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Abstract

In light of the current woes of the Eurozone, it is easy to forget the excitement at the inception of the European Monetary Union fifteen years ago. Eurozone countries willingly gave up their own currency and monetary policy autonomy to join the currency union, lauding its apparent benefits. The collapse of the U.S. housing market in 2007, however, exposed weaknesses in the structure of the Euro area. Countries within the EMU faced different macroeconomic conditions, rendering the ECB incapable of implementing the ideal monetary policy for each member country. Using deviations from each country's ideal policy rate, I examine how each country's macroeconomic conditions affect ECB policy and how ECB policy affects member countries' 10-year government bond yields.

1 Introduction

In light of the current woes of the Eurozone, it is easy to forget the excitement at the inception of the European Monetary Union fifteen years ago. Many Eurozone countries celebrated the apparent benefits of joining the currency union. Although membership to the Eurozone meant giving up their own currency and relinquishing the monetary policy autonomy of their central banks, many countries preferred the newly established European Central Bank to the alternative. Countries that had irresponsible central bankers, in particular, could now enjoy low inflation and newfound macroeconomic stability. By reducing the risks of currency depreciation and inflation, borrowing rates for members of the European Monetary Union converged to the low rates in Germany. Countries enjoyed easy access to credit. Supported by financial inflows, many of these countries borrowed excessively and ran large current account deficits.

When the U.S. housing market collapsed in 2007 and the flow of foreign credit stopped, the member countries that had run current account deficits found themselves in great difficulty. Since the balance of payments surpluses in other members of the European Monetary Union canceled out their deficits, the euro did not depreciate as much as was needed to clear their deficits. Thus, the countries that ran current account deficits had to resort to borrowing. Tightening global credit markets, slowing national economies, rising borrowing costs, and fears of a Eurozone collapse contributed to the vicious cycle that is familiar to Eurozone observers in 2015.

The debt crisis exposed weaknesses in the structure of the Eurozone. If the countries with balance of payments deficits had control over their own monetary

policy decisions, their central banks could have provided the accommodative policy necessary to stimulate their economies. Unfortunately, the member countries had forfeited monetary policy autonomy to join the currency union, and the European Central Bank was unable to provide many of the countries with the easing they required during the sovereign debt crisis. A striking feature of the debt crisis is the different economic conditions faced by member countries of the European Monetary Union. As such, many economists contend that the problems of the Euro area were obvious from the outset and that a one-size-fits-all monetary policy was doomed to fail in a region with dissimilar economies, rigid labor markets, and decentralized fiscal policy.

In this paper, I examine the asymmetric economic conditions faced by the current members of the European Monetary Union using deviations from each country's ideal interest rate. I describe the deviations faced by EMU member countries, decomposing each country's deviation from its ideal policy rate into two terms. The first term describes the macroeconomic differences between each country and the rest of the Eurozone. The second term describes the rest of the Eurozone's deviation from its ideal interest rate. I examine how these deviations differ between EMU member countries. I also examine how each country's deviation from its ideal policy rate affects ECB policy as well as how ECB policy affects member countries' 10-year government bond yields.

The rest of the paper is organized as follows. Section II presents an overview of the related literature. Section III presents the deviation term and its decomposition. Section IV describes the data. Section V describes the empirical strategy. Section VI reports the results, and Section VII concludes.

2 Literature Review

This paper builds upon an existing body of literature on a country's deviation from its ideal interest rate. In their paper on simple monetary policy rules, Clarida et.al (1998) examine the effect of the European Exchange Rate Mechanism (ERM), a system where countries fixed to the Deutsche Mark, on the monetary policies of participating countries. The authors find that the interest rates set by central banks in participating countries during this period were much higher than what these countries' ideal interest rates warranted. Clarida et.al also decompose a participating country's deviation from its ideal interest rate into the sum of the interest rate differential between Germany and the participating country, the difference between the ideal rates in the two countries, and Germany's deviation from its ideal interest rate. This decomposition allows for the attribution of a participating country's deviation from its ideal policy rate to the difficulty in maintaining the fixed exchange rate mechanism, the macroeconomic differences between the country and Germany, and/or macroeconomic stress in Germany.

Following Clarida et.al, many economists have examined these deviations in member countries of currency unions. Quint (2014) examines these deviations in eleven of the twelve original EMU countries (his study excludes Luxembourg) during the European debt crisis and conducts a similar exercise for the states in pre-euro Germany and the United States. He adds to the model a time-varying intercept, which allows the equilibrium real interest rate to change across time and member country. He decomposes each country's deviation from its ideal policy rate into a structural term and a cyclical term. The structural term describes the changes in a country's equilibrium real interest rate over time. The cycli-

cal term describes a country's macroeconomic conditions. Quint finds that the high deviations observed at the introduction of the euro were driven by underlying differences in member countries' macroeconomic conditions. As countries' growth rates converged, the deviations from their ideal policy rates fell. At the onset of the European debt crisis in 2009, their growth rates diverged. Deviations rose once again, driven by differences in Germany and Greece. Quint aggregates EMU countries' deviations to compute Euro area deviations, which he compares to the area-level deviations of other currency regions. He concludes that Euro area deviations should not cause great concern, because they are very similar to the deviations observed in pre-euro Germany and the United States.

Lee and Crowley (2009) was one of the first papers to examine how the ECB responds to the economic conditions of individual countries. The authors perform some counterfactual policy exercises. In the first exercise, the authors use a modified forward-looking Taylor rule to determine what monetary policy decisions the ECB would enact if it only considers one country's macroeconomic conditions. In the second exercise, Lee and Crowley estimate each country's ideal interest rate with the reaction coefficients of each member country's defunct central bank. Finding evidence of structural instability in their estimated pre-euro reaction coefficients of the Taylor rule (joining the EMU affects the estimation of each country's specific reaction coefficients), the authors apply recursive estimations. Taking the difference between the Euro area's ideal policy rate and either a country's ideal rate computed with ECB coefficients or pre-euro country preferences, Lee and Crowley find that ECB monetary policy suits some countries more than others.

