The Aegean Contagion: a Case Study on the GIIPS

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The University of Tokyo, Graduate School of Public Policy
Case Study on International Financial Institutions, 2010 Summer
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Abstract

This report examines high-frequency contagion effects among Greece, Ireland, Italy, Portugal, Spain (GIIPS), France and Belgium during the European sovereign debt crisis. Using daily data of each country's government bond yield spread between January 2008 and July 2010, the origin and direction of negative spillovers are defined and analyzed. Regression analysis furthermore shows that Greece has been the main origin country of high-frequency contagion during the crisis, affecting Ireland and Portugal greatly, but Italy and Spain to a lesser extent. A shift of origins as occurred in the spring of 2009, from Greece to Ireland and back again after Greece revealed its real deficits in November 2009. We also found weak but supportive evidence of a significant shift of contagion. Finally, we examined the transmission channel of the contagion. We found that the contagion effect has a high correlation with the fiscal situation in the affected countries, implying that investors' reassessment of the risks in countries with similar fundamentals as the origin country is the cause of the contagion.

1. Introduction

On 5 November 2009, less than one month in office, George Papandreou's social democratic government revealed that Greece's budget deficit for 2009 had to be readjusted from 6 to 12.7 percent of GDP. It came as a tremendous shock that the previous administration had been able to conceal almost half of its deficit and over the months that followed many more shocks would follow. Even though budget cuts were presented within days and Greece formally announced its plans to cut its deficit according to the Eurozone's Stability and Growth Pact norms by 2012, it did not prevent investors from losing confidence and financial institutions giving out grim outlooks over the following months.

After a series of austerity plans proposed by the Greek government itself, more negative revelations and eventual downgrades of Greece's bonds to 'junk status' by the world's major rating agencies, Greece was forced to ask for help to the International Monetary Fund (IMF) and European Financial Institutions. On 2 May 2010, after days of negotiations, intervention finally came for Greece through a large multi-stakeholder rescue plan coordinated by the IMF, the ECB and other EU member states. Within a week, the bold and ambitious European Financial Stability Facility was installed, affirming rumours that the greatest concern the financial institutions had when they agreed on a rescue plan for Greece was the fear for contagion to other member states such as Portugal and Spain. Already at an early stage of the crisis, analysts noticed that CDS and yield spread of the GIIPS seemed to be worsening almost simultaneously, particularly in comparison to countries such as Germany. Fear of contagion between these countries with similar macroeconomic conditions could therefore not have come as a surprise.

Contagion of crisis and its potentially devastating effects have become a major interest of researchers and International Financial Institutions over the past decades and have especially been receiving increasing attention since the Asian crisis of 1997-1998. How contagion occurs, how it could be prevented and what should be done to contain it are all highly relevant and pressing issues, particularly in light of the current European sovereign debt crisis.

This paper is one of the first attempts to analyze the role of contagion in the European sovereign debt crisis, now often called 'the Aegean Contagion' after its most apparent origin country. At the hand of the daily yield spread data, spillovers are defined and analyzed from the ground-zero or origin country to the affected countries. With modifications, the model that is used is Ito and Hashimoto's (2005) analysis of high-frequency contagion in the Asian crisis. We used it to answer the following questions: given a large shock in one country, does high-frequency contagion occur to others in the European sovereign debt crisis, between 1 January 2008 and July 2010? If so, does this transmission of shocks change over time and are there shifts of origins? Finally, in what direction does the contagion occur and what are its channels of transmission?

The rest of the paper is organized as follows: The introduction will be followed by a brief overview of the European sovereign debt crisis so far, relevant literature on concepts of contagion and the data that is used for this analysis. Then, our methodology will be further explained, after which the origins will be defined and contagion effects will be examined at the hand of the proposed regression analysis. Furthermore channels of transmission will be investigated and financial linkages plus shifting investors' sentiments will be analyzed in light of the current events. Finally, some implications of the model that has been used will be discussed and the final conclusions of this case study will be presented.

2. Background of the European Sovereign Debt Crisis

The Eurozone came into existence with the official launch of the euro on 1 January 1999, after all aspiring member states had met the convergence criteria. Greece qualified in 2000 and was admitted two years later, and physical coins and banknotes were introduced on 1 January 2002 for all. The Eurozone is an economic and monetary union (EMU) that today consists out of 16 European Union (EU) member states. The monetary policy of the Eurozone is in hands of the ECB, but the Eurozone's finance ministers meet as the Euro Group and take political decisions. Finally, there is no common representation or fiscal policy for

the currency union as a whole, which has often been pointed out as a great vulnerability.

After years of convergence and stability, the Eurozone experienced increased widening of the CDS and yield spreads between its member states from the end of 2008 on (figure 1 and 2). This coincides with rapidly growing fiscal deficits (figure 3 and 4) at a time when governments started to adopt fiscal stimulus packages following the Lehman shock and the further global spread of financial and economic distress. Some governments had been borrowing more than others, such as the GIIPS, facilitated by low bond yields and some of the highest growth rates in the EU, mostly due to large foreign capital inflows over the early 2000s.

However, the real onset of the European sovereign debt crisis should be traced to 5 November 2009, when Greece's new Prime Minister George Papandreou's social democratic government revealed that Greece's budget deficit for 2009 had to be readjusted from 6 to 12.7 percent of GDP. This came as a tremendous shock to investors and financial institutions, especially because they had been unaware, or even misled for so long and might be as well by many other countries.

After dozens of proposals by the Greek government to cut deficits on its own, months of social and political unrest following these cuts, considerable help from European institutions that only improved the situation temporarily, and increasingly growing lack of confidence among investors, all major rating agencies downgraded Greek government bonds to 'junk status' from 27 April. CDS and yield spread of Greece, but also to a lesser extent of Portugal and the others, skyrocketed (figure 1 and 2) to almost unimaginable levels. It became clear that much greater intervention from outside was needed. After a mere few days of negotiations, the Eurozone's finance ministers, the ECB and the IMF came up with an unprecedented rescue package for Greece. The markets regained some confidence, especially following the installation of the bold and ambitious European Financial Stability Facility one week later on 9 May 2010. This plan, worth almost a trillion dollars was clearly aimed at ensuring financial stability across Europe and not only for Greece. Rumours were finally confirmed

that the greatest fear policymakers in Brussels and Washington had was that the Greek crisis might spill over to other countries in Europe, perhaps even to the much larger economies of Italy and Spain.

Already from a very early stage in the crisis, analysts had noticed the strikingly similar movements of CDS and yield spreads among the GIIPS (figure 1 and 2), in positive and negative terms. Many warned as well that an unanticipated crisis in Italy or Spain could have devastating effects for Europe as a whole and might perhaps even mean the end of the Eurozone. The potential effects of contagion had been imprinted in the heads of policymakers and researchers at International Financial Institutions by most notably the Asian crisis of 1997-1998. After this crisis, increasing attention has been given to the study of contagion, its prevention and containment. The current European sovereign debt crisis can be used to draw parallels to previous crises or to shine new light on fiscal deficits and financial stability. What is truly remarkable in this crisis so far has been the degree to which some of the world's most advanced economies have been involved and how great the widening of CDS and yield spread occurred among them in such a short period of time. The current European sovereign debt crisis will therefore undoubtedly be an inspiration for these researchers and policymakers for many more years.

Figure 1: Sovereign CDS Spreads (5 Year, bpts)

Source: Bloomberg

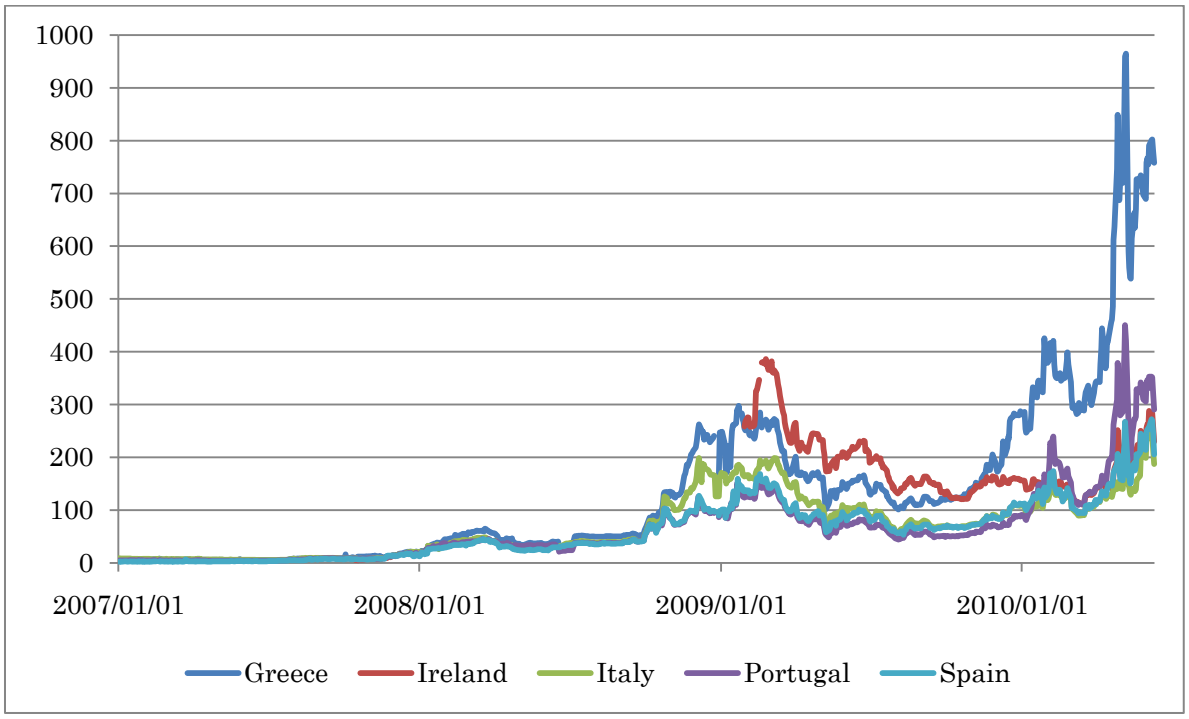


Figure 2: Government Bond Yield (Generic 10 Year, Percentage)

Source: Bloomberg

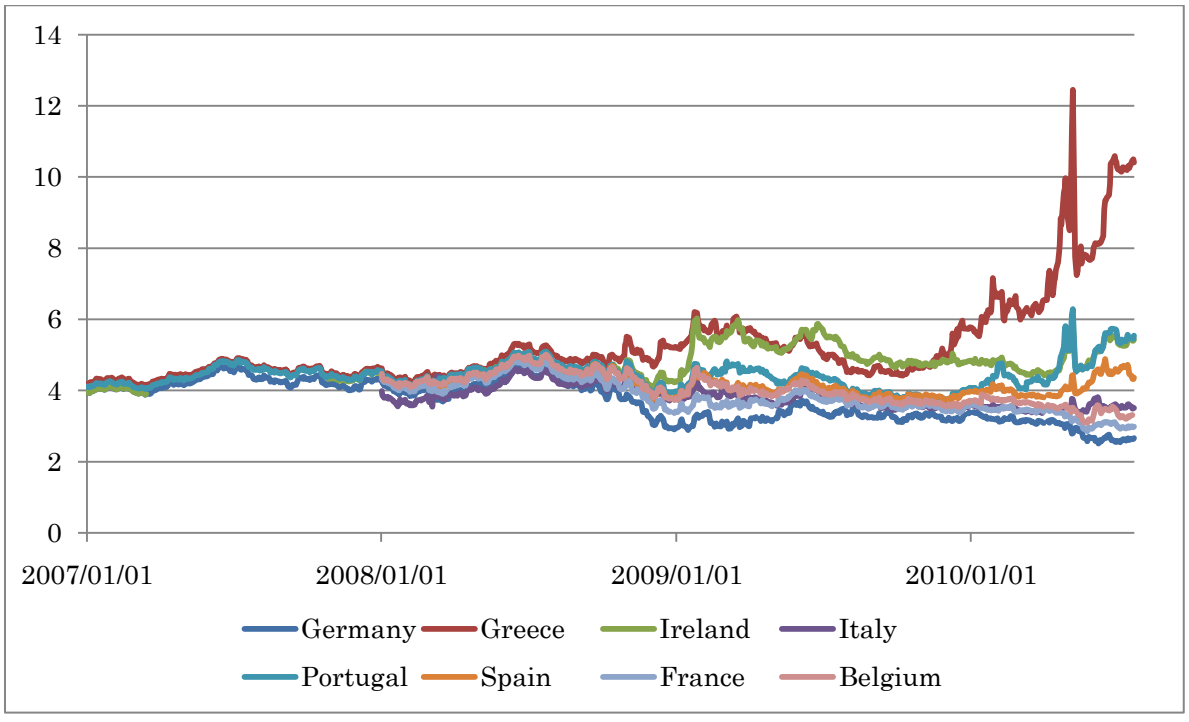


Figure 3: Budget Deficits of the Eurozone Countries (Percentage of GDP)

