 3.4294 |
| Nov-05 | 3.4488 | 3.4587 | 3.453 | 3.4488 | 3.6378 | 3.6276 | 3.4445 | 3.542 | 3.4711 |
| Dec-05 | 3.3033 | 3.3241 | 3.3 | 3.3033 | 3.5025 | 3.5023 | 3.2889 | 3.4022 | 3.3091 |
| Jan-06 | 3.463 | 3.5277 | 3.473 | 3.463 | 3.7572 | 3.686 | 3.4665 | 3.5863 | 3.4754 |
| Feb-06 | 3.4855 | 3.543 | 3.516 | 3.4855 | 3.7755 | 3.6991 | 3.486 | 3.6 | 3.5029 |
| Mar-06 | 3.7672 | 3.8254 | 3.799 | 3.7672 | 4.0735 | 4.0598 | 3.7743 | 3.77 | 3.7887 |
| Apr-06 | 3.9468 | 3.9919 | 3.98 | 3.9468 | 4.2709 | 4.2647 | 3.9515 | 4.03 | 3.9627 |
| May-06 | 3.9762 | 4.0069 | 3.988 | 3.9762 | 4.2985 | 4.2926 | 3.963 | 4.07 | 3.9793 |
| Jun-06 | 4.0643 | 4.0776 | 4.075 | 4.0643 | 4.3781 | 4.3685 | 4.0576 | 4.1 | 4.0626 |
| Jul-06 | 3.9174 | 3.9423 | 3.926 | 3.9174 | 4.2301 | 4.2104 | 3.9091 | 4.0884 | 3.9203 |
| Aug-06 | 3.7566 | 3.785 | 3.761 | 3.7566 | 4.0675 | 4.0407 | 3.76 | 3.9258 | 3.7555 |
| Sep-06 | 3.7051 | 3.7394 | 3.716 | 3.7051 | 4 | 3.987 | 3.7042 | 3.8794 | 3.7133 |
| Oct-06 | 3.7376 | 3.7772 | 3.763 | 3.7376 | 4.0114 | 3.9924 | 3.7467 | 3.9081 | 3.7394 |
| Nov-06 | 3.6888 | 3.7228 | 3.713 | 3.6888 | 3.9427 | 3.9339 | 3.6845 | 3.849 | 3.7288 |
| Dec-06 | 3.9417 | 3.9894 | 3.978 | 3.9417 | 4.2032 | 4.1952 | 3.9529 | 4.1107 | 4.0009 |
| Jan-07 | 4.0962 | 4.1471 | 4.139 | 4.0962 | 4.3605 | 4.3092 | 4.1025 | 4.2375 | 4.1431 |
| Feb-07 | 3.9532 | 4.0099 | 4.001 | 3.9532 | 4.2059 | 4.1879 | 3.9609 | 4.0951 | 4.0014 |
| Mar-07 | 4.053 | 4.1205 | 4.105 | 4.053 | 4.3045 | 4.2828 | 4.1204 | 4.204 | 4.108 |
| Apr-07 | 4.15 | 4.2201 | 4.196 | 4.15 | 4.3946 | 4.3732 | 4.2155 | 4.2821 | 4.2054 |
| May-07 | 4.4158 | 4.4739 | 4.455 | 4.4158 | 4.6301 | 4.611 | 4.4765 | 4.5342 | 4.4602 |
| Jun-07 | 4.5697 | 4.6341 | 4.618 | 4.5697 | 4.8102 | 4.7951 | 4.6474 | 4.7539 | 4.6374 |

| Month/Year | Eurozone | Belgium | France | Germany | Greece | Italy | Ireland | Portugal | Spain |
|---|---|---|---|---|---|---|---|---|---|
| Jul-07 | 4.3456 | 4.4855 | 4.437 | 4.3456 | 4.6705 | 4.6511 | 4.47625 | 4.6069 | 4.4606 |
| Aug-07 | 4.2398 | 4.3973 | 4.325 | 4.2398 | 4.5643 | 4.524 | 4.4021 | 4.4951 | 4.3598 |
| Sep-07 | 4.327 | 4.4845 | 4.411 | 4.327 | 4.6243 | 4.5943 | 4.47805 | 4.5525 | 4.4359 |
| Oct-07 | 4.2367 | 4.3702 | 4.328 | 4.2367 | 4.5391 | 4.5211 | 4.3936 | 4.4715 | 4.3522 |
| Nov-07 | 4.1243 | 4.3445 | 4.259 | 4.1243 | 4.4598 | 4.4765 | 4.3745 | 4.3929 | 4.314 |
| Dec-07 | 4.305 | 4.4647 | 4.419 | 4.305 | 4.6254 | 4.6439 | 4.4853 | 4.5419 | 4.4261 |
