Bank Interventions and Downside Correlation Risk Premium: Evidence from the Global and Euro-area Crisis*

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Abstract

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Keywords: Downside Correlation Risk Premium, Bank Intervention Announcements, Variance Risk Premium, European Banking Union.

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Abstract

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JEL Classification: G15, G21, G28, F36

1 Introduction

The global financial crisis of 2008 and the subsequent sovereign debt crisis in Europe highlighted the need to understand the effectiveness of government interventions into financial institutions at reducing the likelihood of a collapse in the financial system. Since 2008, governments around the world have spent billions on capital injections into financial institutions in an attempt to prevent a collapse of the banking system that would have had disastrous effects for the global economy.

In this paper, we investigate the effectiveness of capital injection announcements from 2008-2013 in the U.S. and the euro area at alleviating the downside correlation risk premium (DCRP) among financial institutions, our proposed measure of the compensation that investors demand for bearing the risk of large correlated drops in banks' stock prices. We also explore the characteristics of successful interventions into banks and why the effectiveness of interventions at reducing the DCRP in the U.S. differs from that in the euro area. We conjecture that, because a single mechanism for pan-European interventions was not in place and interventions in the euro area were country specific, capital injection announcements were perceived as fragmented and were, therefore, insufficient to deter investors from demanding a compensation for bearing downside correlation risk among banks in the region.

Our contribution in this paper is twofold. First, we propose a new measure for the compensation that investors demand for bearing the risk of large correlated drops in banks' stock prices, in light of potential bailouts by central authorities aimed at preventing a system-wide failure. Our measure follows the intuition in Kelly et al. (2012) that the price difference of out-of-the-money (OTM) options on bank indexes and their individual components reveals information about government guarantees to the financial sector. However, in line with Driessen et al. (2009), our measure reveals the risk premium; that is, the difference between the risk-neutral and the physical expectation of the correlation among banks within an index. Specifically, DCRP is computed as the difference between the premium that agents demand for bearing downside variance risk in the bank index and the average downside variance risk premium of all individual banks within the index.

We calculate DCRP in the U.S. and the euro-area banking sectors over the 2008-2013 sample period. We find that DCRP is, on average, negative in the U.S. In particular, U.S. DCRP has a large negative magnitude in the fall of 2008, when the bulk of U.S. bank interventions were announced, suggesting that investors became relatively less concerned about the bank index's downside variance risk than individual banks' downside variance risk. In contrast, the DCRP for euro-area banks is, on average, positive and significant over our sample period, suggesting that investors still demand compensation for bearing downside correlation risk in the euro-area banking system, despite interventions by euro-area member states.

In our second contribution, we use a unique dataset on bank intervention announcements to document whether and how interventions alleviate DCRP and its variance risk premium components. Our hand-collected database provides details on all stand-alone actions and programs announced from September 2008 to December 2013 in the U.S. and individual euro-area countries. We define a time-series dummy variable for government interventions into financial institutions that takes a value of 1 on the days when capital injections were announced and 0 otherwise. In addition, to account for the unexpected component of each intervention announcement, we also construct an intervention surprise measure, which takes a value between 0 and 1 depending on the impact of the capital injection announcement on the stock price of the specific bank being intervened.

We regress DCRP on the intervention dummy or on the intervention surprise measure. Our regression results highlight important differences in the effects of intervention announcements on the DCRP in the U.S. versus the euro area. Specifically, we find that intervention announcements in the U.S. have a significant and economically meaningful impact on reducing DCRP in the country's banking system, while intervention announcements in the euro area have an insignificant effect on the region's DCRP. These results are robust to alternative sample periods, to controlling for concerns about the liquidity and informational content of options, to different magnitudes of downside risk (degrees of options' moneyness), and to categories of financial sector support measures other than capital injections, such as deposit insurance, debt guarantees, asset relief measures, and credit market interventions.

We also analyze which characteristics make interventions more or less successful at reducing DCRP. In particular, we investigate the effect on DCRP of interventions that involved banks from multiple countries, multiple banks, banks that were included in stress tests, banks that are in the country/region's bank index, banks with relatively large market capitalizations, banks that received a relatively large capital injection amount, and banks that have a relatively large *SRisk* (see Brownless and Engle (2012)). We find that intervention announcements in the U.S. are successful at alleviating DCRP, except for interventions that involved only banks that are not included in the bank index. In contrast, for the euro area, only interventions that involved multiple banks have a significant effect at reducing DCRP.