Sturm and Wollershäuer (2008), in particular, examine how the ECB weights each country in its monetary policy decision-making process. Using each country's

deviation from its ideal interest rate, the authors construct a measure of deviation for the whole Euro area and find that small countries - Austria, Belgium, Finland, Greece, Ireland, and Portugal - are overrepresented in the ECB decision-making process. Their weights are greater than what would be warranted by the size of their economies alone. On the other hand, large countries, such as France, Germany, and Italy, are underrepresented relative to their economic sizes. This weighing scheme helped synchronize the member countries' business cycles and reduced aggregate deviations by fifteen percent in the sample period. Drometer, Siemsen, and Watzka (2013) corroborate these results. The authors find that Germany's ideal interest rate traces the EONIA, the interbank lending rate, between 1999 and 2007. At the onset of the European sovereign debt crisis, the ECB placed more weight on the needs of weaker economies. As such, the EONIA was closer to the ideal rates in the weaker economies than it was to Germany's target rate.

I contribute to the existing body of literature in the following ways. To characterize each member country's deviation from its ideal interest rate, I offer a new decomposition of the deviation term. I isolate the terms that relate to one country's deviation from the deviations of the remaining countries in the EMU. I also examine how different macroeconomic conditions in EMU member countries affect ECB policy and vice versa through the ECB's unconventional monetary policy responses. Previous literature on the ECB's one-size-fits-all monetary policy deals primarily with conventional monetary policy. At the onset of the European sovereign debt crisis, the ECB began enacting unconventional monetary policy and affecting the economies of member countries through other channels. I examine the effect member countries' deviations have on unconventional monetary policy and the effect unconventional policy has on 10-year monthly government bond

yields.

3 Theoretical Framework

3.1 Decomposition of the Deviation Term

I begin this section with a discussion of Clarida et.al's seminal 1998 paper, where the authors define a country's deviation term and its decomposition in the context of a fixed exchange rate regime. I will extend their definition of the deviation term and its decomposition to the context of a currency union. They define the deviation term s_t for a country as the difference between its policy rate and its ideal interest rate, i.e. $s_t = i_t - i_t^*$, where the ideal interest rate is given by a forward-looking Taylor rule with the partial adjustment mechanism. For the purposes of this paper, I will not use their forward-looking Taylor rule. Instead, to calculate each country's ideal interest rate, I use the following simple Taylor rule

$$i_t^* = r^n + \gamma_\pi(\pi_t - \pi^*) + \gamma_y \widehat{y_t} \tag{1}$$

where r^n is the long-run equilibrium nominal rate, π_t is the inflation rate at time t, π^* is the inflation target, $\widehat{y_t}$ is the output gap at time t, γ_π and γ_y are the respective reaction coefficients. I assume that all countries willingly joined the Eurozone. This implies that all countries in the Euro area would have the same Taylor rule reaction coefficients even if they could set their own monetary policy. This assumption is not far-fetched even though prior to the introduction of the euro, some of the current Eurozone members had irresponsible central bankers (i.e. Greece and Italy) and suffered from high inflation and macroeconomic instability.

Since the existing body of literature on these deviation terms does not offer great estimates for these reaction coefficients, I default to the reaction coefficients given in Taylor (1993). The deviation term is positive when the effective interest rate is greater than a country's ideal interest rate. A positive deviation term suggests that the monetary policy for the country should be more accommodative. The deviation term is negative when a country's ideal interest rate is higher than the effective interest rate, so a negative deviation term suggests the the monetary policy for that country should be tighter.

I can not only define a deviation term s_t for the country that fixes its currency to another's currency but also define a deviation term s_t^g for the other country, i.e. $s_t^g = i_t^g - i_t^{g*}$. From here on out, I will refer to the first country (the one that fixes its currency) as Italy and the country whose currency Italy is fixed to as Germany for reasons of convenience. By rearranging the terms, Clarida et.al offer the following decomposition of deviation term

$$s_t = (i_t - i_t^g) + (i^{g*} - i_t^*) + s_t^g \tag{2}$$

where the first term is the interest rate differential between Italy and Germany, the second term is the difference between the ideal policy rates in the two countries, and the third term is Germany's deviation from its ideal interest rate. The first term, which is the interest rate differential between Italy and Germany, describes Italy's commitment to maintaining the fixed exchange rate mechanism. The second term, which is the difference between the countries' ideal interest rates, describes the differences in macroeconomic conditions between the two countries. The third term, which is Germany's deviation from its ideal policy rate, describes

its macroeconomic conditions.

I can extend the concept of deviation from the context of a fixed exchange rate regime to the context of a currency union, since the deviation term just is the difference between the effective interest rate in a country and its ideal policy rate. In a currency union, this rate is not set by the country's central bank but rather by the central bank in charge of the monetary policy for the region as a whole. I return to my example with Italy. I define Italy's deviation term s_t as $s_t = i_t^{ITALY} - i_t^*$ where the effective interest rate i^{ITALY} in practice is equal to i^{ECB}, the policy rate set by the ECB. In the same way, I can define the deviation term for the Euro area as a region. The deviation term for the Eurozone s_t^{EMU} can be defined as $s_t^{EMU} = i_t^{ECB} - i_t^{EMU*}$. By rearranging the terms, I obtain a decomposition of the deviation term for Italy that is similar to the decomposition offered by Clarida et.al in their 1998 paper. The decomposition for Italy is

$$\begin{aligned} s_t &= (i_t^{ITALY} - i_t^{ECB}) + (i^{EMU*} - i_t^*) + s_t^{EMU} \\ &= (i^{EMU*} - i_t^*) + s_t^{EMU} \end{aligned} \tag{3}$$

where the terms hold similar meaning. In Clarida et.al's decomposition, the first term is the interest rate differential between Italy and Germany and describes Italy's commitment to maintaining its fixed exchange rate mechanism. As a member of the Eurozone, Italy does not have to maintain a fixed exchange rate regime. It uses the same currency as the rest of the Euro area. In the EMU, Italy's effective interest rate is the policy rate set by the ECB. As a result, the first term in Clarida et.al's decomposition of the deviation term drops from my decomposition of the deviation term for a currency union.