| Jan-08 | 3.9286 | 4.1983 | 4.051 | 3.9286 | 4.2992 | 4.3033 | 4.1575 | 4.2086 | 4.1281 |
| Feb-08 | 3.8893 | 4.1921 | 4.006 | 3.8893 | 4.3317 | 4.3217 | 4.1414 | 4.2099 | 4.0604 |
| Mar-08 | 3.8974 | 4.2963 | 4.108 | 3.8974 | 4.456 | 4.4151 | 4.2837 | 4.4058 | 4.2167 |
| Apr-08 | 4.1209 | 4.4119 | 4.326 | 4.1209 | 4.5846 | 4.5707 | 4.5452 | 4.5631 | 4.3829 |
| May-08 | 4.4025 | 4.6941 | 4.589 | 4.4025 | 4.962 | 4.8504 | 4.7762 | 4.7781 | 4.6133 |
| Jun-08 | 4.6168 | 4.9463 | 4.808 | 4.6168 | 5.2774 | 5.1638 | 5.0494 | 5.0654 | 4.8954 |
| Jul-08 | 4.3534 | 4.7034 | 4.531 | 4.3534 | 4.9935 | 4.8958 | 4.6942 | 4.8041 | 4.6666 |
| Aug-08 | 4.1745 | 4.549 | 4.377 | 4.1745 | 4.8753 | 4.8126 | 4.5428 | 4.6648 | 4.5429 |
| Sep-08 | 4.013 | 4.6196 | 4.343 | 4.013 | 4.9429 | 4.8889 | 4.584 | 4.705 | 4.59 |
| Oct-08 | 3.8982 | 4.6226 | 4.299 | 3.8982 | 5.5047 | 5.1414 | 4.859 | 4.8171 | 4.5993 |
| Nov-08 | 3.2543 | 3.9787 | 3.676 | 3.2543 | 4.8323 | 4.4552 | 4.1645 | 4.0151 | 3.8834 |
| Dec-08 | 2.948 | 3.7713 | 3.412 | 2.948 | 5.2183 | 4.3754 | 4.2626 | 3.9609 | 3.8078 |
| Jan-09 | 3.2937 | 4.3986 | 3.803 | 3.2937 | 5.8094 | 4.7059 | 5.512 | 4.5748 | 4.3904 |
| Feb-09 | 3.1101 | 4.1958 | 3.659 | 3.1101 | 5.6688 | 4.6726 | 5.5013 | 4.5689 | 4.2763 |
| Mar-09 | 2.9925 | 3.9395 | 3.55 | 2.9925 | 5.7355 | 4.3875 | 5.4616 | 4.5377 | 4.0433 |
| Apr-09 | 3.1765 | 3.8647 | 3.588 | 3.1765 | 5.31 | 4.2707 | 5.1957 | 4.3095 | 3.919 |
| May-09 | 3.5856 | 4.178 | 3.951 | 3.5856 | 5.4381 | 4.4766 | 5.454 | 4.3984 | 4.2822 |
| Jun-09 | 3.3821 | 3.9558 | 3.726 | 3.3821 | 5.0338 | 4.4258 | 5.7233 | 4.3858 | 4.126 |
| Jul-09 | 3.2985 | 3.7298 | 3.566 | 3.2985 | 4.5146 | 4.1518 | 4.9626 | 3.9214 | 3.8399 |
| Aug-09 | 3.2554 | 3.701 | 3.535 | 3.2554 | 4.486 | 4.0685 | 4.8398 | 3.8791 | 3.7692 |
| Sep-09 | 3.2185 | 3.6625 | 3.535 | 3.2185 | 4.5144 | 4.0091 | 4.6681 | 3.8457 | 3.8036 |
| Oct-09 | 3.229 | 3.6283 | 3.531 | 3.229 | 4.647 | 4.0663 | 4.6935 | 3.7878 | 3.7842 |
| Nov-09 | 3.1559 | 3.561 | 3.416 | 3.1559 | 4.9871 | 4.0091 | 4.836 | 3.7482 | 3.7427 |
| Dec-09 | 3.3837 | 3.7027 | 3.591 | 3.3837 | 5.7653 | 4.1341 | 4.8379 | 4.0534 | 3.9718 |
| Jan-10 | 3.194 | 3.7621 | 3.459 | 3.194 | 6.8443 | 4.1073 | 4.8437 | 4.3941 | 4.1181 |
| Feb-10 | 3.0991 | 3.6525 | 3.401 | 3.0991 | 6.3526 | 3.9884 | 4.6083 | 4.1991 | 3.8583 |
| Mar-10 | 3.0905 | 3.5339 | 3.417 | 3.0905 | 6.5278 | 3.9732 | 4.4736 | 4.2044 | 3.8134 |
| Apr-10 | 3.0131 | 3.4801 | 3.287 | 3.0131 | 8.9511 | 4.0076 | 5.1137 | 5.123 | 4.027 |