Finally, our findings allow us to make interesting comparisons about the effect of bank intervention announcements on the DCRP between the U.S. and the euro area. These comparisons are particularly relevant as European authorities make substantial progress towards a banking union. Although by the end of 2012 European leaders had already agreed upon the Single Supervisory Mechanism (SSM) involving the European Central Bank (ECB), which opened the possibility of direct pan-European interventions, interventions into euro-area financial institutions are still being performed by local authorities in the member states. One of the main goals of the proposed banking union is, precisely, to improve investors' confidence and minimize the segmentation among interventions on specific euro-area banks and their effects on perceived risk in the euro area as a whole.

We investigate whether the different results between the U.S. and the euro area are driven by a fragmented perception of interventions into banks in the euro area. To do so, we analyze the effect of country-specific interventions on the region's DCRP. We find that euro-area member states' interventions do not prevent investors from demanding compensation for bearing the risk of large correlated drops in banks' stock prices in the region. However, country-specific bank interventions do seem to have an effect on the aggregated downside variance risk premium of individual banks, but this effect is economically meaningful only for banks *within* the intervening country. Moreover, the effect of country-specific interventions on each country's average downside variance risk premium is significantly stronger for countries with lower government-deficit-to-GDP ratios or for countries with lower 5-year CDS spreads. Interestingly, the effect of country-specific interventions on the average downside variance risk premium is also significantly stronger for countries with a higher ratio of total bank assets to GDP.

Related Literature

Our paper contributes to two main strands of literature. First, our paper contributes to the variance and correlation risk premium literature that uses stock and option prices to measure the compensation that investors demand for bearing the risk of extreme individual or system-wide events. Second, our paper contributes to the literature on the effect of macroprudential policies, particularly government interventions into financial institutions.

DCRP stems from the variance risk premium and correlation risk premium literature, and it quantifies the compensation that investors demand for being exposed to the risk of large correlated drops in bank stock prices. Bakshi and Madan (2006), Bekaert and Engstrom (2009), Todorov (2010), and Gabaix (2012) link the variance risk premium to the desire of risk-averse agents to buy protection against extreme events. Bakshi and Kapadia (2003) establish that the stock-specific variance risk premium is insignificant or, at least, much smaller than the index's variance risk premium. Schurhoff and Ziegler (2011) decompose total variance risk into its systematic and idiosyncratic components, and conclude that both components command sizeable premiums and significantly affect option returns.

Driessen et al. (2009) use U.S. index and stock option prices to decompose the variance risk premium into idiosyncratic variance risk and correlation risk premiums. They find that most of the documented variance risk premium of the U.S. index is due to correlation risk premium. Kelly et al. (2012) examine the price difference between index and individual options but focus on tail risk—the risk of extreme drops in stock prices—for particular sectors. They find that the price difference between index and individual options is significant for most sectors, in line with the correlation risk premium evidence in Driessen et al. (2009). However, they find that, for the financial sector, index options that provide a hedge against downside risk are relatively cheaper than a basket of individual options with similar characteristics, which they interpret as evidence of a too-systemic-to-fail government bailout guarantee.

We contribute to this literature by proposing a measure that alters the correlation risk premium measure in Driessen et al. (2009), focusing on options that provide a hedge against downside risk in line with the cost-of-insurance measure in Kelly et al. (2012). In particular, our measure of DCRP uses the prices of put options with an 80 percent degree of moneyness, which provide a hedge against price drops of 20 percent or more in the next month, to calculate the options-implied downside variance for a bank index and for its individual components. Therefore, our measure differs from that in Kelly et al. (2012) in that it measures the risk premium rather than the cost of insurance against negative events.

We also contribute to a broader literature on the effect of central bank interventions into financial institutions. Beck et al. (2010) provide a summary of the broad goals of interventions. Laeven and Valencia (2010), Calderon and Kalus (2012), and Brei et al. (2011) examine the positive and negative effects of bank interventions. Goodhart and Schoenmaker (2006) investigate an additional dimension for macroprudential policy in Europe, namely the cross-border externalities from bank failures. Posen and Veron (2009) and, more recently, Schoenmaker (2012) examine the lessons learned from the global and European crises for a banking union, including having a single mechanism for the resolution of problems that allows for pan-European interventions. Interestingly, Schoenmaker (2012) includes examples of less successful cross-border interventions in the absence of an official banking union framework, and how these interventions raised questions about how systemically important financial institutions (SIFIs) should be handled in the euro area.