Source: Eurostat

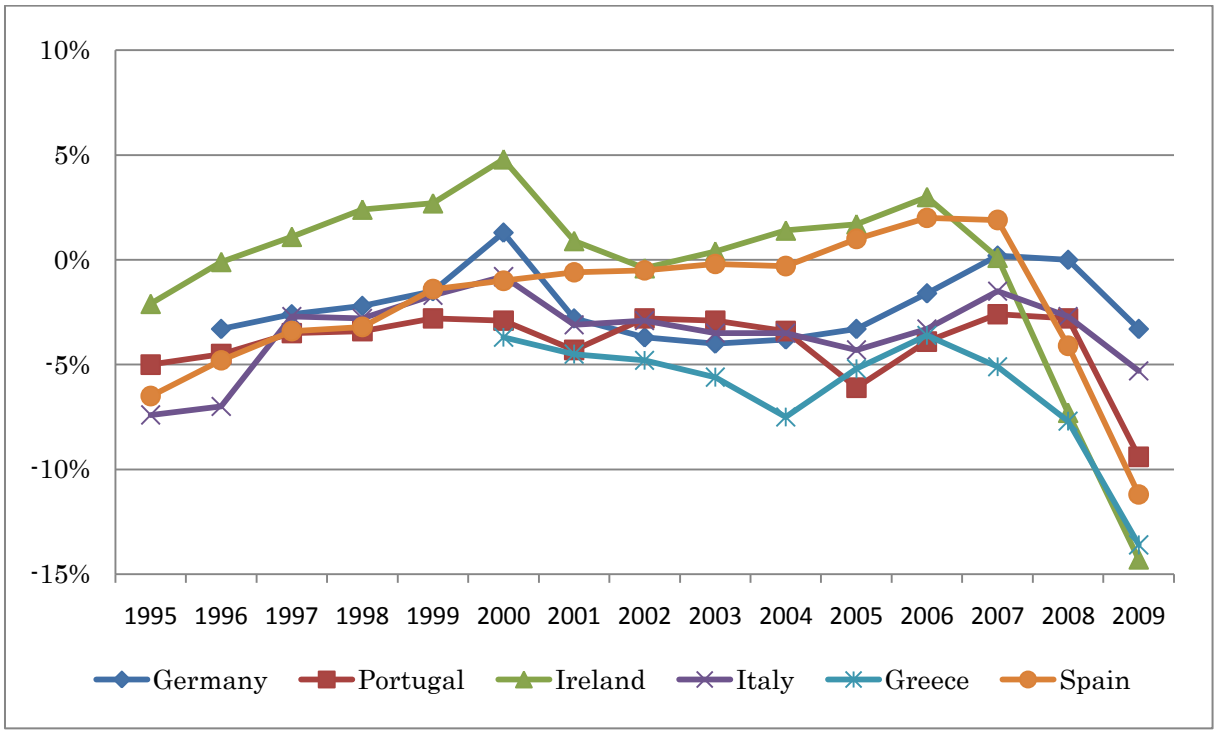
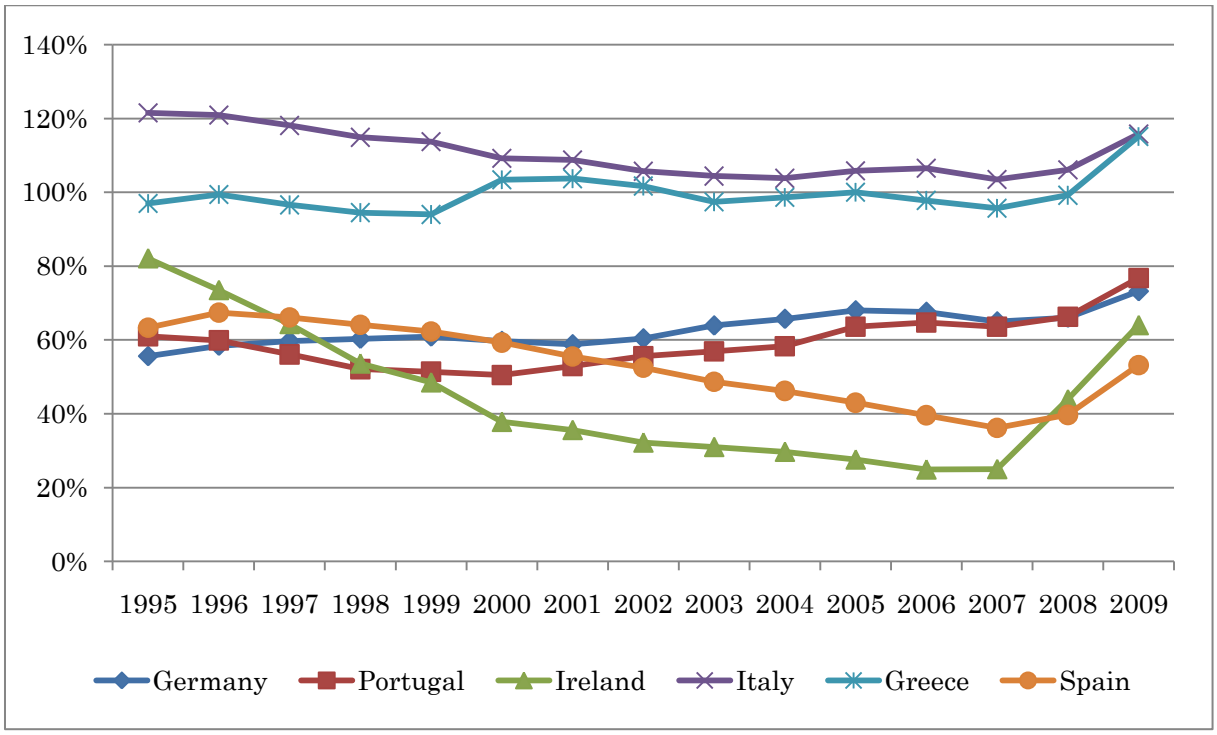


Figure 4: Government Debt of the Eurozone Countries (Percentage of GDP)

Source: Eurostat



3. Literature Review

The number of studies on contagion has been increasing dramatically over the past decades, particularly after the 1992 ERM crisis and 1997 Asian crisis. In this vast body of literature, a myriad of definitions of contagion and its transmission channels has been examined. In an attempt to draw some of the most important and relevant definitions together for this research, first the World Bank's definition of contagion will be discussed, after which a detailed examination of its channels of transmission will follow. Finally, Ito and Hashimoto (2005), whose model helped us to analyze the Aegean Contagion with certain modifications, will be discussed in more detail.

Some of the most important research on contagion has been published by researchers of International Financial Institutions such as the World Bank and the IMF, particularly since the 1997-1998 Asian crisis. The World Bank has recently presented three useful categories of contagion in which much of the established literature can be divided (World Bank, 2010).

Firstly, there is a so-called 'broad' definition of contagion. This definition refers to all cross-country transmission of shocks and spillovers and is sometimes referred to as fundamentals-based contagion through financial or real links. These types of spillovers might reflect normal interdependence, not particularly in times of crisis, in contrast to much research on contagion over the past years.

The so-called 'restrictive' definition explains the transmission of shocks to other countries or the cross-country correlation, beyond any fundamental link among the countries and beyond common shocks. Sometimes this definition is referred to as excess co-movement and excludes herding behavior or fundamental links per se.

Finally, according to the 'very restrictive' definition contagion occurs when cross-country correlations increase during 'crisis times', relative to correlations during ‘tranquil times.’ Such studies usually consider transmissions across borders for a particular asset market, such as the stock market. In the most common approach adopted using this definition no channel of transmission is identified or examined in detail. Fundamental linkages are not acknowledged

using this definition either, only increases in correlation are recognized as contagion.

Despite the variations and differences, it must be clear from this that there is a fairly broad consensus in the empirical literature on financial contagion that this type of spillover refers to a transmission of shocks. Contagion should thus be distinguished from 'normal' interdependencies and spillovers across asset markets. Probably the most important strand of the contagion research up to now uses conditional correlation analysis to test for shifts in linkages across financial markets during crisis periods (Beirne, 2008).

One of the most fundamental questions, addressed in most works on contagion, is through which channels contagion occurs. Since this has also been a central question in this research, a more detailed investigation of the relevant literature to our research will now follow.

Empirical studies on transmission channels of contagion so far most often identified four potential channels of contagion. The first one is the phenomenon of a common shock. For some definitions of contagion, including ours, a common shock is not considered as a transmission channel. However, it is often the case that common shocks can generate a similar situation as contagion, which cannot be overlooked. Caramazza et al. (2004) lists up some examples of common shocks, which include the increase in U.S. interest rates in the early 1980s as an important factor in the Latin American crisis. Also, the large appreciation of the U.S. dollar during 1995-97 and Japan's weak growth in the 1990s is said to be attributable to the weakening of the external sector in several Asian countries before the Asian crisis.

Second, trade linkages are often investigated in contagion research. Strong trade linkages among countries could transmit a shock originating from one country to another, especially during a currency crisis. Using daily data of stock prices and exchange rates during the Asian crisis, Ito and Hashimoto (2005) conclude that it is highly likely that the transmission channel of contagion can be found in trade linkages. According to their classification, this channel takes several forms, including the devaluation of origin countries or appreciation of the trade partner country, which could decrease the export of the affected countries

and worsen the trade balance of the affected country (i.e. competitive effect). Also, countries with a large export share to the worst-hit country can experience a decline in their trade balance and income, which makes investors withdraw funds from the exporting country (i.e. income effect). Finally, depreciation of the origin country can make import prices of the trading partners cheaper, raising economic welfare, other things being constant (i.e. cheaper import effect). Since among these trade linkage channels two out of three channels are related to currency effects and only one effect, the income effect, can occur without currency devaluation, we do not consider trade linkage channels in our analysis for the European single currency zone.

Third, financial linkages can form another channel of transmission. A crisis in one or more countries might induce investors to rebalance their portfolios, to prevent further losses or to retain liquidity. Kaminsky and Reinhart (2000) introduced a useful notion of the 'common creditor hypothesis'. When a crisis breaks out in one country, investors who have positions in that country usually tend to reduce their now increased risk exposure and will sell assets whose returns are likely to be correlated with those of the origin country. Therefore the larger positions the common lender has to both the origin and affected countries, the larger the contagion should be. Also, when both the origin and affected country have larger liabilities to the common lender, the larger the contagion becomes. Kaminsky and Reinhart (2000) concluded that financial sector links via common bank lenders are a powerful channel of contagion. Using different measures of financial linkages, many empirical studies, such as Van Rijckeghem and Weder (2001) and Caramazza et al. (2004), show that financial linkages play a crucial role in transmitting contagion. In section 6 of this paper, we examine the role of the financial linkages in the European sovereign debt crisis.

Fourth, as a channel based on non-fundamentals, shifts in investors' sentiments could be a channel of transmission. A crisis in one country can serve as a 'wake-up call', inducing markets to reassess other countries' risks. Gande and Parsley (2005) examine the effect of a sovereign credit rating change of one country on the sovereign credit spreads of other countries and found evidence of

spillover effects. A negative rating change in one country can have a significant effect on the sovereign credit spreads of other countries in their research. Other things remaining equal, a credit rating change in one country itself has nothing to do with the fundamentals of other countries. However, their findings show that this update of information serves as a source of shift in investors' mind and can thus affect other countries' sovereign credit spreads. Although they did not limit themselves to the analysis of crisis situations, this 'news spillover' effect is worth considering for crisis contagion as well.

Finally, we would like to separately review Ito and Hashimoto (2005) once more in detail, since in this paper basically we follow their method with some modifications. They investigated a rather usefully restrictive definition of contagion, also distinguishing from common shocks: so-called high-frequency contagion in which spillovers occur within days of shocks during crisis from one entity to other interdependent ones. This is a very useful definition to investigate contagion of crises, not only the Asian crisis of 1997-1998, explored through a uniquely operational method of contagion analysis.

There are three outstanding characteristics in Ito and Hashimoto (2005). First, it is the use of daily data, so its definition of high-frequency, capturing the effect of negative shocks within days. This has often been overlooked in analyses with weekly or monthly data. Second, they first identify the direction of contagion, from origin countries to affected countries by defining that origin countries experience the largest effect of a shock because it originates from them. Third, they looked carefully into the transmission mechanisms of contagion and pointed out the relevance of trade links during the Asian crisis.

In the present paper, their approach has been gratefully modified and used to analyze the European sovereign debt crisis. The biggest advantage to follow their approach is that it enables us to detect the origin country empirically without ad hoc assumptions, and identify the direction of contagion. As we will see in the following sections, the origin country is not always as clear as other studies have assumed, and the origin country is not necessarily a single country but may change in the midst of a crisis. Therefore, identifying origin countries

using high frequency data enables us to avoid these problems and investigate the characteristics of the crisis more in detail.

High-frequency contagion in this research is defined as negative spillovers from an origin to other countries in terms of its yield spreads. The origin is the worst-hit country of that day to which investors respond, having effect on other countries' spreads. Particular attention has been given to shifts of contagion as well, resulting from shifts of origins. As Ito and Hashimoto (2005), we also check the consistency of our definition of origin, by cross-checking it against country-specific financial news reports from Bloomberg and other relevant sources, and use this to also investigate the transmission of the contagion. All in all, we believe this method is useful as a first investigation into the European sovereign debt crisis, in particular because its operational methods, clear identification of directions and channels, and successfulness in showing the consistency of their model at the hand of news analyses.

4. Methodology and Data Analysis

In this section, we explain our methodology to examine the contagion in the European sovereign crisis. Also, we identify 'origin countries', the concept which we will cover in the rest of the section, and provide the basement for the following analysis in section 5.

Though we obtained both sovereign CDS spreads and government bond yield, we use government bond yield in our analysis, largely due to its advantage in availability for a large number of countries and the small number of missing data compared to the CDS dataset. The sample period is 1 January 2008 to 22 July 2010 and countries are the GIIPS countries (Greece, Ireland, Italy, Portugal, and Spain) and France and Belgium. Data source is Bloomberg.

In section 4 and 5, we examine two situations: one is 'crisis' situation and the other is 'non-crisis' situation. Although our primary interest is the 'crisis' contagion, we use 'non-crisis' contagion as supplementary evidence.

Origin countries and affected countries for both situations are identified as follows: First, we calculate the daily change of government bond yield spread

against German sovereign bond. A daily change of the government bond yield spread is expressed as:

$$DR(t,j) = R(t,j) - R(t-1,j)$$

where $R(t,j)$ is government bond yield spread against Germany, of country j at date t. Since we use yield spreads against German government bond, which is considered as a safe asset, a rise in the government bond yield spread, DR(t,j), can be thought to reflect the sovereign risk.

Next, we pick up the biggest DR(t,j) for each t, daily change of the government bond yield spread of each date in the sample. Then if the biggest daily change of spread is larger than 0.05%, i.e. DR(t,j)>0.05, the date is labeled "crisis" situation and if the biggest daily change is positive, i.e. DR(t,j)>0, the date t is labeled "non-crisis" situation. In both cases, the biggest DR(t,j) is denoted as "DOR(t,o)", and the country with DOR(t,o), i.e. country o, is called "origin country" of date t. The only thing that make difference between "crisis" and "non-crisis" situation is the threshold choice: crisis situation set the threshold as DOR(t,o)>0.05 and non-crisis situation set it as DOR(t,o)>0. In that sense, crisis situation is a subset of non-crisis situation. Of course, choosing these thresholds cannot avoid arbitrariness and deserves careful consideration.

Whether it is crisis or non-crisis situation, we define these worst-hit countries as "origins" of contagion. Similarly, daily spillover, the situation in which the worst-hit country affects other countries, is defined as "contagion". The underlying assumption here is that the origin country always experiences the largest negative shock on the date t, and if the rise in the spread beyond the threshold affects other countries' spread, then it is "contagion."

First, we examine the crisis situation, when the biggest daily change in the spread is more than 0.05 percent. We obtained 200 dates of crisis days out of original 667 samples. Table 1 lists the origin countries of each date, if any exists, and table 2 shows the number of origins for each country, how many times the country experienced the date when the country is the origin. Figure 5 plots the origin country and is virtually the same as table 1, though helpful as well to have

a closer look at some of the aspects of the origins. It is easily seen that Greece and Ireland became origin countries in the end of 2008 and over the first half of 2009 and later on, Greece became the only main origin country and continues to be through July 2010.

In addition to the shift in origin countries, we can see a cutoff around November 2009. After November 2009, there is a clear intensification of the Greece origins, probably triggered by the revelations on Greece's real deficit on 5 November 2010. Ireland became sparse after mid-2009, replaced by Greece.

Moreover, news events from this time, such as strikes and downgrades, almost all originated from Greece. To check the consistency of our definition of origin, we cross-checked against country-specific financial news reports from Bloomberg and other relevant news sources, just like Ito and Hashimoto (2005) have. Indeed, all outstanding six big negative events occurred after November 2009 and seem to be only dates of the largest nation-wide strikes and protests in Greece over the past few months plus the major downgrade to 'junk status' at the end of April.

Secondly, we also examine "non-crisis" situation where the threshold is set at DOR(t,o)>0. Figure 6 plots the origin countries and table 2 lists the numbers of origins for each country. From these analyses, we can identify Italy, Ireland and Greece as non-crisis origin countries. First, the timeline shows a clear intensification of Italy throughout 2008, gradually getting sparse after the end of the year. These Italy origin cases almost entirely disappear in crisis situation, where the threshold is set at DOR(t,o)>0.05, implying that the daily changes in spreads were less than 0.05 percent. Except for Italy, the timeline shows a similar pattern as that of the crisis situation. During the mid-2008 Ireland and Greece became intense, and then after November 2009, the great intensification of Greece can be observed.