| May-10 | 2.6565 | 3.1477 | 2.919 | 2.6565 | 7.6969 | 4.1367 | 4.7988 | 4.6656 | 4.2539 |
| Jun-10 | 2.5739 | 3.4414 | 3.047 | 2.5739 | 10.4134 | 4.0864 | 5.4961 | 5.6811 | 4.5531 |
| Jul-10 | 2.6676 | 3.2979 | 2.942 | 2.6676 | 10.2843 | 3.9461 | 5.0289 | 5.1759 | 4.2081 |
| Aug-10 | 2.1124 | 2.8283 | 2.465 | 2.1124 | 11.346 | 3.819 | 5.6784 | 5.4283 | 4.045 |
| Sep-10 | 2.276 | 3.1335 | 2.656 | 2.276 | 10.4499 | 3.871 | 6.5685 | 6.2841 | 4.1198 |
| Oct-10 | 2.5163 | 3.3161 | 2.911 | 2.5163 | 10.5586 | 3.9349 | 6.9167 | 5.9337 | 4.2077 |
| Nov-10 | 2.6666 | 3.9938 | 3.151 | 2.6666 | 11.8429 | 4.6589 | 9.1912 | 6.9539 | 5.4999 |

| Month/Year | Eurozone | Belgium | France | Germany | Greece | Italy | Ireland | Portugal | Spain |
|---|---|---|---|---|---|---|---|---|---|
| Dec-10 | 2.9597 | 3.9665 | 3.36 | 2.9597 | 12.4567 | 4.8062 | 9.0537 | 6.5815 | 5.4441 |
| Jan-11 | 3.1529 | 4.2544 | 3.529 | 3.1529 | 11.2132 | 4.7145 | 8.966 | 6.938 | 5.3503 |
| Feb-11 | 3.1689 | 4.2576 | 3.542 | 3.1689 | 11.7776 | 4.8346 | 9.1573 | 7.3657 | 5.37 |
| Mar-11 | 3.3523 | 4.2925 | 3.71 | 3.3523 | 12.7352 | 4.8162 | 10.0133 | 8.3034 | 5.2839 |
| Apr-11 | 3.238 | 4.2221 | 3.559 | 3.238 | 15.3509 | 4.725 | 10.3468 | 9.4965 | 5.2783 |
| May-11 | 3.0187 | 4.167 | 3.384 | 3.0187 | 15.8428 | 4.7765 | 10.8054 | 9.3771 | 5.3543 |
| Jun-11 | 3.0234 | 4.0859 | 3.404 | 3.0234 | 15.9693 | 4.8764 | 11.4506 | 10.6295 | 5.4357 |
| Jul-11 | 2.5367 | 4.361 | 3.219 | 2.5367 | 14.4843 | 5.8577 | 10.6232 | 10.5533 | 6.0586 |
| Aug-11 | 2.2166 | 4.0172 | 2.91 | 2.2166 | 17.3929 | 5.1273 | 8.4348 | 10.1146 | 5.0302 |
| Sep-11 | 1.8853 | 3.6404 | 2.596 | 1.8853 | 21.7842 | 5.531 | 7.4619 | 10.6749 | 5.1174 |
| Oct-11 | 2.0235 | 4.3578 | 3.093 | 2.0235 | 22.2803 | 6.0813 | 7.88975 | 11.4683 | 5.5263 |
| Nov-11 | 2.2762 | 4.971 | 3.38 | 2.2762 | 29.966 | 7.0013 | 9.0245 | 13.4039 | 6.2008 |
| Dec-11 | 1.8249 | 4.0583 | 3.137 | 1.8249 | 31.3132 | 7.0287 | 8.13615 | 12.7713 | 5.0397 |
| Jan-12 | 1.7856 | 3.6512 | 3.043 | 1.7856 | 31.27 | 5.9335 | 7.05615 | 15.6469 | 4.9439 |
| Feb-12 | 1.8165 | 3.5729 | 2.872 | 1.8165 | 32.4469 | 5.1738 | 6.8695 | 13.3657 | 4.968 |
| Mar-12 | 1.8635 | 3.4983 | 2.761 | 1.8635 | 33.2393 | 4.9364 | 6.88645 | 13.3318 | 4.8491 |

**Note: for the periods Oct 2011 - Mar 2012 and Mar 2007 to Sept 2007, no 10 year data for Ireland was available. The numbers shown are an average yield for 9 year and 15 year bonds. Source: Bloomberg Finance L.P.**

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