As far as we know, our paper is the first to compare the effectiveness of interventions in the U.S. and the euro area at reducing investors' reward for bearing correlation risk among banks around market downturns. We show that, unlike in the U.S., interventions by euro-area member authorities are not successful at reducing DCRP. We investigate how differences in country-specific characteristics among euro-area countries explain the different results for the euro area. We show that investors have a fragmented perception of interventions into banks in the euro area, where interventions are more effective at reducing the downside variance risk premium of banks within the intervening country, especially if these interventions are originated in less-fiscally constrained countries or countries whose sovereign debt is perceived as less risky.

The rest of the paper is organized as follows. Section 2 describes the data and methodology. Section 3 compares the effects of U.S. and euro-area bank intervention announcements on DCRP. Section 4 investigates the characteristics of interventions and, for the euro area, of the countries intervening. Section 5 concludes.

2 Data and Methodology

In the first part of this section, we introduce our measure of downside correlation risk premium (DCRP). In the second part, we describe our novel hand-collected dataset of U.S. and euro-area bank intervention announcements. Finally, in the third part, we aggregate intervention announcements into categories according to their characteristics and, for euro-area countries, we collect a number of country-specific characteristics to determine what makes some interventions more or less successful at reducing DCRP.

2.1 The Downside Correlation Risk Premium

Our measure of DCRP relies on the intuition that the variance of a stock index can be expressed as a function of the average variance of its components plus a combination of pairwise correlations. Following this relation, the variance risk premium of an index can be expressed as a combination of the weighted average variance risk premium of its components plus a correlation risk premium component. More specifically, following the convention in the literature (Bollerslev et al. (2009); Drechsler and Yaron (2011)), the variance risk premium of the bank index is defined as

$$VRP_t^{index} = E_t^Q(\sigma^2_{r,t+1}) - E_t^P(\sigma^2_{r,t+1}). \quad (1)$$

That is, the difference between the risk-neutral (Q) and the physical (P) time-t expectation of the index's return variation between dates t and $t+1$ months, $\sigma^2_{r,t+1}$. Following Driessen et al. (2009), equation (1) can be decomposed into

$$VRP_t^{index} = \sum_i l_i VRP_t^i + \sum_i \sum_{j \neq i} \omega^i \omega^j [E_t^Q(\rho_{r_{t+1}{}^i r_{t+1}{}^j}) - E_t^P(\rho_{r,t+1^i r,t+1^j})], \quad (2)$$

where VRP_t^i is the variance risk premium of the i-th component of the index, $\rho_{r_{t+1}{}^i r_{t+1}{}^j}$ is the correlation between the returns of stock i and stock j over the period from months t to $t+1$, and $l_i = (\omega^i)^2 + \sum_{j \neq i} \omega^i \omega^j \frac{\sigma_{r_j}}{\sigma_{ri}} \rho_{r^i r^j}$ is the relative-volatility weight on each component's variance risk premium, assuming constant weights. $\sum_i \sum_{j \neq i} \omega^i \omega^j [E_t^Q(\rho_{r^i_{t+1} r^j_{t+1}}) - E_t^P(\rho_{r^i_{t+1} r^j_{t+1}})]$ is a collection of the correlation risk premiums among all individual components in the index, which we denote as CRP_t^{index}. Then, equation (2) can be rewritten as

$$CRP_t^{index} = VRP_t^{index} - \sum_{i \in index} l_i VRP_t^i. \tag{3}$$

Thus, the correlation risk premium is the extra variance risk premium in the index that is not accounted for by its individual components, hence the premium for being exposed to common system-wide risk. Our measure of DCRP is constructed from equation (3), except we use 80 percent OTM option prices, which provide a hedge against price drops of 20 percent or more within the next month.