Table 1. Origin Countries of Each Date

2008/1/23	Italy	2009/2/12	Ireland	2009/11/13	Greece	2010/4/7	Greece
2008/1/31	Belgium	2009/2/13	Ireland	2009/11/16	Greece	2010/4/8	Greece
2008/3/4	Belgium	2009/2/16	Portugal	2009/11/18	Greece	2010/4/13	Greece
2008/3/5	Italy	2009/2/17	Greece	2009/11/19	Greece	2010/4/14	Greece
2008/3/6	Greece	2009/2/24	Greece	2009/11/24	Greece	2010/4/15	Greece
2008/3/10	Italy	2009/2/25	Italy	2009/11/25	Greece	2010/4/16	Greece
2008/3/13	Portugal	2009/2/27	Greece	2009/11/26	Greece	2010/4/19	Greece
2008/3/14	Spain	2009/3/2	Ireland	2009/12/4	Greece	2010/4/20	Greece
2008/4/24	Ireland	2009/3/3	Portugal	2009/12/7	Greece	2010/4/21	Greece
2008/5/9	Greece	2009/3/4	Ireland	2009/12/8	Greece	2010/4/22	Greece
2008/8/19	Italy	2009/3/6	Ireland	2009/12/9	Greece	2010/4/26	Greece
2008/9/15	Greece	2009/3/11	Ireland	2009/12/14	Greece	2010/4/27	Portugal
2008/9/18	Portugal	2009/3/12	Greece	2009/12/15	Greece	2010/4/28	Greece
2008/9/29	Italy	2009/3/19	Ireland	2009/12/17	Greece	2010/5/4	Greece
2008/10/22	Greece	2009/3/30	Greece	2009/12/18	Greece	2010/5/5	Greece
2008/10/23	Greece	2009/3/31	Ireland	2009/12/21	Greece	2010/5/6	Greece
2008/10/24	Greece	2009/4/8	Ireland	2010/1/6	Ireland	2010/5/7	Greece
2008/10/27	Ireland	2009/4/15	Ireland	2010/1/12	Greece	2010/5/12	Portugal
2008/10/29	Greece	2009/4/20	Italy	2010/1/13	Greece	2010/5/13	Greece
2008/10/30	Italy	2009/4/21	Greece	2010/1/14	Belgium	2010/5/14	Greece
2008/10/31	Ireland	2009/4/27	Ireland	2010/1/20	Greece	2010/5/17	Greece
2008/11/3	Ireland	2009/5/11	Greece	2010/1/22	Greece	2010/5/19	Greece
2008/11/12	Italy	2009/5/12	Greece	2010/1/26	Spain	2010/5/20	Italy
2008/11/13	France	2009/5/13	Portugal	2010/1/27	Greece	2010/5/21	Greece
2008/11/17	Greece	2009/5/14	Ireland	2010/1/28	Greece	2010/5/25	Spain
2008/11/25	Greece	2009/5/21	Portugal	2010/2/2	Greece	2010/5/28	Italy
2008/12/1	Greece	2009/5/28	Greece	2010/2/3	Portugal	2010/5/31	Spain
2008/12/2	Ireland	2009/5/29	Ireland	2010/2/4	Portugal	2010/6/1	Greece
2008/12/4	Italy	2009/6/2	Spain	2010/2/5	France	2010/6/2	Greece
2008/12/5	Ireland	2009/6/3	Ireland	2010/2/8	Greece	2010/6/3	Portugal
2008/12/11	Greece	2009/6/4	Portugal	2010/2/12	Greece	2010/6/4	Ireland
2008/12/12	Greece	2009/6/8	Italy	2010/2/15	Greece	2010/6/7	Belgium
2008/12/15	Greece	2009/6/19	Ireland	2010/2/16	Greece	2010/6/8	Portugal
2008/12/29	Italy	2009/6/22	Greece	2010/2/18	Greece	2010/6/11	Greece
2009/1/6	Ireland	2009/6/23	Ireland	2010/2/23	Greece	2010/6/14	Spain
2009/1/9	Greece	2009/6/24	Ireland	2010/2/24	Greece	2010/6/15	Greece
2009/1/12	Ireland	2009/7/7	France	2010/2/25	Greece	2010/6/16	Greece
2009/1/13	Spain	2009/7/8	Greece	2010/3/4	Greece	2010/6/22	Greece
2009/1/14	Ireland	2009/7/24	Greece	2010/3/8	Greece	2010/6/23	Greece
2009/1/15	Spain	2009/8/12	Portugal	2010/3/9	Greece	2010/6/24	Greece
2009/1/16	Belgium	2009/8/14	Belgium	2010/3/11	Portugal	2010/6/25	Belgium
2009/1/19	Ireland	2009/8/17	Greece	2010/3/17	Ireland	2010/6/28	Greece
2009/1/20	Ireland	2009/8/19	Greece	2010/3/18	Greece	2010/6/29	Spain
2009/1/21	Ireland	2009/8/26	Ireland	2010/3/19	Greece	2010/7/5	Spain
2009/1/22	Greece	2009/8/31	Greece	2010/3/22	Greece	2010/7/8	Greece
2009/1/23	Greece	2009/9/1	Greece	2010/3/24	Ireland	2010/7/12	Portugal
2009/2/4	Spain	2009/9/3	Greece	2010/3/29	Greece	2010/7/14	Ireland
2009/2/5	Italy	2009/9/25	Greece	2010/3/30	Greece	2010/7/15	Greece
2009/2/10	Greece	2009/9/30	Greece	2010/3/31	Italy	2010/7/19	Greece
2009/2/11	Greece	2009/10/1	Italy	2010/4/6	Greece	2010/7/22	Portugal

Figure 5. Crisis Contagion: Timeline of Origin Countries

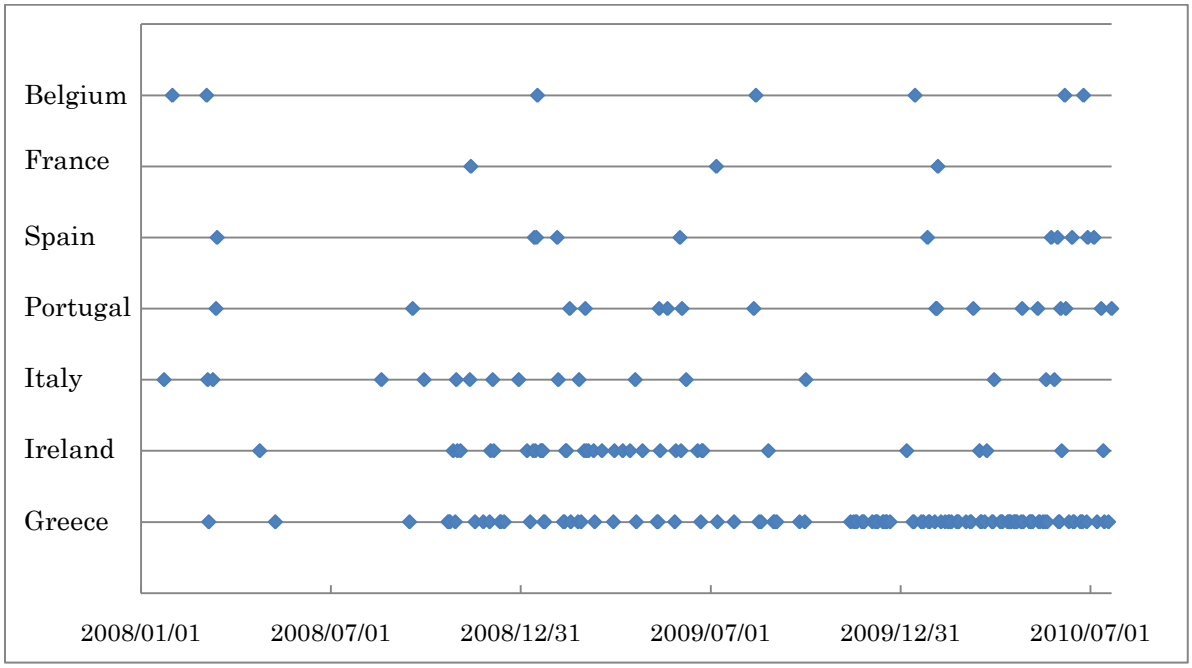


Figure 6. Non-Crisis Contagion: Timeline of Origin Countries

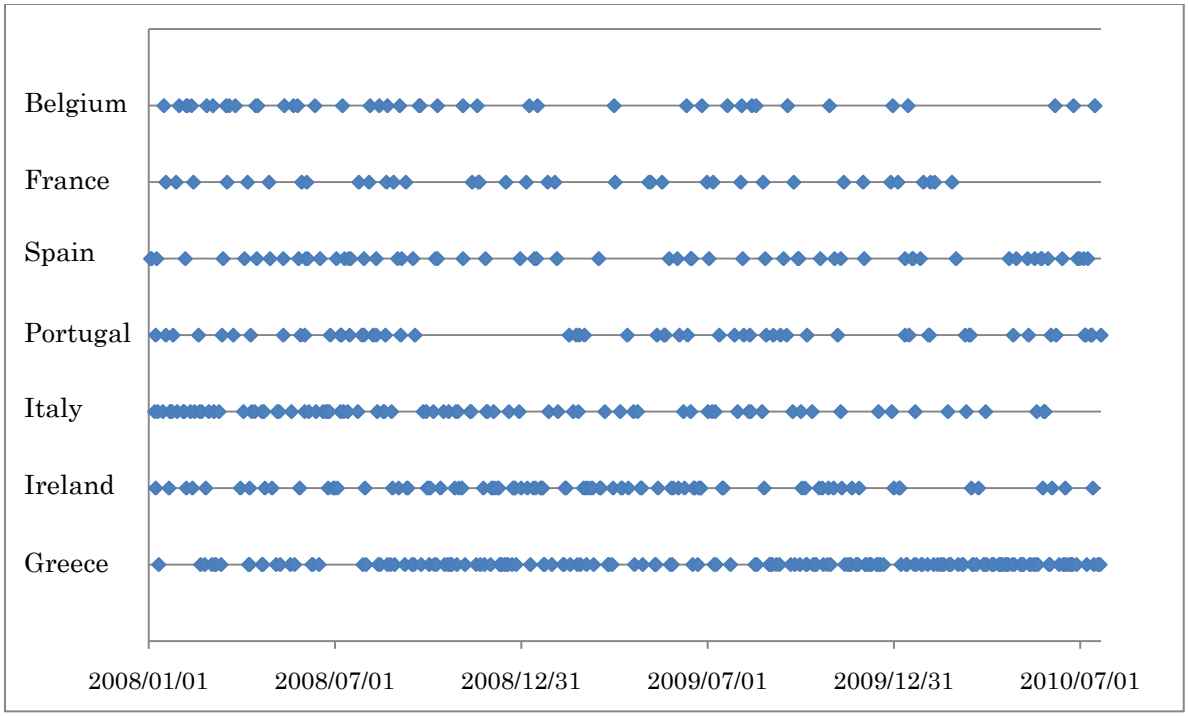


Table 2. Number of Origins for Each Country

Note: In non-crisis contagion, overlapping countries are counted individually. Total is the total number of days when DOR>0

	Greece	Ireland	Italy	Portugal	Spain	France	Belgium	Total
Crisis	110	35	17	17	11	3	7	200
Non-Crisis	175	88	83	57	62	37	42	527

5. Regression Results

In this section, using regression analysis we examine whether there was a contagion during the European sovereign debt crisis. In the previous section, we identified origin countries of both crisis and non-crisis situation. To repeat our definition, if these origin countries affect other countries' change in spreads, it is identified as "contagion." This identification of contagion is what we do in this section.

Before moving onto the regression analysis, we present graphical interpretation of contagion. Figure 7a and 7b plot the bilateral daily changes of government bond spreads, setting Greece as the origin, and Portugal (figure 7a) and France (figure 7b) as the affected countries. From our definition of origin country, all of the plots are below the 45-degree line (an origin country at date t has larger daily change in spread than any other countries in the sample), and located in area above 0.05% points of x-axis. When comparing these two graphs, one can see there seems to be a difference in how an origin country affects other countries, suggesting that Greece may have huge impact on Portugal, and little impact on France. In the rest of the section, we empirically show which origin country affected which country.

Figure 7a. Daily Changes in Greece and Portugal Spreads (Greece Origin Case)

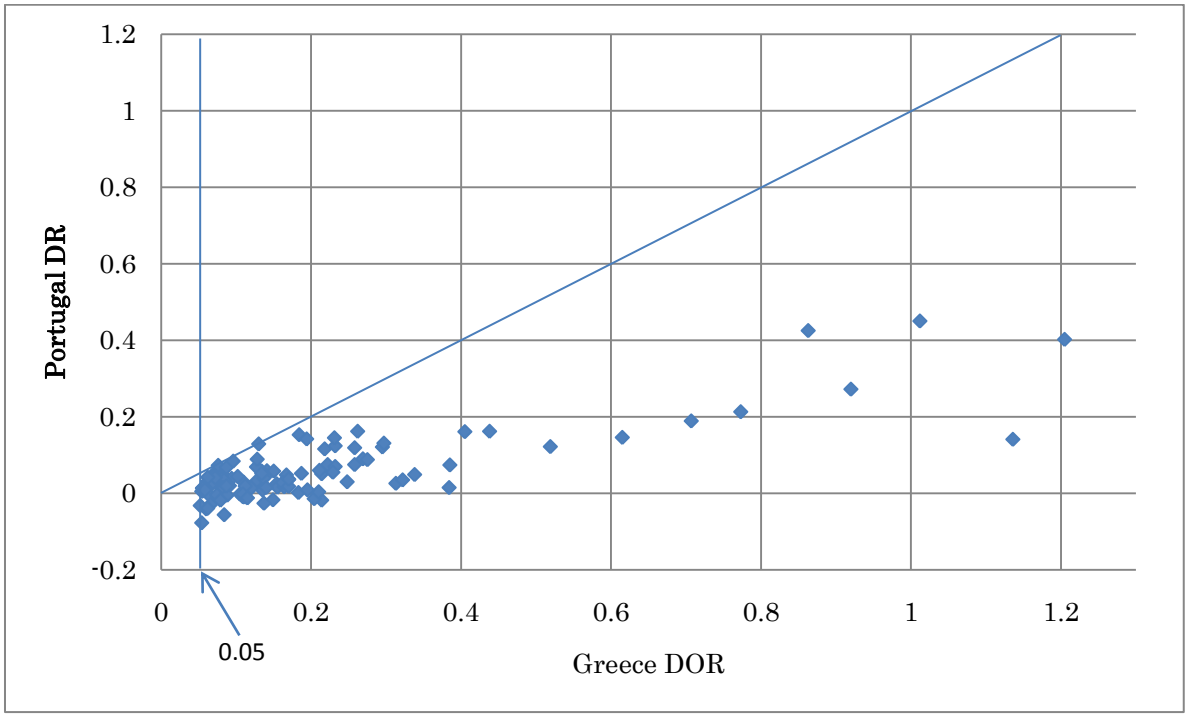
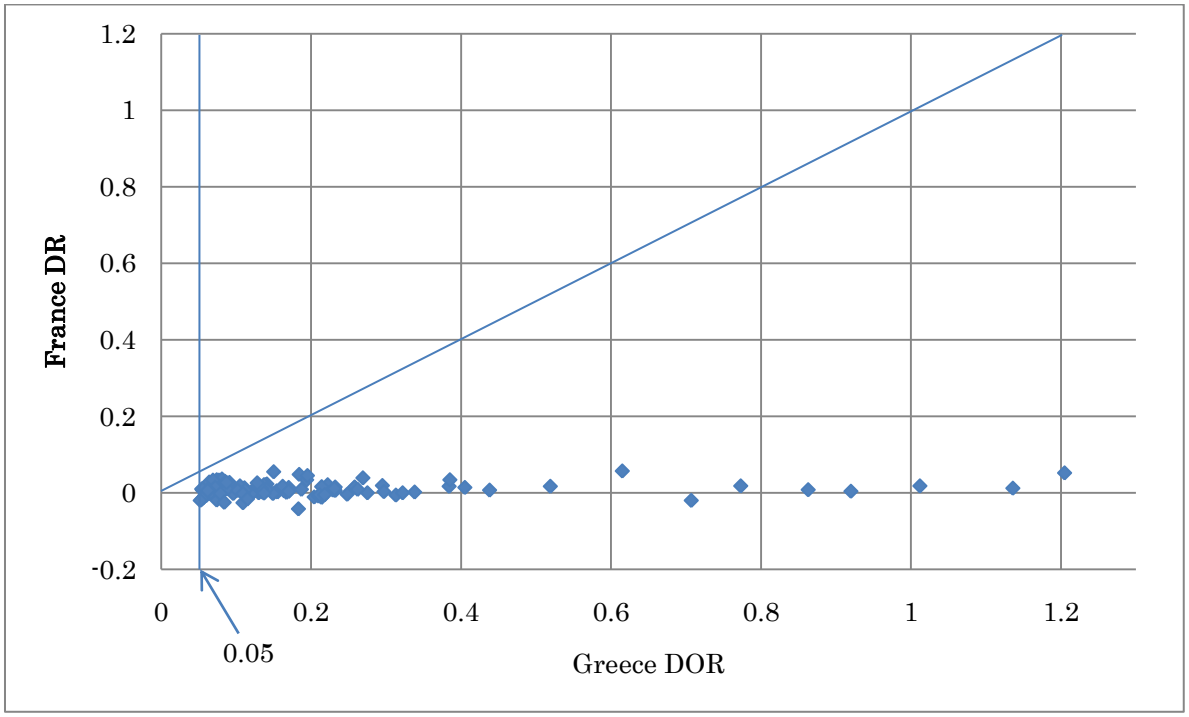


Figure 7b. Daily Changes in Greece and Spain Spreads (Greece Origin Case)



The equation estimated is as follows:

$$\text{affected}(t,j) = a_0 + a_1 \text{origin}(t,o) + e(t,j)$$

where affected(t,j) is the daily change of government bond yield spread of affected countries, which is the same as DR(t,j); origin(t,o) is the daily change of the government bond yield spread of the origin country and is equal to DOR(t,o)

We use 2SLS for the estimation, because there may be endogeneity in this case. The instrument variable for origin(t,o) is the one-day lagged stock price index of origin countries. As the stock price index, we use the Athens Stock Exchange General Index (Greece), ISEQ Index (Ireland) and FTSE MIB Index (Italy). All the data are from Bloomberg. Since we also assume heteroskedasticity in the error term, a heteroskedasticity robust standard error is used. We estimate the model both for crisis contagion and non-crisis contagion separately.