More than just presenting a decomposition of the deviation term, I seek to determine the sources of a country's deviation from its ideal interest rate. In other words, it is more interesting to know whether a country's deviation is from its own macroeconomic conditions or the macroeconomic conditions of the other countries in the currency union. The decomposition of the deviation term, in its current form, does not allow for the aforementioned attributions. I revisit my example with Italy. Since Italy is a member of the EMU, Italy's macroeconomic conditions affect the macroeconomic conditions of the region as a whole. Similarly, Italy's deviations from its ideal interest rate affect the deviations of the region as a whole. To disentangle the terms, I expand the ideal interest rates for Italy and the Euro area using the simple Taylor rule previously defined. After rearranging the terms, country i's deviation from its ideal policy rate is

$$s_{it} = \textit{macroeconomic differences}_{it} + \textit{rest of EMU stress}_{t} \tag{4}$$

where the first term

$$\textit{macroeconomic differences}_{it} = \sum_{j \neq i} \frac{\omega_j}{1-\omega_i} [\gamma_{\pi}^{ECB}(\pi_{jt} - \pi_{it}) + \gamma_{y}^{ECB}(\hat{y}_{jt} - \hat{y}_{it})] \tag{5}$$

and the second term

$$\textit{rest of EMU}_{it} = \sum_{j \neq i} \frac{\omega_j}{1-\omega_i} [i_t^{EMU} - (r_{ECB}^{n} + \gamma_{\pi}^{ECB}(\pi_{jt} - \pi_{ECB}^{*}) + \gamma_{y}^{ECB}\hat{y}_{jt})]. \tag{6}$$

Let country j represent all countries in the Eurozone that are not country i. In the first term, I aggregate the differences in inflation and output between all country

j's (the rest of the EMU) and country i. Since inflation and output are measures of a country's macroeconomic health, the first term precisely describes the macroeconomic conditions between the rest of the EMU and country i. In the second term, I calculate and aggregate the deviations from the ideal policy rates for all country j's weighted by their economic size in the rest of the Eurozone. This is precisely the rest of the EMU's deviation from its ideal policy rate. Thus, my decomposition allows for the attribution of a country's deviation from its ideal policy rate to its own macroeconomic conditions and/or the macroeconomic conditions in the other countries of the currency union.

3.2 Simulations

To gain more intuition about how deviations are different between member countries, I construct a hypothetical currency union with three countries of different economic sizes and examine what happens to the countries' deviation terms when each country experiences an asymmetric shock. In my currency union, the first country produces fifty percent of the region's output. The second country produces thirty percent of the region's output. The last country produces the remaining twenty percent of the region's output.

Suppose each country in the currency area experiences an asymmetric inflation shock (the macroeconomic conditions in the other two countries stay the same). A graph of the results can be found in Figure 1 of the appendix. In all three countries, I observe that as inflation increases in each country, its deviation from its ideal interest rate becomes more negative. This is because the effective interest rate in the currency union is too low for the country experiencing the shock.

Each country needs tighter monetary policy than what is offered by the region's central bank. Of particular note is the slope of each line, which tells us by how much the deviation increases with each percentage-point increase in inflation. For the country that produces fifty percent of the region's output, the slope is the least steep. For the country that produces twenty percent of the region's output, the slope is the most steep. As a country's weight in the region increases, its influence in the region grows. Since the region's monetary policy is a response to the weighted average of the macroeconomic conditions of each member country, the central bank's monetary policy decision suits the largest country more than it suits the smallest country in the region.

A similar study on the output gap corroborates these results. A graph for the output gap can be found in Figure 2 of the appendix. I examine what happens to the deviation term of each member country in the currency union when it faces an asymmetric shock to its output gap. I observe that, as a country's output gap becomes more positive, its deviations from its ideal interest rate become more negative. This is because the effective interest rate in the currency union is too low for the country experiencing the shock under these circumstances. Each country needs tighter monetary policy than what is offered by the region's central bank. Here too, the slope is the least steep for the country that produces fifty percent of the region's output and the most steep for the region that produces twenty percent of the region's output. This corroborates our previous findings that the responsiveness of the deviations to a shock are least extreme for the country that produces the most output in the currency union and most extreme for the country that produces the least output in the currency union. These results suggest that asymmetric shocks affect the small economies in a currency union the most and

are most harmful to them.

4 Data

4.1 Sources

I use monthly, quarterly, and yearly data beginning in 1999, the year the euro was introduced in the eleven original countries of the Eurozone. Eurostat publishes the Harmonised Index of Consumer Prices (HICP) at a monthly level and each country's weight in the Eurozone at a yearly level. The OECD Main Indicators Database releases quarterly data for real GDP and monthly data for 10-year government bond yields. The Deutsche Bundesbank publishes key ECB interest rates at monthly intervals. The ECB's policy announcements are found on its website. In particular, the central bank synthesized a list of important unconventional monetary policy measures they pursued in a PowerPoint presentation available to the public. While there are currently nineteen countries in the Euro area (Lithuania joined the EMU on January 1, 2015), I exclude three of the EMU member countries from my sample. I omit Cyprus and Malta from the data set, because their quarterly real GDP data are unavailable. I exclude Lithuania, because my data set ends in 2014. These exclusions will not have a large bearing on the results. Cyprus and Malta are small countries in the Euro area, and each contributes trivially to the Eurozone's GDP. I am also more interested in the results for the countries that feature prominently in the news.

To calculate quarterly inflation for each country in the Eurozone as well as the Eurozone itself, I keep the price level of every third month of each year and

take the year-over-year percentage change in the price level. While there has been much discussion about the best method by which to estimate potential GDP, there has been no consensus on this matter (Cotis et.al 2005). In fact, the ECB itself has no potential GDP estimation method that they abide by as an institution and, instead, uses many different potential GDP calculations when formulating monetary policy decisions. I use the univariate Hodrick-Prescott filter, one of the most widely used, for my estimation of potential GDP. Each country's output gap is calculated by taking 100 times the difference between the log values of real and potential GDP. The real GDP values for the Eurozone as a whole are important to note here. They do not reflect the changing composition of the Eurozone. In other words, real GDP for the Eurozone as a whole is the sum of the real GDPs of all sixteen countries in my data set during the sample period. I calculate the output gap for the Euro area as a region in two different ways. In the first method, I use the HP filter on the region's real GDP values to estimate the potential GDP values of the currency union. In the second method, I take the weighted sum of each country's output gap, which is computed using the HP filter on each country's individual real GDP values. The weight of a country is zero in the period before it joins the Eurozone and greater than zero thereafter. I compare the output gaps estimates I obtain from these two methods by plotting their corresponding deviation terms in a graph (Figure 3 in the appendix). The differences are trivial. Unless otherwise specified, I use the output gap I obtain for the Euro area using the first method.