We construct DCRP using option and stock prices for the U.S. and euro-area benchmark bank indexes (KBW and Eurostoxx, respectively) for a daily sample running from 2008 to 2013. A key difference between these two indexes is that the euro-area bank index includes banks domiciled in several countries. Specifically, for the duration of our sample, the Eurostoxx bank index includes banks domiciled in Austria, Belgium, France, Germany, Greece, Italy, Ireland, the Netherlands, and Spain. Both bank indexes are calculated as a weighted average of the price of major publicly traded bank stocks and should, therefore, serve as a benchmark of the banking sector. Specifically, the KBW (Keefe, Bruyette & Woods) index aggregates the price of the most relevant U.S. banks (approximately 24 institutions) weighted according to free-float market capitalization. The relevance of a bank is determined by KBW according to several criteria, including trading volume and market capitalization.[1] The Eurostoxx banks index aggregates the price of the largest banks in the euro area (approximately 28 institutions), which are also weighted according to free-float market capitalization.[2]

To obtain our measure of DCRP, we calculate the variance risk premium components in equation (3) using the definition of the variance risk premium in equation (1). Specifically, to calculate the downside variance risk premium of each bank index as well as its components, we approximate the one-month-ahead expectation of the return variation under the risk-neutral measure, $E_t^Q(\sigma_{r,t+1}^2)$, as the square of the implied volatility of OTM put options. In particular,

[1] The rules for inclusion of a bank in the KBW index can be found at www.kbw.com/content/equities-PDFs/IndexRules.pdf.

[2] The current components of the KBW index can be found at www.kbw.com/content/research-reports/BKX.pdf, and those of the Eurostoxx banks index can be found at www.stoxx.com/download/indexes/factsheets/estxsupersectorsfs.pdf.

we use options with a fixed degree of moneyness of 80 percent for the index and its individual components. In Section 3.3, we investigate the robustness of our results using options with a degree of moneyness of 90 percent, which provide a hedge against a 10 percent or larger drop in the index's price within the next month. The options-implied volatility for the indexes and their components are obtained from Bloomberg. To reduce the potential adverse effect of outliers, especially for bank-specific options, we winsorize all options-implied volatilities at the 1 percent level.

We approximate the expectation of each bank index's return variation under the physical measure, $E_t^P(\sigma^2_{r,t+1})$, using an AR(1) in-sample forecast of the one-month-ahead realized variance conditional on the index's time-t implied variance—our proxy for $E_t^Q(\sigma^2_{r,t+1})$—and the time-t realized variance.[3] Following the literature, we calculate the one-month realized variance as the sum of the square of daily stock returns for the last 22 days. Daily stock prices for the indexes and their components are also obtained from Bloomberg. To avoid any look-ahead bias caused by using the full sample, we use only the information available at each point in time to calculate the expectation of the realized variance under the physical measure.

To calculate the physical expectation of the return variation for each individual bank within the index, we also rely on an AR(1) estimation using each bank's options-implied variance, the time-t realized variance of the bank's stock return, and the options-implied variance of the bank index. We find that adding the options-implied variance of the bank index improves the forecast of all banks' one-month-ahead realized variance considerably compared with a model that includes either each bank's realized variance or both its realized and options-implied variance. For euro-area (U.S.) banks, the average adjusted R-squared when we forecast the one-month-ahead realized variance using only the realized variance is 0.45 (0.48). When we include each bank's options-implied variance, the average adjusted R-squared increases to 0.46 (0.60); and, when we add the bank index's implied variance, it increases to 0.50 (0.62).

[3] An empirical counterpart of the variance implied by OTM options under the physical measure cannot be calculated because large drops (of 20 percent or more over a one-month period) in stock prices are rarely observed. Therefore, we rely on the realized variance to calculate an approximation of the expectation of the downside variance under the physical measure.

To calculate l_i, the relative-volatility weights in equation (3), we obtain estimates of the variance-covariance matrices of all banks within the bank indexes (and, implicitly, the correlations between them) as well as their relative market capitalizations, ω^i. Specifically, we estimate daily variance-covariance matrices using one-month (22-day) rolling windows of all banks' stock returns and assume that their relative weights, calculated using each bank's market capitalization relative to the total market capitalization of the index, remain constant throughout this window. At each point in time, we use the one-day-lagged relative-volatility weights to obtain the weighted average downside variance risk premium, $\sum_{i \in index} l_i VRP_t^i$.