First, we estimate the regressions for crisis situation. We set Greece and Ireland as origin countries. Table 3 shows the list of results of the regression analyses. One can see that some of the regressions of Greece as the origin case give positive coefficients that are significantly different from zero. In two cases, where Ireland and Portugal are the affected countries, p-values are close to 0. Secondly, in Greece origin case, we found that the slopes vary across regressions. The largest coefficient, 0.257, is the case where Portugal is the affected country; Greece to Ireland comes next with 0.198. On the other hand, the coefficients of Greece to France is slightly negative and Belgium is around 0.05, and the effects of Greece to Italy and Spain are somewhere in-between. In cases in which Ireland is the origin we could not get reliable results, probably because of the lack of samples: the case in which Ireland is the origin has only 35 samples.

Next, we estimate the model for non-crisis situation. We set Greece, Ireland and Italy as origin countries. Table 4 summarizes the results. The results of Greece origin case are not so different from those of crisis contagion: Estimated slope is positive and significantly different from zero in the cases where Ireland and Portugal are the affected countries, then Italy and Spain come to next; and

we found no sign of contagion in the cases where France and Belgium are the affected countries.

What matters here is Ireland origin case. In the crisis situation, the estimated slopes are not significantly different from zero, though the point estimates are positive in 4 out of 6 cases. In non-crisis case, things are opposite: estimated slopes in all the regressions are positive and significantly different from zero.

One potential reason is the increase in the sample size: the non-crisis regressions have 88 samples (86 in the regressions, due to missing values in lagged stock price index). This explanation is probable because out of 88 samples, 35 still remain in crisis situation, implying that the results obtained from crisis contagion regression is just a product of small sample size. Another potential reason is the difference in characteristics of contagion between crisis and non-crisis situation. As the word "non-crisis" represents, the situation where the largest daily change in spread is positive is common. A crisis situation is by definition different from that usual situation and it is natural to think that the characteristics of contagion can be different. It is not clear whether the increased sample size or the difference in characteristics of contagion is attributable to the increase in significance of regression. Nonetheless, the results in non-crisis contagion suggest that Ireland might have affected other countries both in crisis and non-crisis situation, given the fact that large portion of Ireland origin cases in non-crisis situation still remain in crisis situation.

In Italy origin case, no regression results are significant and estimated slopes are slightly negative. Since Italy origin cases disappear in crisis situation, we can conclude that Italy did not affect other countries in both crisis and non-crisis situation.

To summarize the results of our origin analysis and regressions, we may conclude that high-frequency contagion did occur from Greece to most notably Ireland and Portugal and to a lesser extent to Italy and Spain. Although in crisis contagion regression, we could not find evidence that Ireland affected other countries, possibly due to the lack of sample, non-crisis case provides a weak but supportive evidence to conclude that there was contagion from Ireland. Indeed,

Greece has been the main origin country throughout the European sovereign debt crisis, but during the spring of 2009 some of the largest shocks originated from Ireland.

To put it in chronological order, in early 2008 Italy was the origin country in non-crisis situation, but the negative shock was small and did not affect other countries. From mid-2008 to mid-2009, Ireland and Greece were the origins, where Greece affected Ireland and Portugal, and to lesser extent Italy and Spain. Also, though the evidence is not so concrete, Ireland might have affected other countries in this period. After November 2009, Greece experienced the intense second wave of the crisis and became the only origin country, affecting Ireland and Portugal, to lesser extent Italy and Spain, but not France and Belgium.

Table 3. Crisis Contagion: Regression Result (Origin: Greece, Ireland)

Note: *, ** and *** denote 10%, 5% and 1% statistical significance respectively. Numbers in parenthesis and brackets are heteroskedasticity-robust t-values and p-values respectively.

Origin	Affected				
Greece	Ireland	Constant	0.006		
		Coefficient	***0.198	(3.66)	[0.00]
		R-squared	0.51		
		# of obs	109		
	Italy	Constant	0.021		
		Coefficient	0.053	(0.85)	[0.40]
		R-squared	0.13		
		# of obs	109		
	Portugal	Constant	0.004		
		Coefficient	***0.257	(4.13)	[0.00]
		R-squared	0.65		
		# of obs	109		
	Spain	Constant	0.015		
		Coefficient	0.077	(1.20)	[0.23]
		R-squared	0.30		
		# of obs	109		
	France	Constant	0.012		
		Coefficient	-0.014	(-0.51)	[0.61]
		R-squared	NA		
		# of obs	109		
	Belgium	Constant	0.014		
		Coefficient	0.010	(0.22)	[0.83]
		R-squared	0.05		
		# of obs	109		

Origin	Affected				
Ireland	Greece	Constant	-0.083		
		Coefficient	1.053	(0.82)	[0.42]
		R-squared	NA		
		# of obs	35		
	Italy	Constant	-0.021		
		Coefficient	0.367	(0.52)	[0.60]
		R-squared	0.00		
		# of obs	35		
	Portugal	Constant	-0.003		
		Coefficient	0.367	(0.31)	[0.76]
		R-squared	0.13		
		# of obs	35		
	Spain	Constant	0.005		
		Coefficient	0.129	(0.15)	[0.88]
		R-squared	0.09		
		# of obs	35		
	France	Constant	0.016		
		Coefficient	-0.022	(-0.04)	[0.97]
		R-squared	NA		
		# of obs	35		
	Belgium	Constant	0.022		
		Coefficient	-0.032	(-0.03)	[0.97]
		R-squared	NA		
		# of obs	35		

Table 4. Non-Crisis Contagion: Regression Result (Origin: Greece, Ireland and Italy)

Note: *, ** and *** denote 10%, 5% and 1% statistical significance respectively. Numbers in parenthesis and brackets are heteroskedasticity-robust t-values and p-values respectively.

Origin	Affected				
Greece	Ireland	Constant	0.001		
		Coefficient	***0.192	(5.76)	[0.00]
		R-squared	0.54		
		# of obs	171		
	Italy	Constant	0.009		
		Coefficient	**0.088	(2.43)	[0.02]
		R-squared	0.21		
		# of obs	171		
	Portugal	Constant	0.001		
		Coefficient	***0.254	(7.06)	[0.00]
		R-squared	0.68		
		# of obs	171		
	Spain	Constant	0.008		
		Coefficient	0.066	(1.46)	[0.15]
		R-squared	0.24		
		# of obs	171		
	France	Constant	0.008		
		Coefficient	0.015	(0.95)	[0.34]
		R-squared	0.062		
		# of obs	171		
	Belgium	Constant	0.006		
		Coefficient	0.033	(1.22)	[0.22]
		R-squared	0.15		
		# of obs	171		

Origin	Affected				
Ireland	Greece	Constant	-0.007		
		Coefficient	*0.217	(1.73)	[0.09]
		R-squared	0.26		
		# of obs	86		
	Italy	Constant	-0.011		
		Coefficient	**0.214	(2.05)	[0.04]
		R-squared	0.27		
		# of obs	86		
	Portugal	Constant	-0.003		
		Coefficient	***0.291	(3.11)	[0.00]
		R-squared	0.35		
		# of obs	86		
	Spain	Constant	-0.005		
		Coefficient	**0.177	(2.15)	[0.04]
		R-squared	0.22		
		# of obs	86		
	France	Constant	-0.002		
		Coefficient	***0.128	(3.37)	[0.00]
		R-squared	0.2556		
		# of obs	86		
	Belgium	Constant	-0.001		
		Coefficient	***0.143	(2.51)	[0.01]
		R-squared	0.31		
		# of obs	86		

Table 4. (Cont.) Non-Crisis Contagion: Regression Result (Origin: Greece, Ireland and Italy)

Note: *, ** and *** denote 10%, 5% and 1% statistical significance respectively. Numbers in parenthesis and brackets are heteroskedasticity-robust t-values and p-values respectively.

Origin	Affected				
Italy	Greece	Constant	0.299		
		Coefficient	-6.298	(-0.18)	[0.86]
		R-squared	NA		
		# of obs	83		
	Ireland	Constant	0.143		
		Coefficient	-3.040	(-0.17)	[0.86]
		R-squared	NA		
		# of obs	83		
	Portugal	Constant	0.033		
		Coefficient	-0.520	(-0.13)	[0.90]
		R-squared	NA		
		# of obs	83		
	Spain	Constant	0.038		
		Coefficient	-0.671	(-0.15)	[0.88]
		R-squared	NA		
		# of obs	83		
	France	Constant	0.037		
		Coefficient	-0.734	(-0.17)	[0.86]
		R-squared	NA		
		# of obs	83		
	Belgium	Constant	0.043		
		Coefficient	-0.829	(-0.17)	[0.86]
		R-squared	NA		
		# of obs	83		

6. Transmission Channels of the Contagion

In the previous section, we empirically showed that contagion had occurred in the European sovereign debt crisis. However, questions remain: how can the contagion occur? In what way can a sovereign crisis in one country spread into other countries? What makes the difference between country pairs between which contagion occurs and not? In this section, we approach these questions and examine how the contagion took effect during the crisis. In this section, we use the data of crisis situation, since the crisis contagion is our main interest.

As we saw in the literature review of the transmission channels of crises, there are four hypotheses to explain contagion: the common shocks, trade links, financial links, and shift in investors' mind. In this paper, we consider two of them, the financial links and the shift in investors' mind. We do not consider the other two hypotheses for the following reasons: A contagion caused by common shocks does not fit into our definition, and the European sovereign debt crisis does not involve currency movement among the member countries, which is necessary for trade links to fully serve as a transmission mechanism.

Instead, financial linkages may be crucial factor in spreading crisis. Figure 8 is a chart in New York Times website article, titled "In and Out of Each Other's European Wallets", published May 1, 2010. The chart graphically shows how much European countries lend and owe each other and how large the financial interconnection between European countries is. Not only in media accounts but many policy debates, it is often mentioned that in the European sovereign debt crisis financial linkages may trigger contagion. Indeed, given the strong financial interconnection among European countries, as the figure depicts, it is highly likely that the financial linkages play a crucial role in transmitting a crisis in one country to another.

Additionally, we examine the hypothesis of non-fundamental channels of contagion, i.e. the shift in investors' mind. As expressed in the word "the Aegean contagion", the already-worsened crisis situation was severely aggravated by the disclosure of the real fiscal deficit of Greece, which had nothing to do with the fundamentals in other countries. It does not go too far to say that it was not change in the fundamental per se, but the update of the information that

triggered the second wave of the crisis. Therefore, the disclosure of the real fiscal deficit in Greece might have served as a "wake-up call", inducing the investors to reassess the risk of other countries with similar fundamentals.

First, we examine the financial links. The methodology is as follows: first, for each contagion pair we develop two indices measuring the depth of contagion, both for Greece and Ireland origin case. One is 'the contagion coefficient' for both Greece and Ireland origin case, the same index as the one used in Ito and Hashimoto (2005). The contagion coefficient is calculated as the sample average of DR(t,j)/DOR(t,o) over all the t in each origin case. This variable measures the ratio of reaction of spreads in non-origin countries against the spreads of the origin country, the biggest and more than 0.05 percentage change in sovereign spreads. The other contagion index is the estimated slope of regressions. In the previous section we estimated the following equation with 2SLS for each origin-affected country pair:

$$\text{affected}(t,j) = a_0 + a_1 \text{origin}(t,o) + e(t,j)$$

Unless there are any factors generating bias in the estimation, $\hat{a}_1$ is an unbiased and consistent estimator of a_1, how much affected(t,j) reacts to the rise in origin(t,o). Thus the estimated slope, $\hat{a}_1$, measures the degree of contagion for each i and o.

Next, following Ito and Hashimoto (2005) and Caramazza et al. (2004), we construct several indicators to measure the financial linkages of each contagion pair, so that each country pair has both the contagion coefficient and the financial indicators. As the last step, we calculate the correlation coefficient between the contagion indices and each financial indicator. The higher the correlation is, the financial indicators have greater effect in strengthening the contagion.