The ECB has three key interest rates, which are the main refinancing operations rate, the deposit facility rate, and the marginal lending facility rate. For the purposes of this paper, I use the marginal lending facility rate as the actual interest

rate. The marginal lending facility rate is the rate at which credit institutions obtain overnight liquidity against sufficient assets. It is one of the two standing facilities, which are the Eurozone equivalent of the U.S. discount window. Like the U.S. discount window, the rate is set by the central bank. While the EURIBOR and the EONIA are measures of the overnight rate at which Eurozone banks lend to each other, subtle differences between the EURIBOR/EONIA and U.S. fed funds rate (the policy rate that Clarida et.al use in their seminal paper) render the marginal lending facility rate the preferred policy rate for this exercise. I also note here that I will use the ECB's policy announcements synonymously with the implementation of its unconventional monetary policy measures. This is because expectations adjust when the central bank announces its unconventional policy decisions.

4.2 Quantifying Deviations from Ideal Interest Rates

I graph the deviations for the Euro area, Germany, Austria, Italy, and Greece during the pre-financial crisis period (1999-2007), financial crisis period (2008-2010), and the post-financial crisis period (2011-2014). The graphs are found in Figures 4-6 in the appendix. Germany represents large economies in the EMU that are running current account surpluses, i.e., countries that are not besieged by the current sovereign debt crisis. Austria represents small economies in the EMU that are running current account surpluses. Italy represents large economies in the EMU that are running current account deficits, i.e., countries that are besieged by the current sovereign debt crisis. And finally, Greece represents small economies in the EMU that are running current account deficits.

I discuss the key findings. During the pre-financial crisis, the deviations in the four countries began to converge to the Euro area's deviation from its ideal interest rate. This is supported by the fact that after the countries joined the EMU, their macroeconomic conditions began to converge. During this period, we observe that the Eurozone's deviation from its ideal interest rate is positive and non-zero. Perhaps this is because the ECB set tight monetary policy measures in expectation of future macroeconomic developments. Other than for Greece, the deviations in the other three countries were quite close to the deviation for the Eurozone during the financial crisis. While the U.S. housing bubble collapsed in the fall of 2007, the onset of the European sovereign debt crisis occurred much later. Consequently, the deviations for small and large countries running current account surpluses and deficits did not diverge during the financial crisis. Observe that the deviations for Greece during this period suggest that the ECB's monetary policy was too loose for the country between 2008 and 2010. While this might seem strange to the observer, it is important to note that the Greek federal government had falsified much of its economic data during this period of time. The deviations for the four countries diverge as expected during the post-financial crisis period. Italy and Greece's deviations from their ideal interest rates are positive. Struggling with sovereign debt crises, their countries needed more accommodative monetary policy than what the ECB offered. Greece's deviations are particularly large. On the other hand, Italy's deviations are still very close to the Eurozone's deviations from its ideal interest rate. As a small country, Greece's weight in the ECB decision-making process is small. Italy, on the other hand, is a large country. The ECB takes its macroeconomic conditions more into account when making policy decisions for the region as a whole. As expected, Germany and Austria's deviations are negative,

since they are running current account surpluses. The findings support the fact that asymmetric shocks are most harmful to small economies.

5 Empirical Strategy

I examine how each country's deviation terms affects ECB policy and how ECB policy affects member countries' 10-year government bond yields. To answer the first question, I use the following empirical strategy. I examine whether past Eurozone deviation and member country deviation contribute to a change in the probability for the ECB to announcing unconventional monetary policy measures in the current quarter. I recognize that there is a lag on the ECB's policy response to the macroeconomic conditions in the Euro area, so these events are not contemporaneous. The regression model is as follows.

$$\begin{aligned} \textit{Unconventional Policy}_t = \alpha &+ \beta\, \textit{Cumulative Eurozone Deviation}_t \\ &+ \gamma\, \textit{Cumulative Member Country Deviation}_t \\ &+ \delta I(i > 4\%)_t + \epsilon_t \end{aligned} \tag{1}$$

where $\textit{Unconventional Policy}_t$ is a dummy variable that indicates whether the ECB made an unconventional monetary policy announcement this quarter. Note that the variables $\textit{Cumulative Eurozone Deviation}_t$ and $\textit{Cumulative Member Country Deviation}_t$ show a region or country's deviations from its ideal interest rate accumulated over a time period. To capture different policy horizons for the ECB, I use the cumulative deviation over the past year, the past three years, and the past five years. Thus, I restrict my data to the years after 2004 because of how I construct

the cumulative deviation terms. The reason why I use these variables as opposed to one quarter's level of deviation is because there are very few unconventional monetary policy measures the ECB believes to be important (listed in the institution's PowerPoint). In fact, there are only six such policy announcements when using quarterly data, and there are no events before 2007. Having so few data points makes it very difficult to test whether one quarter's level of deviation alone contributes to a change in the probability for the ECB to announce unconventional monetary policy measures in the present. I also include the variable $I(i > 4\%)_t$ in our model. This variable indicates whether the effective interest rate in the Euro area during the current quarter is greater than four percent, which is the ECB's target nominal interest rate if inflation is on target and the output gap is zero. When the nominal interest rate is greater than four percentage-points, it is very unlikely for the ECB to enact unconventional monetary policy measures to stimulate the economy. It still has conventional monetary policy at its disposal. I use this benchmark, because I am interested in the period when unconventional monetary policy measures enter the central bank's toolbox.