Figure 8: Europe's Web of Debt

Source: Nelson, D. Schwartz "In and Out of Each Other's European Wallets" New York Times, Retrieved on 31 August 2010 from:

(http://www.nytimes.com/interactive/2010/05/02/weekinreview/02marsh.html)

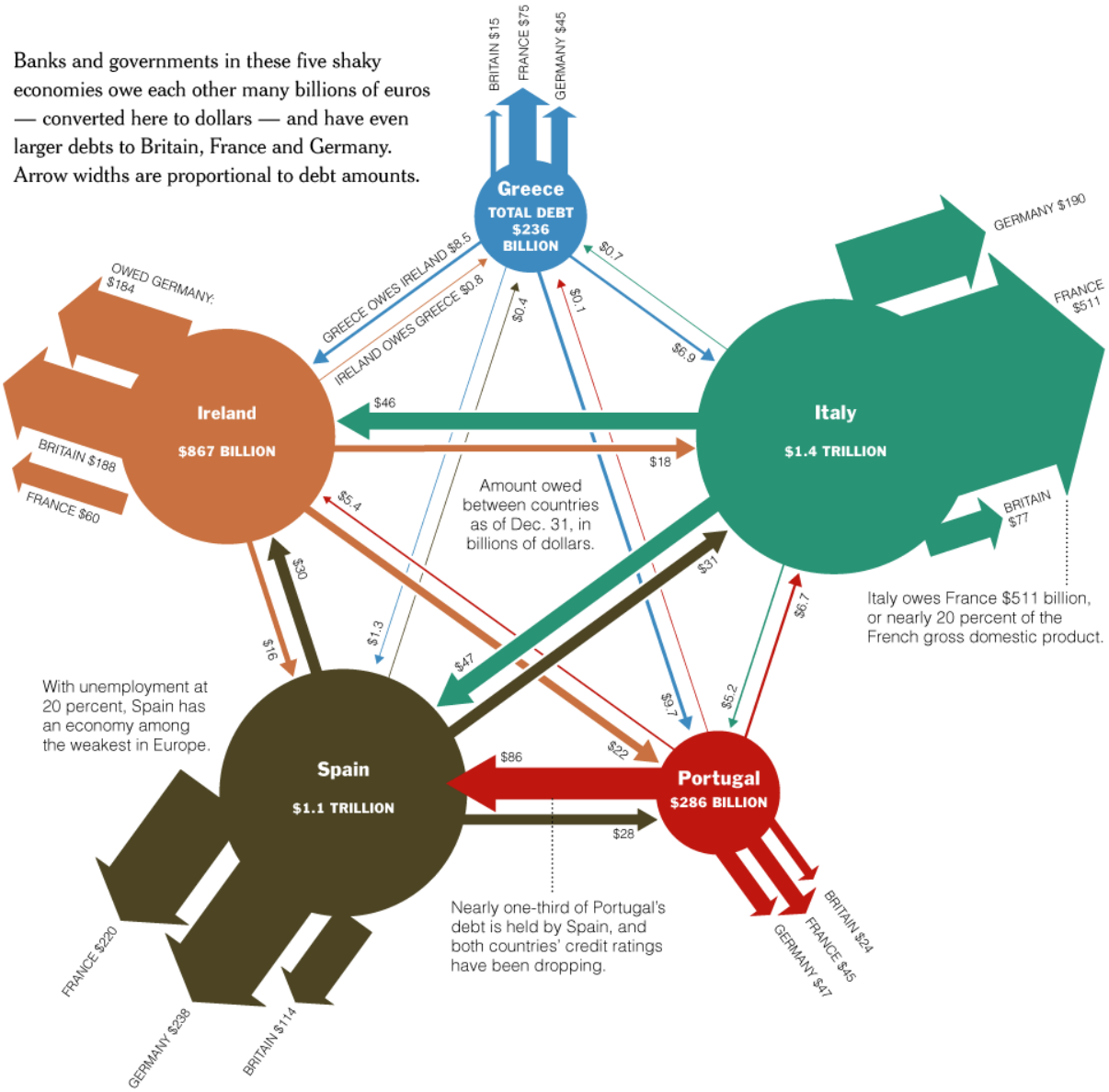


Table 5 shows the summary of the four financial indices. The first two indices are to examine 'the common lender hypothesis', originally presented in Kaminsky and Reinhart (2000). The hypothesis assumes an indirect channel of transmission: the common lender to both the origin and the affected country, which is often assumed as banks, serves as a 'financial intermediary' of the crisis. When a crisis breaks out in one country, investors who have positions in that country usually tend to reduce their now increased risk exposure and will sell assets whose returns are likely to be correlated with those of the origin country. Therefore, (1) the larger positions the common lender has to the origin and affected countries, the larger the contagion should be. Also, (2) when both the origin and affected country have larger liabilities to the common lender, the larger the contagion becomes.

The first index, the Common Creditor Index (CCI) (Lender-based) is used in Ito and Hashimoto (2005). This index is constructed to mainly capture the lender's aspect of the common lender hypothesis, that is, (1) in the explanation above. On the other hand, the second index, the Common Creditor Index (CCI) (Borrower-based) is constructed to capture the borrower's aspects of the hypothesis, which is (2) above. We identify France, Germany, the United Kingdom, and the United States as the common creditors, given their large amount of lending and borrowing share in the GIIPS countries.

The second two indices, the Composite Common Creditor variable, CCC (Lender: Origin) and CCC (Lender: Affected) are mainly used in Caramazza et al (2004). Unlike in the original usage, we use these indices to capture the direct financial link between the origin and the affected country in our analysis. Following their methodology, we calculate the share of the borrower's external liabilities owed to the lender (CCA) and the share of the lender's portfolio lent to the borrower (CCB). The composite common creditor variable (CCC) is then calculated as the product of these two indices. CCC (Lender=Origin) sets the origin country as the lender and the affected country as the borrower, while CCC (Lender=Affected) sets the affected country as the lender and the origin country as the borrower.

Table 5. Summary of Financial Indices

Note: Arrows represent lending: i → j means the amount of lending from country i to j.

Index	Definition
Common Creditor Index (CCI) (Lender-based)	$\sum_{\text{common creditors}} \left(\frac{\text{common creditor} \rightarrow \text{origin}}{\text{common creditor} \rightarrow \text{world}} \times \frac{\text{common creditor} \rightarrow \text{affected}}{\text{common creditor} \rightarrow \text{world}} \right)$
Common Creditor Index (CCI) (Borrower-based)	$\sum_{\text{common creditors}} \left(\frac{\text{common creditor} \rightarrow \text{origin}}{\text{world} \rightarrow \text{origin}} \times \frac{\text{common creditor} \rightarrow \text{affected}}{\text{world} \rightarrow \text{affected}} \right)$
Composite Common Creditor variable (CCC) (Lender=Origin)	(the share of the borrower's external liabilities owed to the lender) × (the share of the lender's portfolio lent to the borrower) $= \frac{\text{origin} \rightarrow \text{affected}}{\text{world} \rightarrow \text{affected}} \times \frac{\text{origin} \rightarrow \text{affected}}{\text{origin} \rightarrow \text{world}}$
Composite Common Creditor variable (CCC) (Lender=Affected)	(the share of the borrower's external liabilities owed to the lender) × (the share of the lender's portfolio lent to the borrower) $= \frac{\text{affected} \rightarrow \text{origin}}{\text{world} \rightarrow \text{origin}} \times \frac{\text{affected} \rightarrow \text{origin}}{\text{affected} \rightarrow \text{world}}$

Table 6 and figure 9a and 9b show the result of the analysis. We found no or even negative correlation between the contagion indices and financial indices. Figure 9a and 9b plot the contagion indices (contagion coefficient in figure 9a and estimated slope in 9b) and four financial linkage indicators, showing that there is no clear relationship between the two variables. It is often mentioned that financial linkages play a certain role in transmitting the crisis. Although it is highly intuitive and straightforward to think so, we could not find any supportive evidence.

Next, we consider the other possibility, shifts in investors' mind, using fiscal data of the affected countries. Our hypothesis is that when the fiscal situation in one country is in a severe situation, the country is vulnerable contagion from the origin country. This can be interpreted in the following way: facing a crisis in one country, the investors may reassess the risks in other countries with similar fundamentals. This can be a variety of financial linkages hypothesis: While the financial linkages hypotheses analyzed above emphasize the role of financial "links" in transmitting crisis, the interpretation here puts an emphasis on the "similar fundamentals" in the affected countries. A thought experiment may make it easier to understand the mechanism: if you are an investor facing losses in one country with fiscal crisis, which country would you think become the next source of loss? You may reassess the risks in countries with large or increasing government debt and think that these countries would be the target.

We calculated the correlation coefficient between the contagion indices used in the previous analysis and four fiscal indicators of the affected countries: 1) consolidated government debt (percentage of GDP), 2) change in the GDP ratio of government debt, 3) fiscal deficit (percentage of GDP) and 4) change in the GDP ratio of fiscal deficit. To categorize these four variable, 1) is stock variable, 2) and 3) are change in stock variable, or almost equivalently, flow variable, and 4) is the change in flow variable. All the data are annual data and as of 2009, when the crisis, especially the second wave, was getting severe. We assign these variables to affected countries, whatever the origin country is.

Table 6 and figure 10a and 10b show the result. The correlation coefficients are all positive and relatively high. The correlation between the contagion coefficient and the fiscal deficits and the change in government debt is around 0.5. The scatter plot of figure 10a and 10b also confirms this positive correlation.

The results also show that the flow variable (the fiscal deficits) and equivalently, the change in the stock variable (the change in the government debt) have higher correlation with the contagion indices (around 0.5). On the other hand, the stock variable (the government debt) and the change in the flow variable (the change in the fiscal deficit) are not highly correlated with the depth of contagion (the correlation coefficients vary from 0.1 to 0.4). This might imply that the contagion was caused by investors' risk assessment, facing the now worsening fiscal situation. The reason that stock variable itself does not have such a high correlation as flow variable might be that what investors care is the direction of the fiscal situation, whether fiscal balance is getting worse or better.

To check the result in a different manner, we let the fiscal variables and contagion coefficient vary across time. We calculate contagion coefficients for each quarter and for each origin case (Greece and Ireland). In Greece origin case, 2008Q1-Q3 and 2010 Q2, in Ireland origin case 2008Q1-Q3, 2009Q3-Q4, and 2010Q2 have only zero or just a few samples for each quarter, we could not calculate contagion coefficient for these quarter. We treat data in these quarters as missing values. Finally we have 60 samples (contagion coefficients for time-varying contagion pairs). As the last step, we calculated correlation coefficient between contagion coefficients and lagged quarterly change in government debt of the affected countries.

The results are summarized in table 7 and figure 11. The correlation coefficient is 0.177, still positive, though it is not so high in the analysis above. The depth of contagion is still positively correlated with the changes in fiscal situation in the affected countries, even with time-varying contagion coefficient and fiscal variables. It is worth to note that the correlation almost disappears when we use the non-lagged fiscal variable. The correlation coefficient is no more than 0.07. This difference might be also supporting our analysis above, because it is usual that government debt of a certain quarter is published during the next

quarter. It suggests that it might not be the fundamental per se but the update of information that induces investors reassess the risks.

To summarize the results we obtained from this section, we found no positive evidence for financial linkage hypothesis. On the other hand, we found that the contagion is highly correlated with the fiscal situation in the affected countries, possibly suggesting that the contagion was transmitted by investors' reassessment of risks in countries with similar situations as the origin countries. This correlation is robust to several fiscal and contagion indices and even to time-varying indices.

However, the analysis in this section has several limitations. First, fiscal situation in affected countries cannot explain factors related to origin countries, which is insufficient for a transmission channel analysis: it would not be the case that countries with worsening fundamentals are hit by contagion whatever origin country is. Ultimately, transmission channels of contagion should be explained by the factors related to the links between origin and affected country. Moreover, it is puzzling that while the investors' reassessment effect is a likely cause of contagion, the other side of a coin, financial linkage, does not seem to be playing a role in contagion. For investors to face financial loss in an origin country and withdraw the funds from the affected countries, there should be financial linkages between countries, whether it is direct or indirect. Finally, since we have only handful of samples (contagion pairs) and could not control for other factors, any results remain to be tentative. Further research is therefore a necessity to better understand the origins and spread of crises.

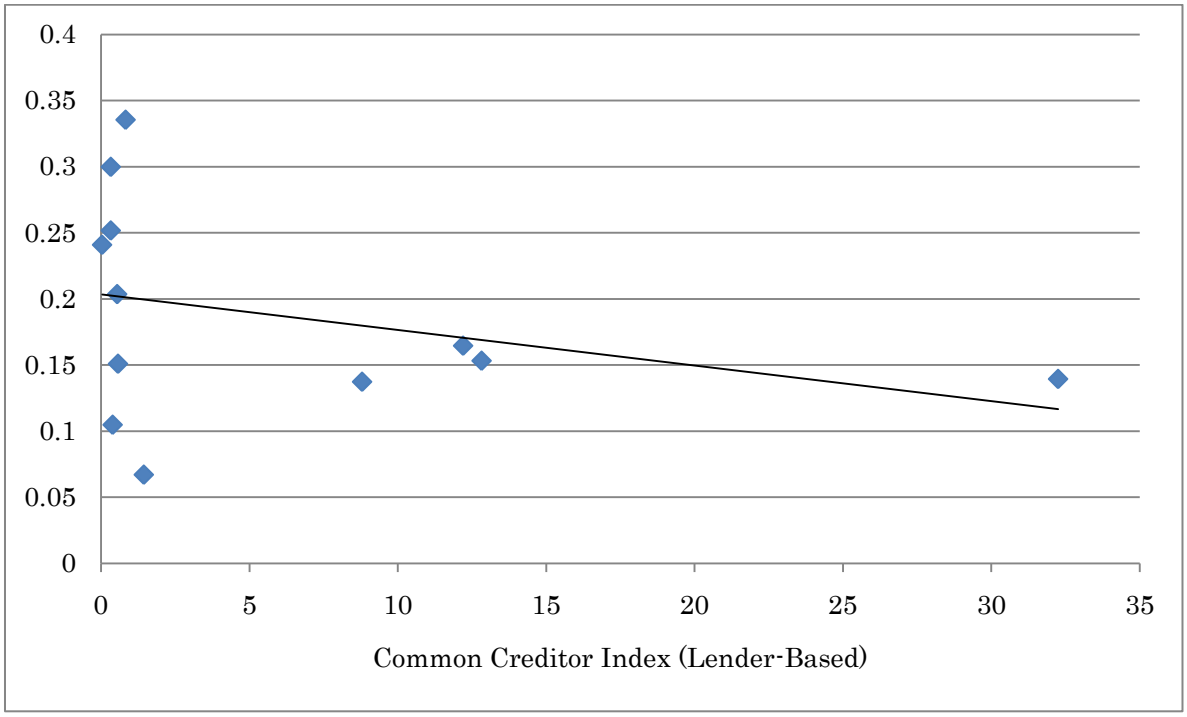
Table 6. Results on the Transmission Channel Analysis

Original Data Source: Eurostat, Bank for International Settlement (BIS), Consolidated International Claims of Reporting Banks on Individual Countries, by Nationality of Reporting Banks, BIS Quarterly Review, March 2010

Note: The financial data are as of end-September 2009. Fiscal data are as of 2009 and transformed to percentage of GDP.

Contagion Pair		Contagion Indices		Financial Indices				Fiscal Indices			
Origin	Affected	contagion coefficient	regression slope	CCI lender	CCI borrower	CCC origin	CCC affected	gov. debt	change in gov. debt	fiscal deficit	change in fiscal deficit
Greece	Ireland	0.25	0.20	0.33	169.45	2.36		0.64	0.20	0.14	0.07
Greece	Italy	0.20	0.05	0.55	169.45	2.32	0.10	1.16	0.10	0.05	0.03
Greece	Portugal	0.24	0.26	0.04	79.36	20.14	0.09	0.77	0.11	0.09	0.07
Greece	Spain	0.15	0.08	0.57	196.43	0.03	0.04	0.53	0.14	0.11	0.07
Greece	France	0.07	-0.01	1.44	189.64	51.05	0.16	0.78	0.10	0.08	0.04
Greece	Belguim	0.10	0.01	0.39	160.15	2.15	0.10	0.97	0.07	0.06	0.05
Ireland	Greece	0.30	1.05	0.33	169.45			1.15	0.16	0.14	0.06
Ireland	Italy	0.16	0.37	12.20	122.41	5.59		1.16	0.10	0.05	0.03
Ireland	Portugal	0.34	0.37	0.83	57.32	29.04	1.30	0.77	0.11	0.09	0.07
Ireland	Spain	0.15	0.13	12.83	141.90	1.97	8.62	0.53	0.14	0.11	0.07
Ireland	France	0.14	-0.02	32.25	136.99	17.70	4.50	0.78	0.10	0.08	0.04
Ireland	Belguim	0.14	-0.03	8.80	115.68	64.02	0.96	0.97	0.07	0.06	0.05
corr. coefficient with contagion coefficient				-0.32	-0.47	-0.18	-0.06	0.10	0.47	0.52	0.39
corr. coefficient with regression slope				-0.26	-0.10	-0.28	0.01	0.38	0.45	0.52	0.20

Figure 9a. Contagion Coefficient and Financial Indices



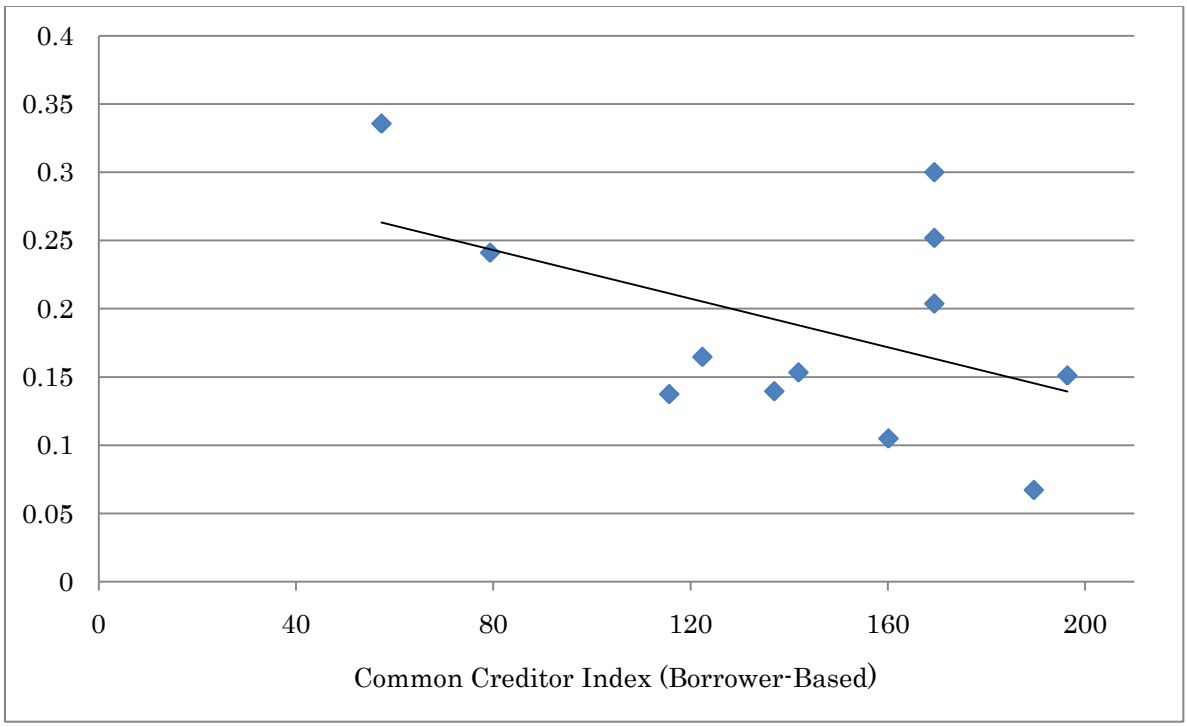
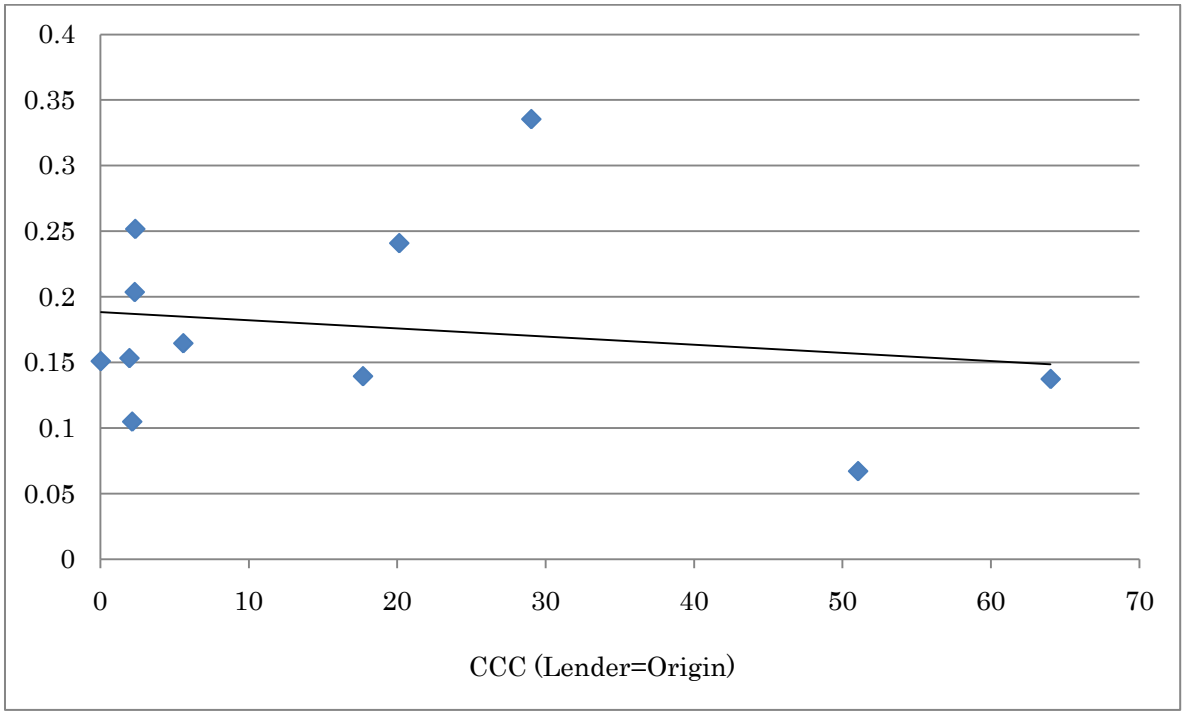


Figure 9a. Contagion Coefficient and Financial Indices (Cont.)



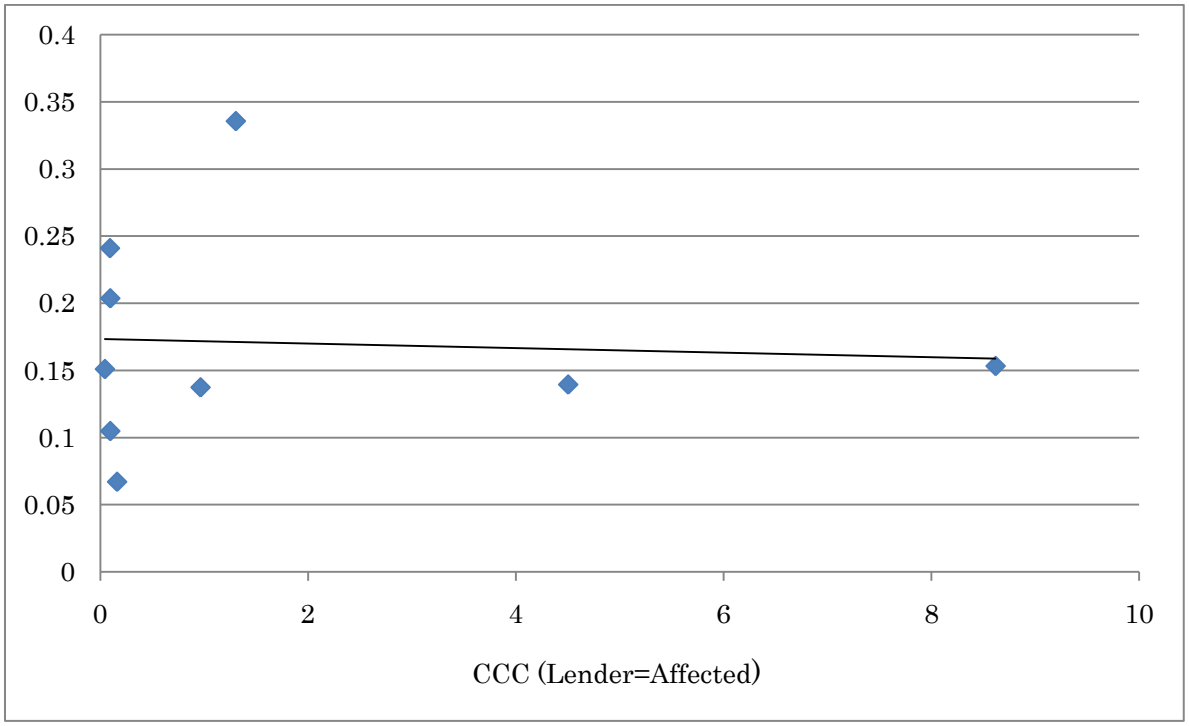
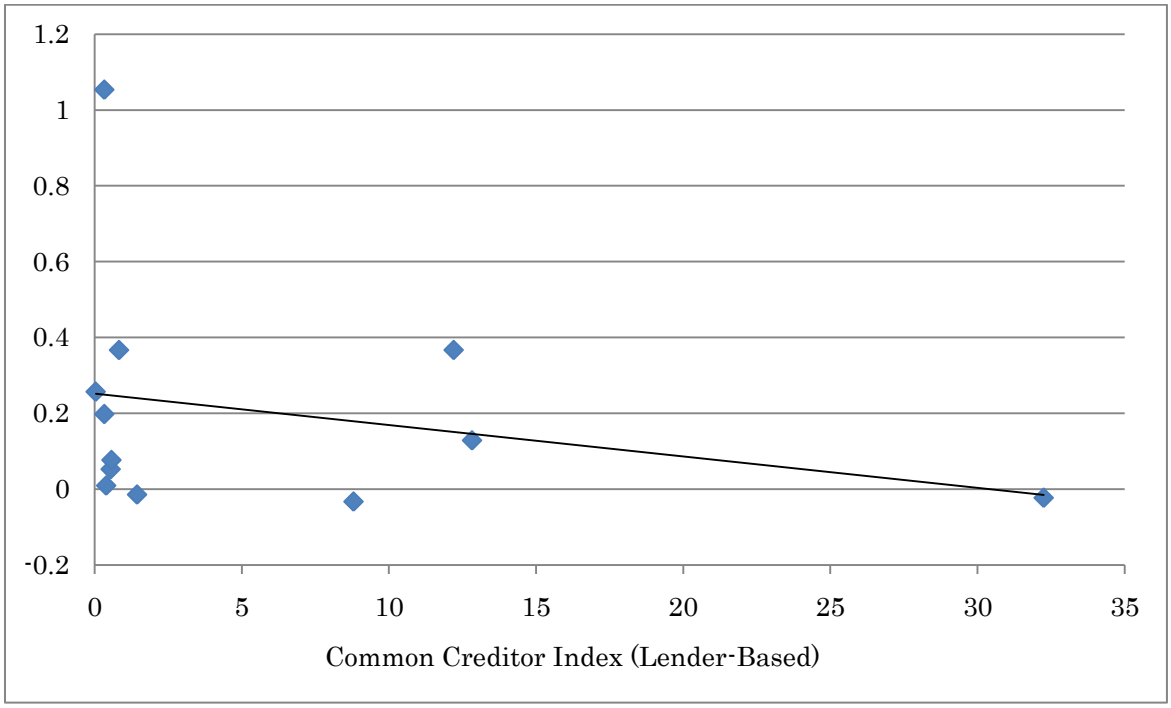


Figure 9b. Estimated Slope and Financial Indices



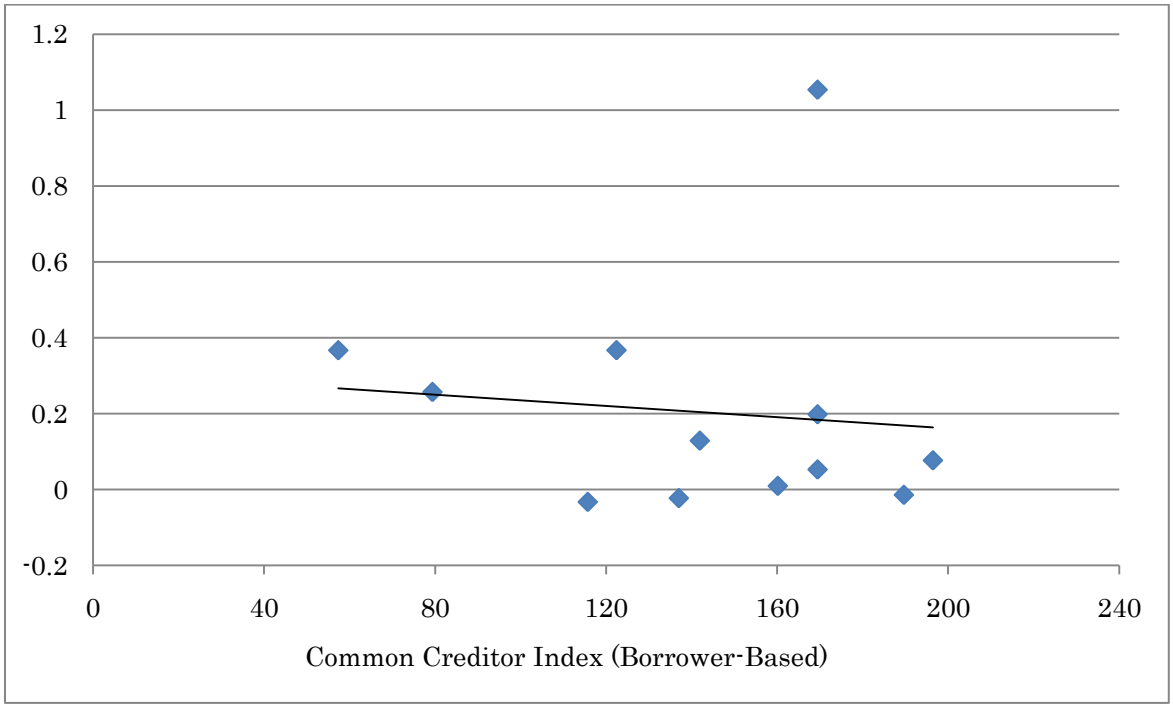
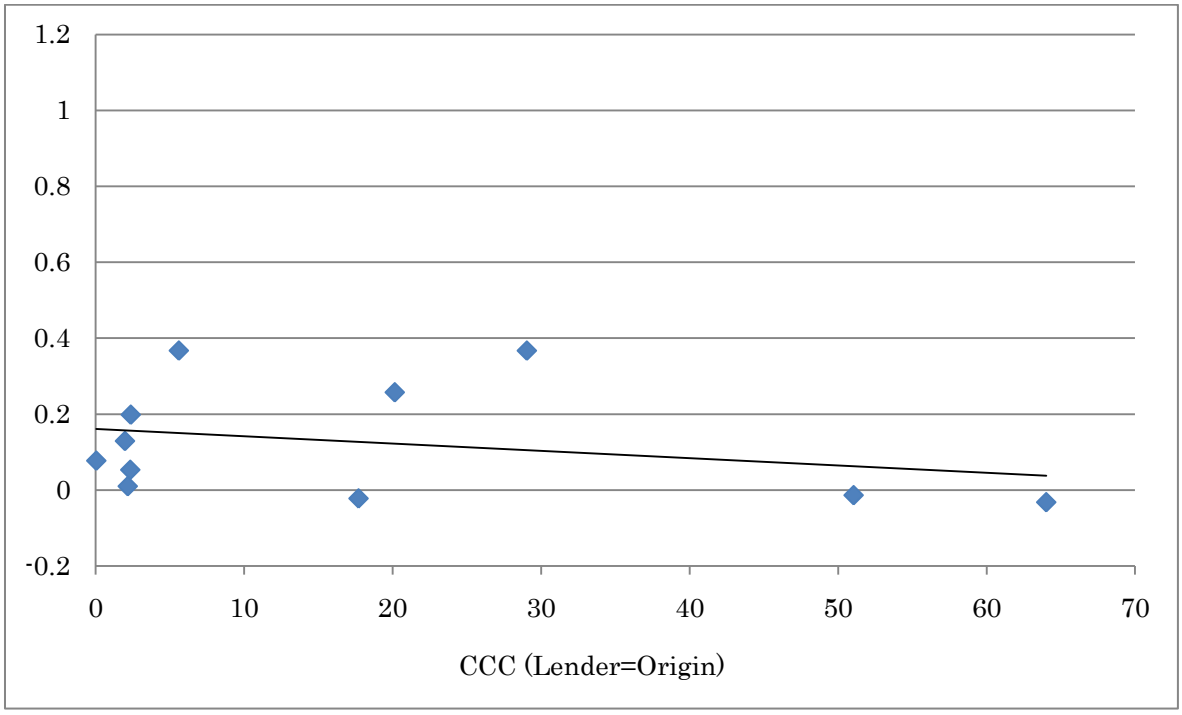


Figure 9b. Estimated Slope and Financial Indices (Cont.)