The second question asks whether ECB policy affects member countries' 10-year monthly government bond yields. To answer this question, I use the following empirical strategy. I test whether past ECB announcements of unconventional monetary policy measures contribute to a change in the difference between a member country and Germany's 10-year government bond yields. The difference between these bond yields is the difference in expectations between their short-term interest rates and the difference between their risk premia. Germany is often regarded as the healthiest economy in the Eurozone and, consequently, its 10-year government bonds are the safest in the region. Its expected short-term in-

terest rates and risk premium are low. The difference between a country's 10-year government bond yield and Germany's 10-year government bond yield measures the macroeconomic differences between the two countries. In my study, I use a simple difference-in-differences model and examine whether past unconventional monetary policy announcements have an additional effect on PIIGS countries – Portugal, Ireland, Italy, Greece, and Spain – and Germany's 10-year government bond yield differences. The regression model is as follows.

$$\begin{aligned} \textit{Yield Differentials}_{it} = \alpha + \beta \text{Treatment}_i + \gamma \textit{Months Since}_t \\ + \delta \textit{Treatment}_i \times \textit{Months Since}_t \\ + \zeta \textit{Never Before}_t + \epsilon_{t.} \end{aligned} \tag{2}$$

The variable $Treatment_i$, an indicator variable, takes many forms, since we have several treatment groups. All PIIGS countries are in our first treatment group. The other treatment groups contain only one of the PIIGS countries. The variable $\textit{Months Since}_t$ tells us the number of months it has been since the last unconventional monetary policy announcement was made. The interaction term $\textit{Treatment}_i \times \textit{Months Since}_t$ describes the additional effect an unconventional monetary policy announcement has on yield differentials between Germany and one or all of the PIIGS countries. The dummy variable $\textit{Never Before}_t$ indicates whether the month lies in the period of time before the first policy announcement was made. I report the results in the next section.

6 Results

I examine the results from the first regression, which examines whether a member country's cumulative deviation term contributes additionally to the probability of the ECB in making an unconventional monetary policy announcement in the current quarter. In other words, I am examining what each country's weight is in the ECB's decision-making process. Is each country's weight its economic size in the Euro area? Or, is its weight different from its economic size in the currency union? In particular, I am interested in whether the ECB places more weight on the PIIGS countries when making unconventional monetary policy decisions. Past literature on the topic has found that the ECB took a "Robin Hood" approach when making conventional monetary policy decisions for the region during the European sovereign debt crisis (Drometer et.al 2013). I expect for the ECB to adopt the same weighing mechanism when making unconventional monetary policy decisions. Hence, my expectation is that the effect of the PIIGS countries' cumulative deviations terms on the likelihood for the ECB to announce unconventional monetary policy measures is positive and significant while the effect of their German and French counterparts is insignificant.

The results of the first regression are reported in Tables 2-4 of the appendix. For the PIIGS countries, I find that the results are, for the most part, negative and insignificant. These are not the results that we expected to find. The results, while insignificant, suggest that an additional one percentage-point increase in a country's cumulative deviation term, holding all else equal, decreases the probability for the ECB to make an unconventional monetary policy announcement in the current quarter. These results are due to the difficulty in assessing the effect of

the deviation terms on unconventional monetary policy, for which I have limited data. While the Taylor rule describes conventional monetary policy well, there is yet to be a similar model for unconventional monetary policy. What the results do show is that the probability of an ECB policy announcement decreases when the ECB's effective interest rate is greater than its nominal interest rate target of four percent. When the ECB's policy rate is greater than four percent, there is no need for the central bank to enact unconventional monetary policy measures. The ECB has the option to lower its policy rate when the region faces an economic downturn. We find that the results are also negative and insignificant for Germany and France.

I also examine the results of the second regression, which examines whether past unconventional monetary policy announcements have an additional effect on the 10-year government bond yield differentials between Germany and the PIIGS countries. The effect could go in either direction. I might find that the more months it has been since the ECB's last unconventional monetary policy announcement, the greater the yield differentials are between Germany and my treatment group. This is possible because policy announcements have an immediate effect on the expected short-term interest rates and risk premia in Germany and the treatment group, resulting in an immediate decrease in their yield differentials. Over time, the yield differentials would increase again because of the underlying macroeconomic differences between Germany and the PIIGS countries. This is why the likelihood for the ECB to make an unconventional monetary policy announcement becomes more likely the more months it has been since it last made a policy announcement. On the other hand, I might find that the passage of an additional month since the ECB's last policy announcement lowers the yield dif-

ferentials between Germany and the PIIGS countries. This is possible because the effect of the policy announcement and, subsequently, the implementation of the unconventional measures can last well after the initial announcement.

The results are reported in Table 5 of the appendix. I find that the passage of another month has an additional effect on the yield differentials between Germany and some of my treatment groups. These results are significant. The passage of another month decreases the yield differential between Germany and the PIIGS countries as a whole by 0.00275 percentage-points. It decreases the yield differential between Germany and Portugal by 0.00213 percentage-points. It decreases the yield differential between Germany and Ireland by 0.00118 percentage points. It decreases the yield differential between Germany and Greece by 0.00624 percentage-points. While the effect of unconventional monetary policy on Greece is the most pronounced, it is important to note just how large the yield differentials are between the two countries. The unconventional monetary policy measures, while effective, only do so much in providing more accommodative monetary policy to countries that are besieged by sovereign debt crises.

7 Conclusion

In this paper, I define each country's deviation from its ideal interest rate. When extending this concept from the context of a fixed exchange rate regime to the context of a currency union, I decompose a country's deviation from its ideal interest rate into two terms. The first term describes the macroeconomic differences between the country and the rest of the Euro area. The second term is the weighted sum of the deviations in the rest of the Eurozone. This decomposition allows for

a country's deviation from its ideal policy rate to be attributed to the macroeconomic circumstances in its own country and/or the macroeconomic circumstances in the rest of the Eurozone.

To examine how a country's economic size in the region affects its deviation from its ideal interest rate, I construct a hypothetical currency union composed of three countries of different economic sizes. When each country experiences an asymmetric shock to inflation or output, its deviation from its ideal policy rate increases in magnitude. However, the magnitude of the deviation increases the least for the largest economy and the most for the smallest economy. This is because a country's influence in the region grows as its weight in the region increases. Since the region's monetary policy is a response to the weighted average of the macroeconomic conditions of each member country, the central bank's monetary policy decision suits the largest economy more than it suits the smallest economy in the region. Asymmetric shocks, therefore, hurt small economies in the currency union the most.