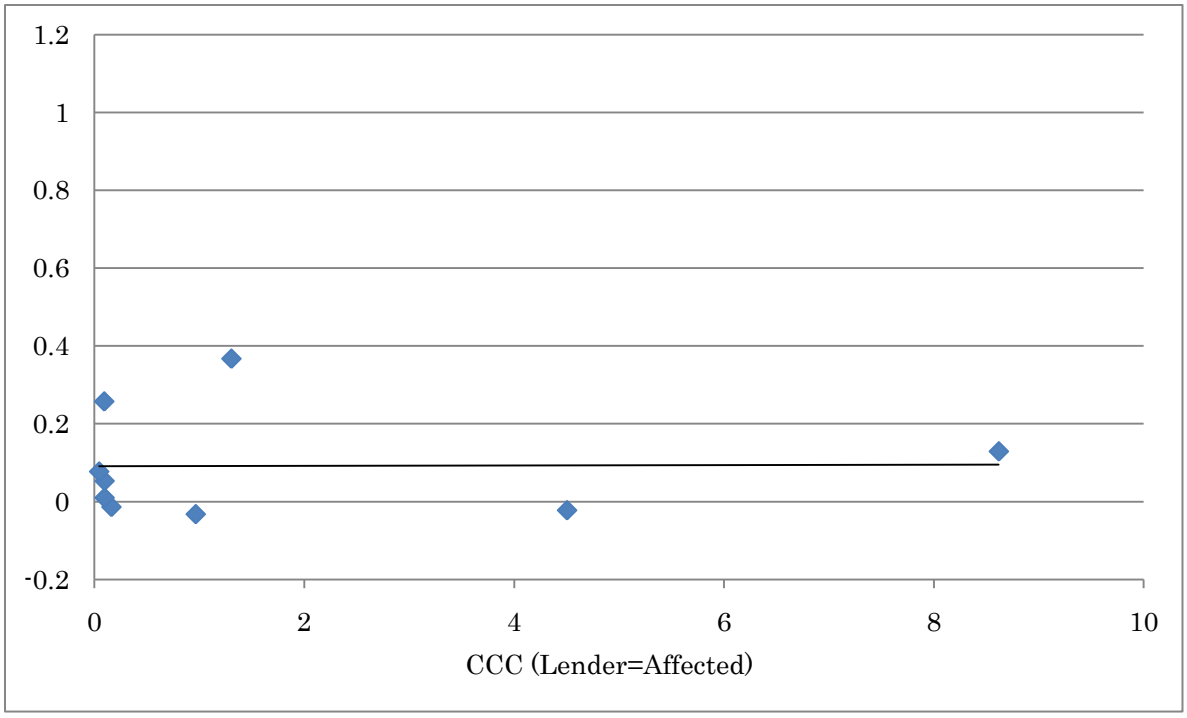
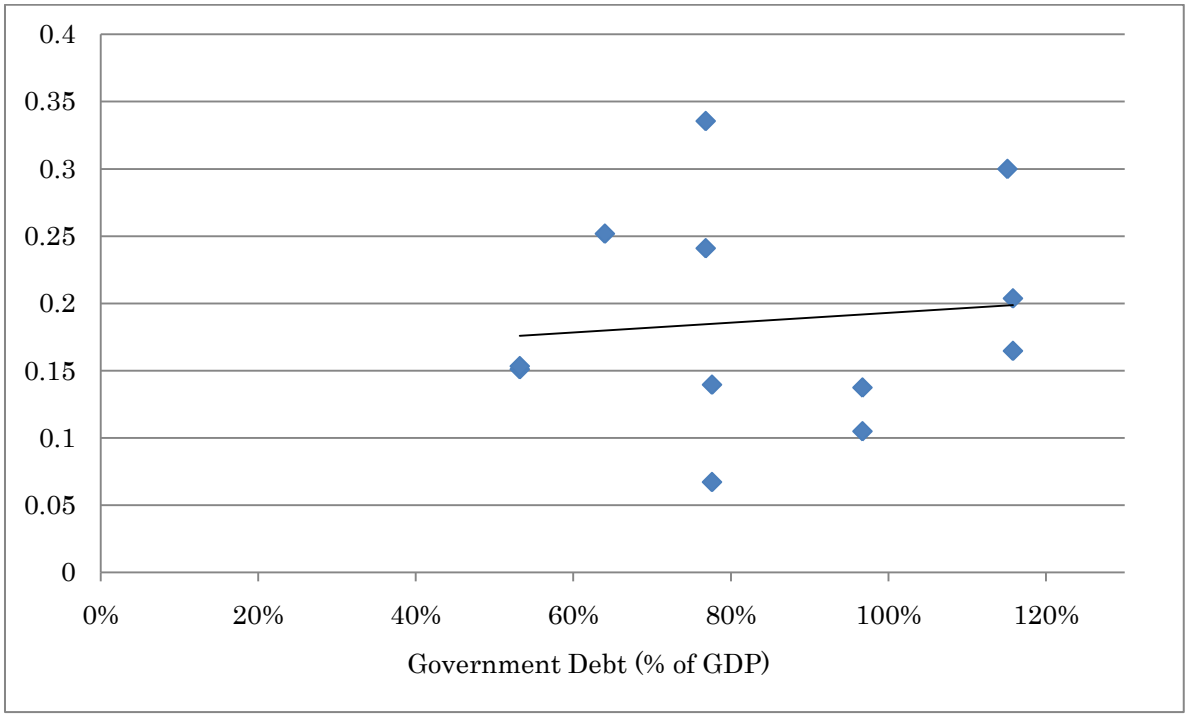


Figure 10a. Contagion Coefficient and Fiscal Indices



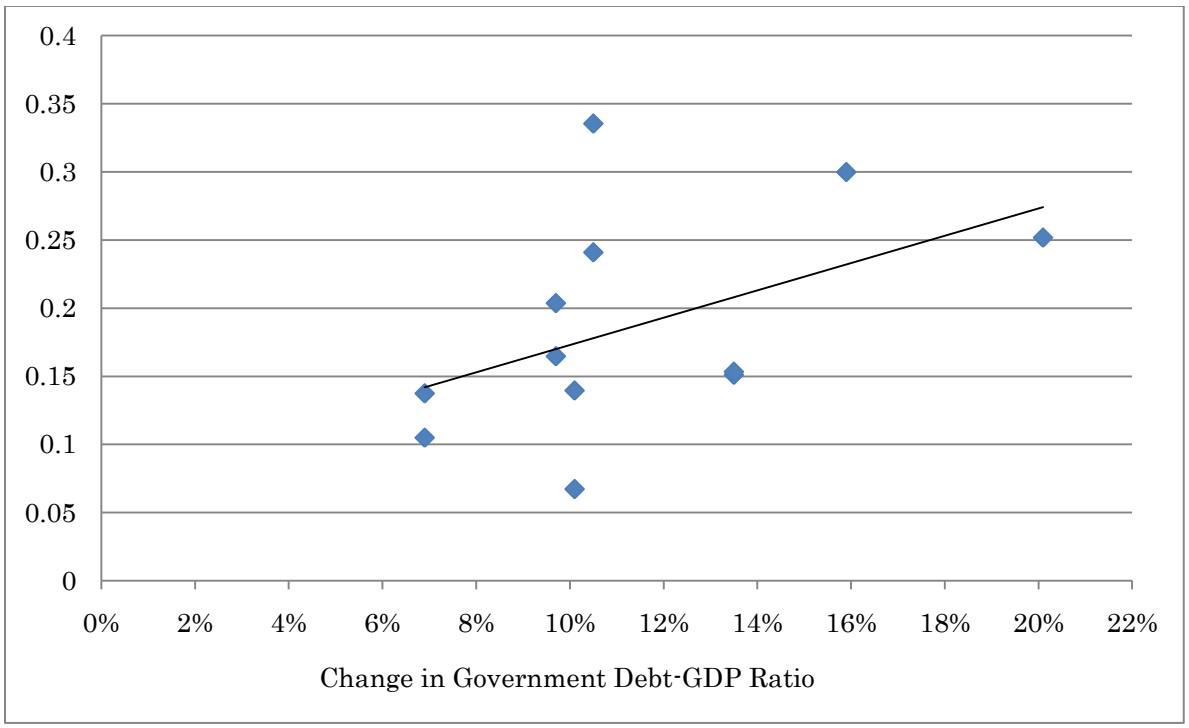
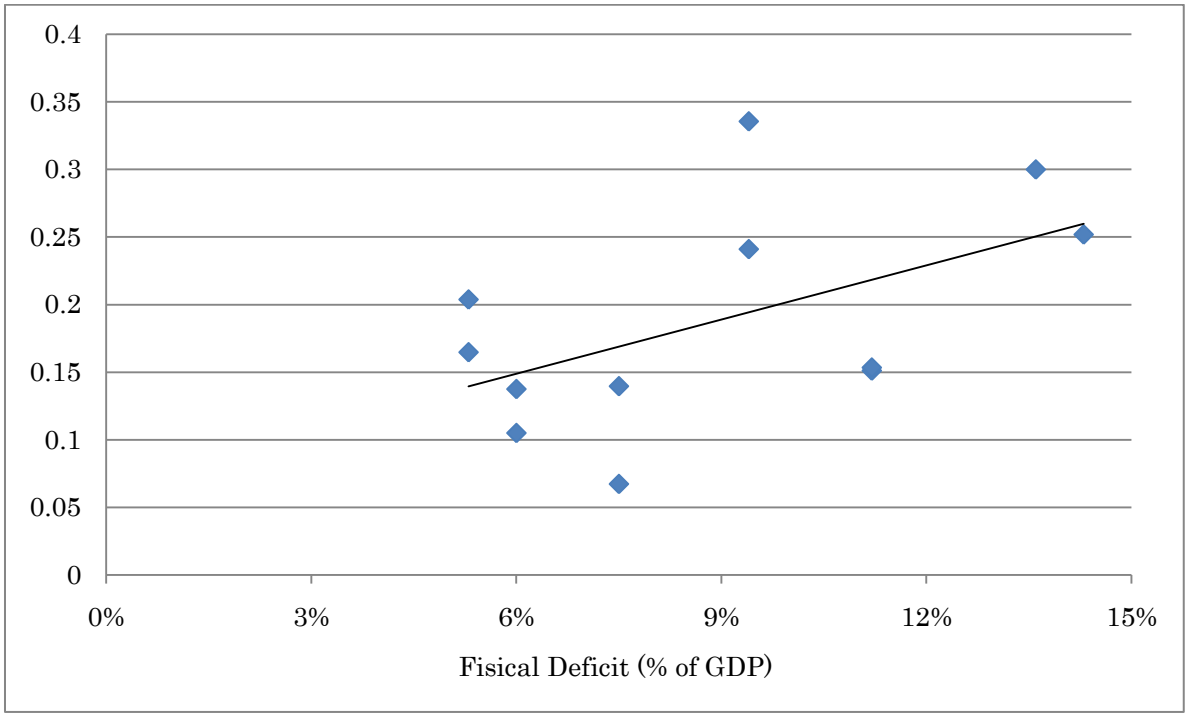


Figure 10a. Contagion Coefficient and Fiscal Indices (Cont.)



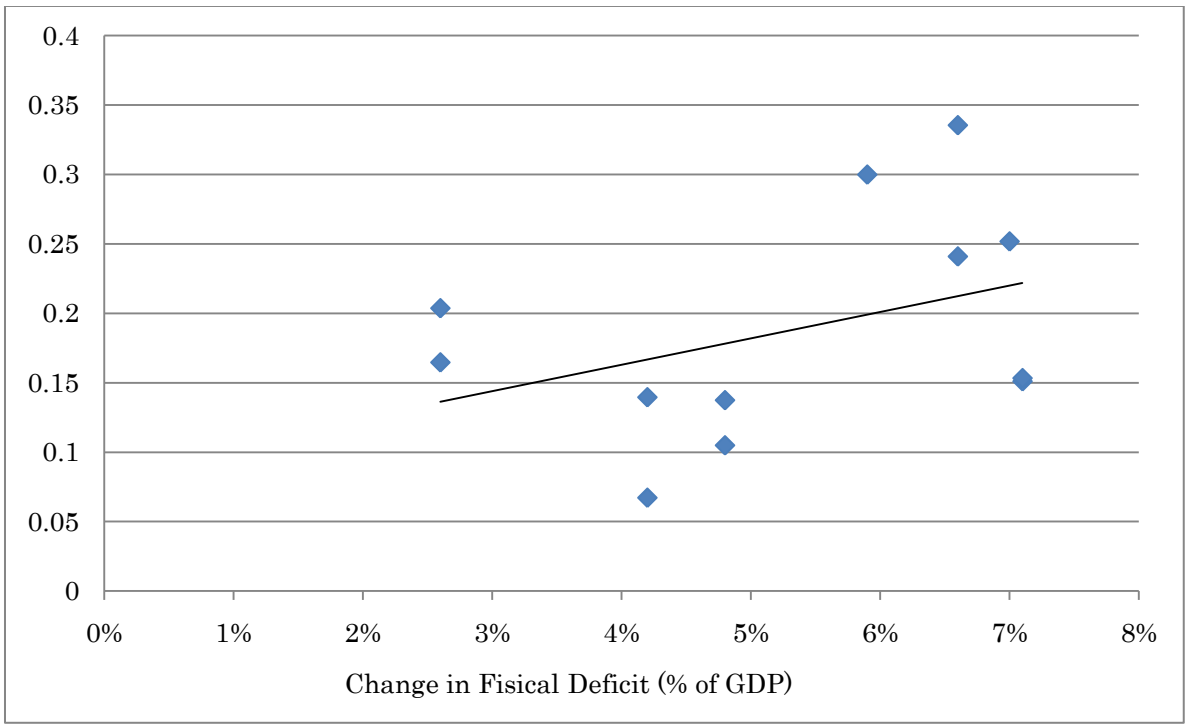
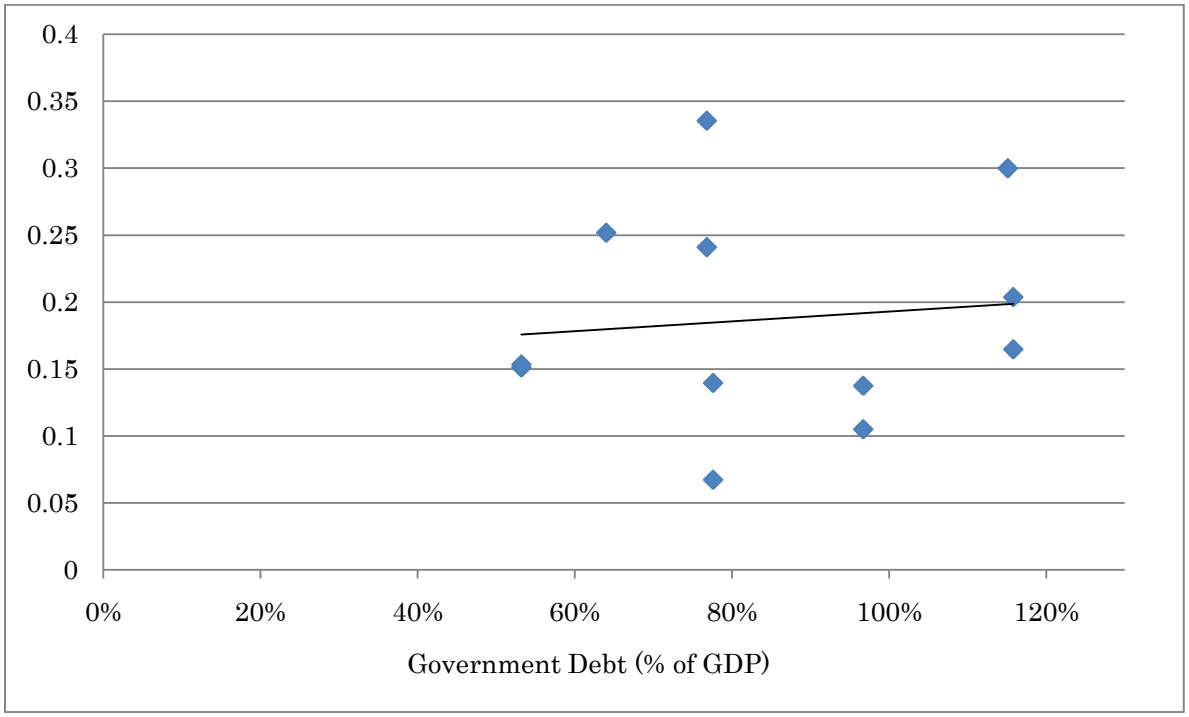