These findings are consistent with my deviation estimates for EMU member countries between 1999 and 2014. In particular, we examine the deviations in Germany, Austria, Italy, and Greece. All four countries' deviations converged to the Eurozone's deviation from its ideal interest rate during the pre-financial crisis period (1999-2007). Since the European sovereign debt crisis hit the region after the financial crisis, most countries' deviations remained similar to the Eurozone's deviation between 2008 to 2010. At the onset of the sovereign debt crises in their respective countries, Italy and Greece's deviations from their ideal interest rates were positive. They needed more accommodative monetary policy than what the ECB offered during the time period. Greece's deviations are particularly large,

because its weight in the ECB decision-making process is small. On the other hand, as a large country, Italy's deviations from its ideal interest rate were still very close to the Eurozone's deviations in 2011 to 2014. Thus, the ECB takes its macroeconomic conditions more into account when making policy decisions for the region as a whole.

I then examine whether individual countries' deviation from their ideal policy rates affect the ECB's unconventional monetary policy and whether these announcements affect each country's 10-year government bond yield differentials with Germany. The results on the implicit weighing scheme behind the ECB's decision-making process are inconclusive. While past literature has shown that the Taylor rule describes conventional monetary policy well and that the ECB has taken a "Robin Hood" approach in the European sovereign debt crisis, it is difficult to determine each country's influence in the ECB's unconventional monetary policy decisions (Drometer et.al 2013). Future research can shed more light on this matter. The results do show, however, that when the ECB makes unconventional monetary policy announcements, the announcements are effective in providing accommodative monetary policy, albeit small, to the countries in the EMU that are besieged by sovereign debt crises: the PIIGS countries. Through this alternative channel, the ECB can decrease the yield differentials between Germany and many of the PIIGS countries, lowering the expected short-term interest rates and risk premia for the PIIGS countries. Since the yield differential is a measure similar to the deviation term, the results show that unconventional monetary policy can decrease the PIIGS countries' deviations from their ideal interest rates. While these policy announcements provide some aid to countries that are struggling with sovereign debt crises, it is clear that more can be done for these countries. Past

unconventional monetary policy announcements have not been enough.

Further studies can be done on the topic. I can run the same exercises using Clarida et. al's forward-looking Taylor rule with the partial adjustment mechanism instead of the simple Taylor rule. Using the forward-looking Taylor rule allows for the differentiation between the central bank's responses to the output gap and inflation expectations. It would be particularly interesting to use a multi-country DSGE model to quantify each country's deviation terms and examine the effect these deviation terms have on the ECB's unconventional monetary policy announcements and vice versa. The DSGE model, which is beyond the scope of this paper, could offer a better and more sophisticated understanding of each country's deviation of its ideal interest rate.

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Appendix

A. Simulation

The following two graphs are from our simulations in Section 3.2. The first graph describes what happens to each country's deviation term as it experiences an asymmetric inflation shock. The second graph describes what happens to each country's deviation term as it experiences an asymmetric output shock.

Figure 1: Deviation and Asymmetric Inflation Shocks

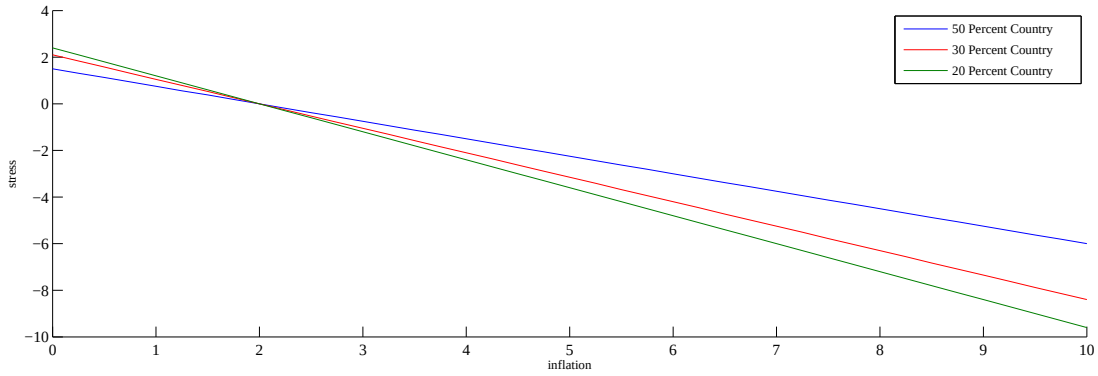
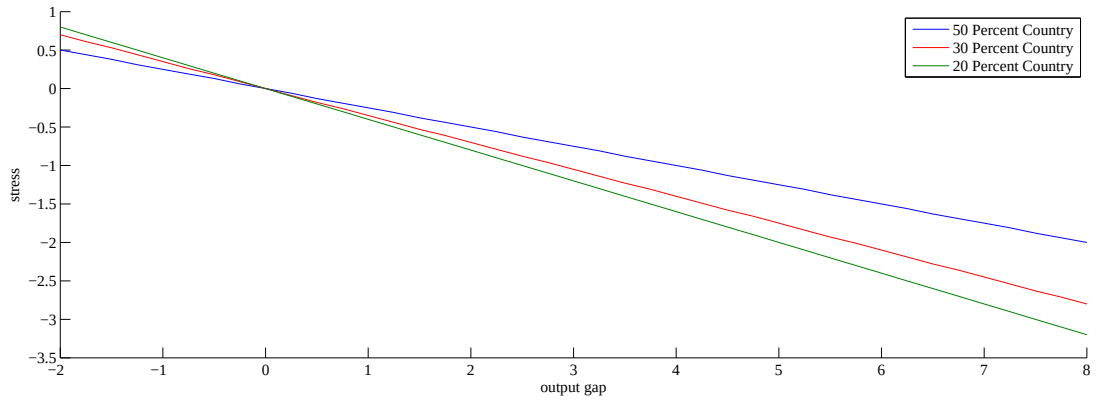


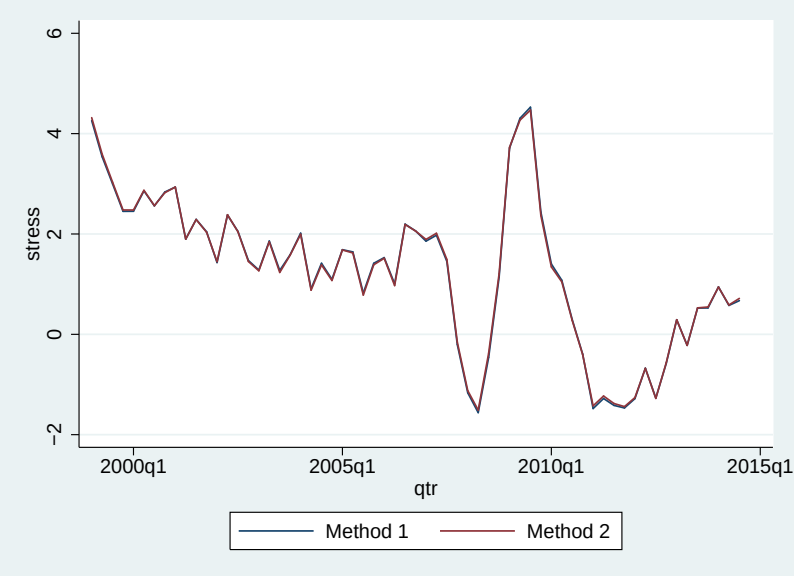
Figure 2: Deviation and Asymmetric Output Shocks



B. Graphs of the Deviation Terms

The following graph is a comparison of the deviation terms we would obtain by estimating the Eurozone's output gaps in the two methods I describe in Section 4.1.

Figure 3: Comparison of the Two Methods



The following graphs are the Eurozone, Germany, Austria, Italy, and Greece's deviation terms from 1999 to 2014.

Figure 4: Pre-Financial Crisis (1999-2007)

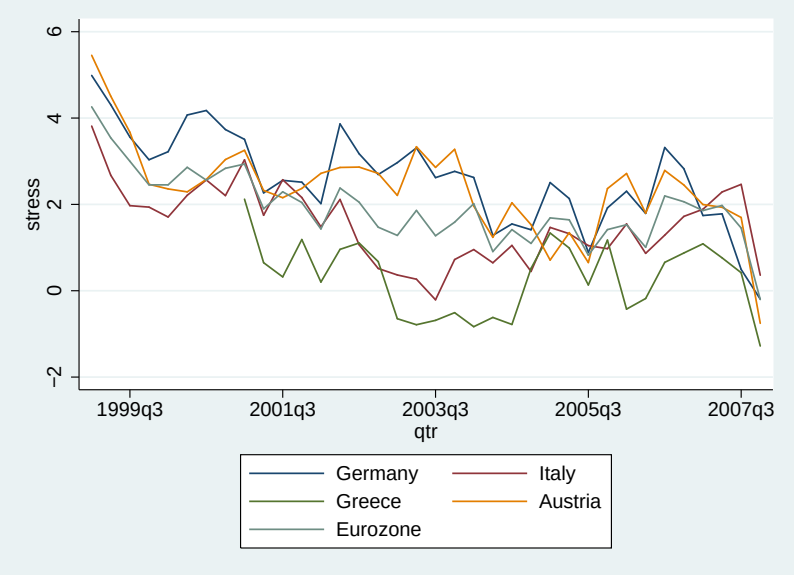


Figure 5: Financial Crisis (2008-2010)

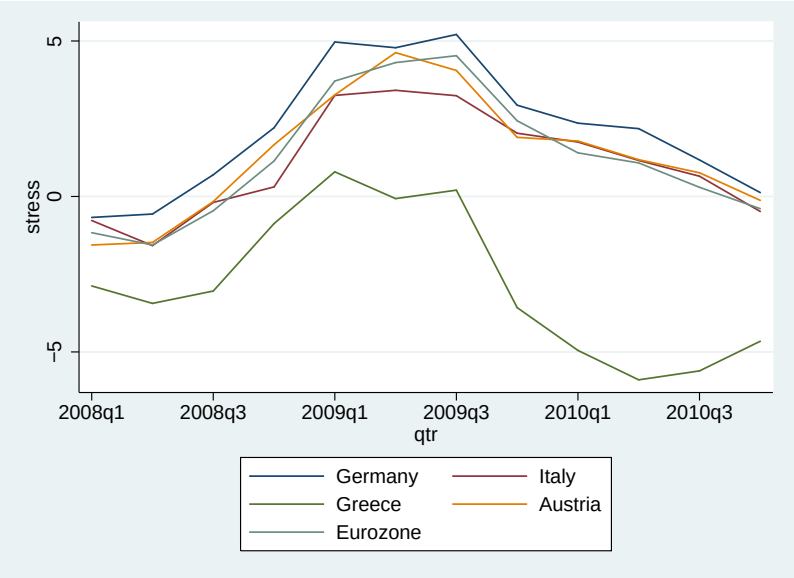
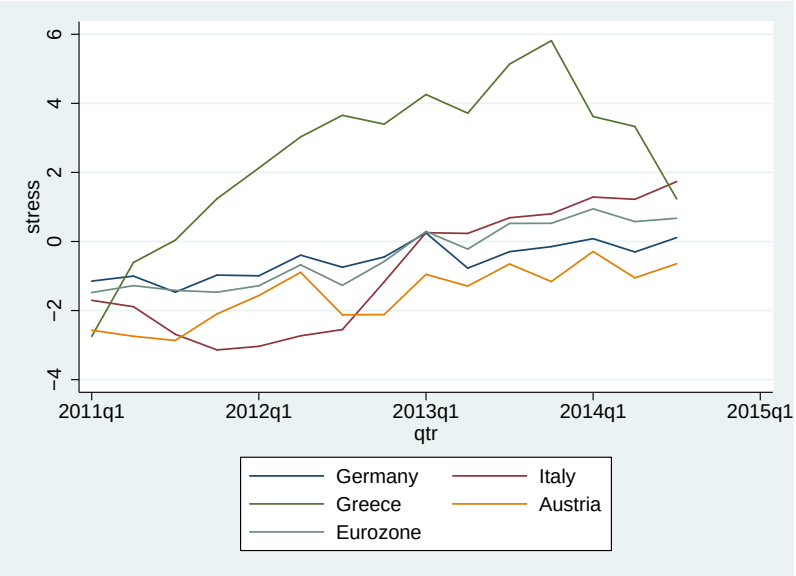


Figure 6: Post-Financial Crisis (2011-2014)



C. The ECB's Unconventional Monetary Policy Announcements

Table 1: List of the ECB's Unconventional Monetary Policy Announcements

Date	Description
9 August 2007	Provides extra liquidity in dollars.
8 October 2008	Changes tender procedure and for the standing facilities corridor.
4 June 2009	Introduces the purchase program for covered bonds.
10 May 2010	Introduces Securities Markets Programme.
8 December 2011	Announces measures to support bank lending and money market activity.
2 August 2012	Introduces Outright Monetary Transactions.
6 September 2012	Announces the technical features of Outright Monetary Transactions.
4 July 2013	Provides forward guidance for future interest rates.