Figure 10b. Estimated Slope and Fiscal Indices



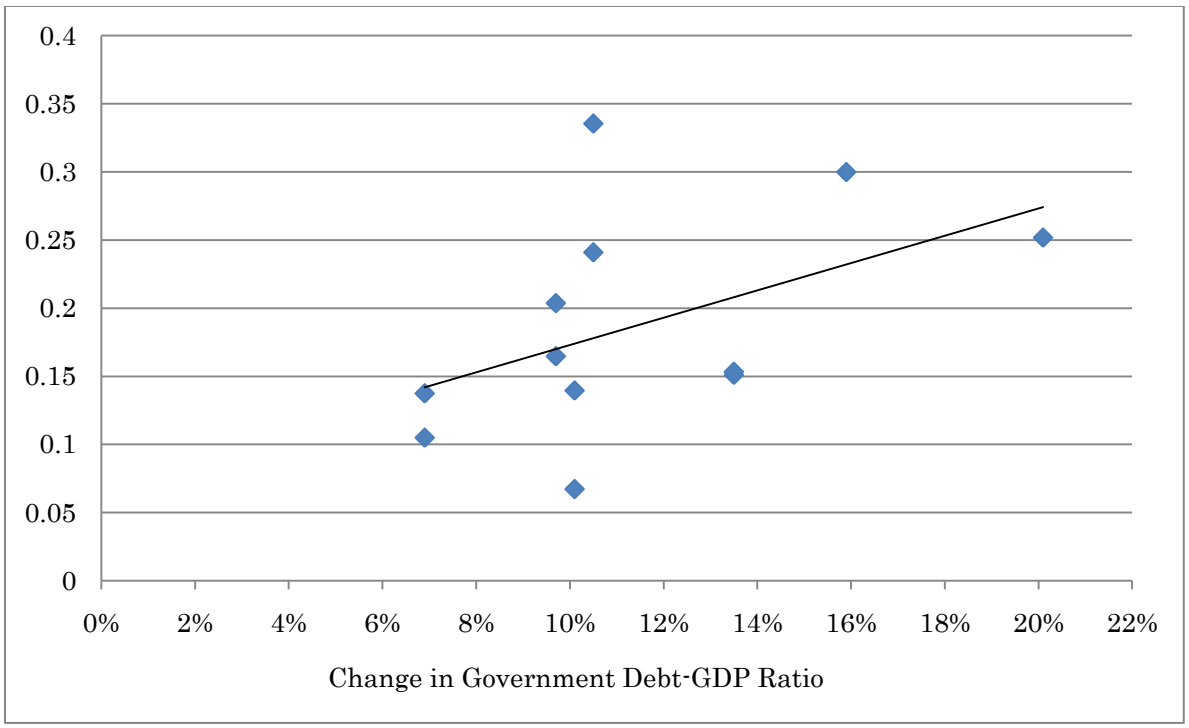
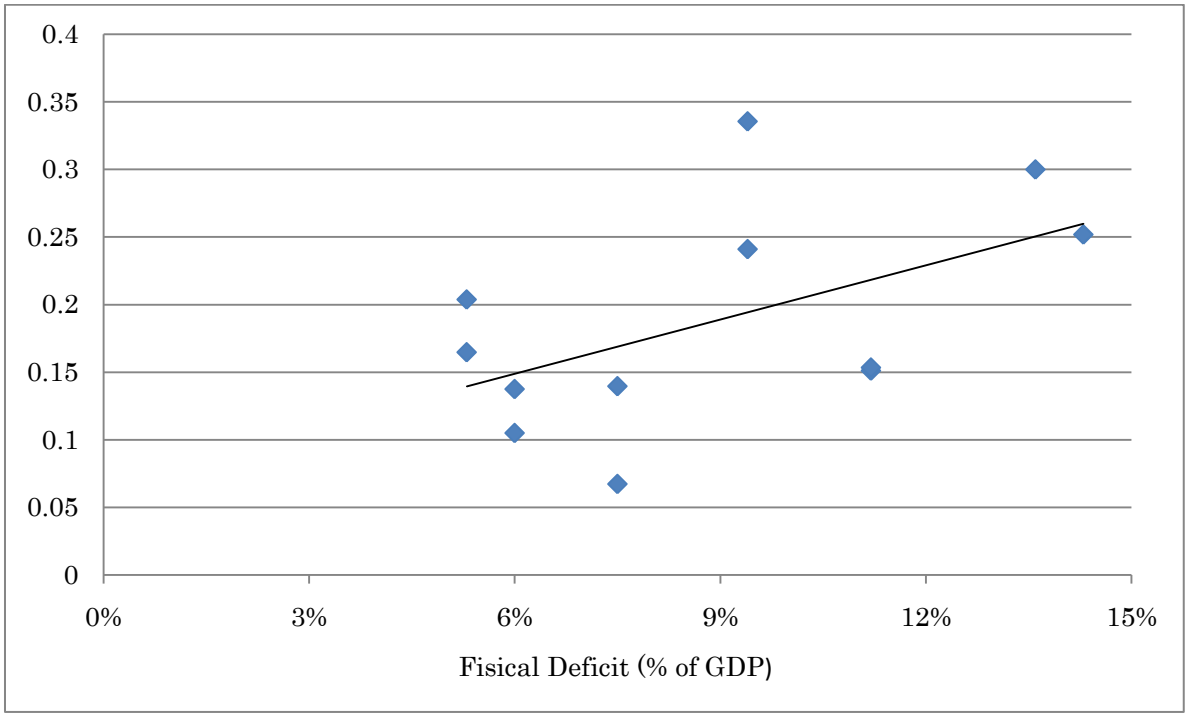


Figure 10b. Estimated Slope and Fiscal Indices (Cont.)



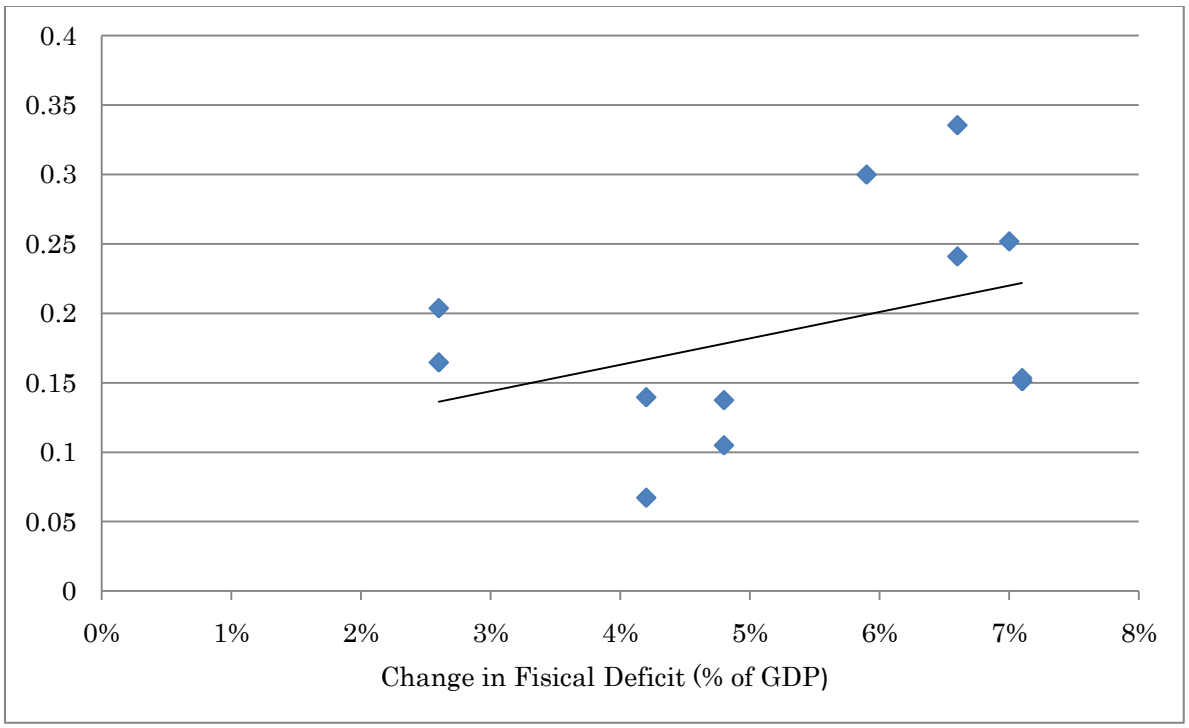
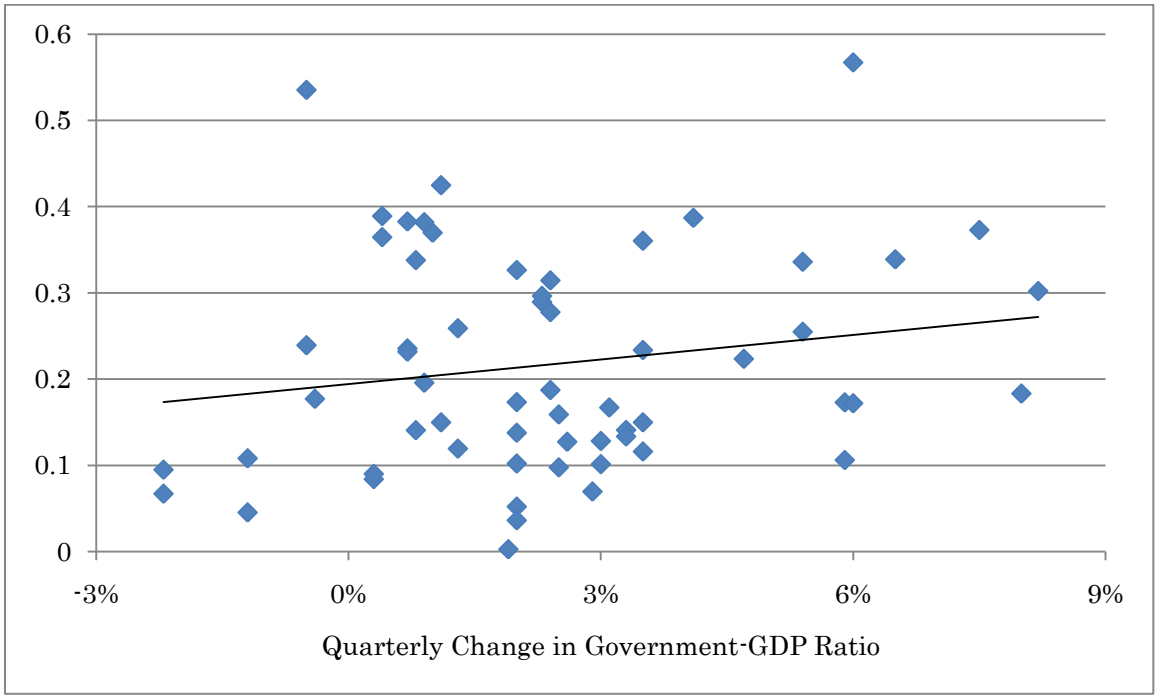


Table 7. Results on the Transmission Channel Analysis Using Quarterly Data

Note: ⊿Debt is a quarterly change in government debt/GDP ratio of the affected country. The source of fiscal data is Eurostat.

Quarter	Origin	Affected	Contagion coef.	⊿Debt
2008Q4	Greece	Ireland	0.34	6.5
		Italy	0.54	-0.5
		Portugal	0.36	0.4
		Spain	0.38	0.9
		France	0.14	0.8
		Belgium	0.24	0.7
	Ireland	Greece	0.37	1.0
		Italy	0.24	-0.5
		Portugal	0.39	0.4
		Spain	0.20	0.9
		France	0.34	0.8
		Belgium	0.23	0.7
2009Q1	Greece	Ireland	0.34	5.4
		Italy	0.42	1.1
		Portugal	0.29	2.3
		Spain	0.10	3.0
		France	0.08	0.3
		Belgium	0.16	2.5
	Ireland	Greece	0.38	0.7
		Italy	0.15	1.1
		Portugal	0.30	2.3
		Spain	0.13	3.0
		France	0.09	0.3
		Belgium	0.10	2.5
2009Q2	Greece	Ireland	0.37	7.5
		Italy	0.57	6.0
		Portugal	0.19	2.4
		Spain	0.14	3.3
		France	0.14	2.0
		Belgium	0.17	5.9
2009Q2 (cont.)	Ireland	Greece	0.18	8.0
		Italy	0.17	6.0
		Portugal	0.31	2.4
		Spain	0.13	3.3
		France	0.10	2.0
		Belgium	0.11	5.9
2009Q3	Greece	Ireland	0.30	8.2
		Italy	0.33	2.0
		Portugal	0.25	5.4
		Spain	0.39	4.1
		France	0.22	4.7
		Belgium	0.26	1.3
2009Q4	Greece	Ireland	0.28	2.4
		Italy	0.07	2.9
		Portugal	0.18	-0.4
		Spain	0.13	2.6
		France	0.00	1.9
		Belgium	0.05	2.0
2010Q1	Greece	Ireland	0.17	3.1
		Italy	0.11	-1.2
		Portugal	0.23	3.5
		Spain	0.12	3.5
		France	0.04	2.0
		Belgium	0.07	-2.2
	Ireland	Greece	0.12	1.3
		Italy	0.05	-1.2
		Portugal	0.36	3.5
		Spain	0.15	3.5
		France	0.17	2.0
		Belgium	0.09	-2.2
Correlation coefficient			0.177	

Figure 11. Quarterly Contagion Coefficient and Change in Government Debt



7. Conclusion

This paper has been one of the first attempts to analyze the role of contagion in the European sovereign debt crisis, today often referred to as the Aegean Contagion after its most apparent origin country. With modifications, Ito and Hashimoto's (2005) analysis of high-frequency contagion in the Asian crisis has been used to empirically investigate the Aegean Contagion. At the hand of daily government bond yield spread data, negative spillovers have been defined and analyzed from their origin to the affected countries.

This paper has shown that Greece was the main origin country of high-frequency contagion during the crisis between January 2008 and June 2010, affecting Ireland and Portugal greatly, and Italy and Spain to a lesser extent. Although the evidence is not as convincing, Ireland might have affected other countries from late 2008 to mid 2009. A shift of origins has occurred in the spring of 2009, from Greece to Ireland and back again, after Greece revealed its real deficits in November 2009. Finally, we found that the degree of the contagion is highly correlated with the fiscal situations in the affected countries, suggesting that the contagion was transmitted by investors' reassessment of risks in countries with similar fundamentals as the origin country.

However, massive and important, many aspects could not be covered in this short research paper. Much more investigation is needed to determine the differences between for example the two main waves of contagion coming from Greece during the crisis (before and after November 2009). Furthermore, the crisis seems not to be over yet so renewed analysis at a later stage will be needed, which could also include countries like Belgium, Hungary and the UK that have all shown striking GIIPS-like movements over the past few months as well. Finally, the role of positive spillovers and especially the positive role IFIs seem to have had in these in responding to this European sovereign debt crisis could prove a very interesting follow-up topic on the mitigation of crisis and prevention of contagion. Academics and practitioners alike will be interested in this crisis and its contagion for many more years – for now it proves to be a great case study for what is still to come in a world with rising sovereign debts and ever-increasing interdependence.

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