D. Regression Tables

The following three tables show the regression results for whether additional deviation in member countries effect the likelihood for the ECB to make an unconventional monetary policy announcement this quarter.

Table 2: Unconventional Monetary Policy and PIIGS Countries' Cumulative Deviation Terms

VARIABLES	(1) Unconventional Policy	(2) Unconventional Policy	(3) Unconventional Policy
Eurozone's One-Year	-0.00719		
	(0.0103)		
PIIGS's One-Year	-0.0112		
	(0.0124)		
Eurozone's Three-Year		-0.000978	
		(0.00441)	
PIIGS's Three-Year		-0.00246	
		(0.00829)	
Eurozone's Five-Year			-0.000948
			(0.00252)
PIIGS's Five-Year			-0.00349
			(0.00545)
Rate Above Four	-0.0782**	-0.0792**	-0.0792**
	(0.0374)	(0.0375)	(0.0374)
Constant	0.202***	0.202***	0.204***
	(0.0162)	(0.0164)	(0.0167)
Observations	711	711	711
R-squared	0.008	0.007	0.007

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: This table shows whether PIIGS Countries' additional cumulative deviation terms change the likelihood of having an ECB announcement this quarter. For this regression, we use the cumulative deviation terms we constructed by aggregating the deviation terms of all the countries in the PIIGS Countries with their weights in the PIIGS Countries. The results are similar for the cumulative deviation terms we constructed by aggregating the deviation terms of all the countries in the PIIGS Countries with their weights in the Eurozone.

Table 3: Unconventional Monetary Policy and Greece's Cumulative Deviation Terms

VARIABLES	(1) Unconventional Policy	(2) Unconventional Policy	(3) Unconventional Policy
Eurozone's One-Year	-0.00713		
	(0.0103)		
Greece's One-Year	-0.00230		
	(0.00603)		
Eurozone's Three-Year		-0.000926	
		(0.00441)	
Greece's Three-Year		-0.00196	
		(0.00346)	
Eurozone's Five-Year			-0.000835
			(0.00252)
Greece's Five-Year			-0.00271
			(0.00356)
Rate Above Four	-0.0790**	-0.0788**	-0.0780**
	(0.0374)	(0.0375)	(0.0375)
Constant	0.202***	0.200***	0.200***
	(0.0162)	(0.0164)	(0.0166)
Observations	711	711	711
R-squared	0.007	0.007	0.007

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: This table shows whether Greece's additional cumulative deviation terms change the likelihood of having an ECB announcement this quarter. The results are similar for the other PIIGS Countries.

Table 4: Unconventional Monetary Policy and Germany's Cumulative Deviation Terms

VARIABLES	(1) Unconventional Policy	(2) Unconventional Policy	(3) Unconventional Policy
Eurozone's One-Year	-0.00720		
	(0.0103)		
Germany's One-Year	-0.00363		
	(0.00831)		
Eurozone's Three-Year		-0.000988	
		(0.00442)	
Germany's Three-Year		-0.000772	
		(0.00307)	
Eurozone's Five-Year			-0.000920
			(0.00252)
Germany's Five-Year			-0.000596
			(0.00172)
Rate Above Four	-0.0784**	-0.0795**	-0.0794**
	(0.0374)	(0.0375)	(0.0374)
Constant	0.202***	0.202***	0.203***
	(0.0163)	(0.0165)	(0.0167)
Observations	711	711	711
R-squared	0.007	0.007	0.007

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: This table shows whether Germany's additional cumulative deviation terms change the likelihood of having an ECB announcement this quarter. The results are similar for France.

Table 5: Yield Differences and Past Unconventional Monetary Policy Announcements

VARIABLES	(1) Differences	(2) Differences	(3) Differences	(4) Differences	(5) Differences	(6) Differences
PIIGS	2.947***					
	(0.117)					
PIIGS x Months Since	-0.00278***					
	(0.000163)					
Portugal		2.192***				
		(0.239)				
Portugal x Months Since		-0.00208***				
		(0.000325)				
Ireland			1.108***			
			(0.242)			
Ireland x Months Since			-0.00109***			
			(0.000329)			
Italy				0.136		
				(0.243)		
Italy x Months Since				4.09e-05		
				(0.000331)		
Greece					6.460***	
					(0.204)	
Greece x Months Since					-0.00626***	
					(0.000294)	
Spain						0.132
						(0.243)
Spain x Months Since						-8.87e-05
						(0.000331)
Months Since	0.0142	0.0105	0.0102	0.00993	0.0118	0.00993
	(0.0125)	(0.0139)	(0.0140)	(0.0141)	(0.0118)	(0.0141)
Never Before	-14.84	-12.06	-11.82	-11.60	-13.00	-11.60
	(12.43)	(13.76)	(13.94)	(14.00)	(11.73)	(14.00)
Constant	0.674***	1.619***	1.701***	1.774***	1.297***	1.774***
	(0.105)	(0.107)	(0.108)	(0.109)	(0.0912)	(0.109)
Observations	2,380	2,380	2,380	2,380	2,380	2,380
R-squared	0.322	0.170	0.148	0.141	0.396	0.141

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: This table shows the effect of the passage of an additional month since the last unconventional monetary policy announcement on yield differentials between Germany and the PIIGS countries. Estimates are from a difference-in-difference model.