2.2 Bank Intervention Announcements

To examine the effect of central bank interventions on DCRP, we use a unique dataset on bank intervention announcements. Our dataset builds upon the "Financial Sector Rescue Plan" database maintained by the Bank of International Settlements (BIS). The BIS database was initiated in October 2008 under the auspices of the Committee on the Global Financial System (CGFS) and covers the following five main categories of financial sector support measures: capital injections (emergency loans; does not include immediate outright nationalization); deposit insurance; debt guarantees; asset relief measures (purchase or guarantee of risky non-performing bank assets); and credit market interventions. The BIS database includes all stand-alone actions and programs announced from September 2008 to December 2011 in 29 countries, including the U.S. and individual euro-area countries.[4]

We revise the BIS database using Factiva and other news sources to ensure that the date of each intervention corresponds to the first time it was announced. Because the BIS database ends in 2011, we also extend the database to the end of 2013 by hand-collecting news about all characteristics of bank intervention announcements during this period. In Section 3.3, we perform robustness tests on the subsample period of the original BIS database between 2008 and 2011.

Using our intervention announcements database, we define a time-series dummy variable for

[4]To test the effectiveness of interventions on DCRP, we also consider interventions into banks not included in the KBW or Eurostoxx bank indexes. In Section 4, we investigate the additional effect of interventions into banks in each country's bank index at alleviating DCRP.

government interventions into financial institutions for the U.S. and the euro area separately. This variable takes the value of 1 on the days when new capital injections were announced and 0 otherwise. Because our measures of downside variance and correlation risk premiums are only defined over trading days, we match interventions that take place on a non-trading day to the next trading day. While the BIS database covers five categories of central bank interventions, we focus our analysis on capital injections, as they were at the core of most rescue packages and were critical for banks to withstand market pressures during the financial crisis (see, for instance, Brei et al. (2011)). Other types of support measures either did not address solvency problems, as was the case for deposit insurance and debt guarantees, or were deployed at very few institutions, as was the case for asset purchases and insurance. Overall, our dataset contains 46 capital injection announcements in the U.S. and 106 announcements across individual euro-area countries between 2008 and 2013.

Our intervention dummy variable implicitly assumes that each intervention announcement was received by the market entirely as a surprise, which may not always be the case. To account for the unexpected component of each intervention announcement, we also construct an intervention surprise measure. This measure takes a value between 0 and 1 depending on the impact of the intervention announcement on the stock price of the specific bank being intervened. Specifically, the surprise measure is calculated as 1 minus the p-value that results from comparing the return of the bank stock in the day following the announcement with a normal distribution of daily returns for the full sample. The intuition for this announcement surprise measure is the following: If an intervention announcement has sizeable effects on the intervened banks' stock prices, then the announcement would have come entirely as a surprise and the intervention surprise measure would converge to our intervention dummy variable; that is, the p-value tends to zero. If stocks of an intervened bank are not publicly traded, the intervention surprise measure is calculated based on the impact of the intervention announcement on the price of the bank index of the country where the bank is domiciled.

To disentangle the effect of bank interventions from the effect of other macroeconomic announcements that might have an impact on our risk premium measures, we control for the surprise in macroeconomic news announcements in the U.S. and the euro area. Specifically, we use daily data on real-time activity indexes from Scotti (2013). The surprise indexes in Scotti

(2013) are constructed as the weighted average of the surprises from the set of macroeconomic releases in Aruoba et al. (2009). These macroeconomic releases include industrial production, employment, real retail sales, personal income, manufacturing PMI, the slope of the yield curve, and stock market returns.

2.3 Characteristics of Interventions and Countries Intervening

In addition to examining the effect of intervention announcements on DCRP, we also analyze which characteristics make certain interventions more or less successful at reducing investors' compensation for bearing systemic risk. To do so, we construct the following seven conditional intervention dummy variables for the U.S. and the euro area:

1. Multiple country (defined for euro area only): Equals 1 on days when capital injections were announced in more than one country in the euro area. The capital injections do not necessarily need to be part of the same general program.

2. Multiple banks: equals 1 on days where capital injections were announced for more than one bank (may or may not be in the same country).

3. Involved in stress test: Equals 1 on days when capital injections were announced for banks that were involved in stress tests. For the U.S., we use the list of banks that were involved in the 2012 Comprehensive Capital Analysis and Review (CCAR).[5] For the euro area, we use the list of banks that were involved in the European Banking Authority's (EBA) 2011 EU-wide stress tests.[6]

4. In bank index: Equals 1 on days when capital injections were announced for banks that are in the KBW index for the U.S. and in the Eurostoxx index for the euro area.

5. Large bank: Equals 1 on days when capital injections were announced for a bank with large market capitalization. A large bank is defined as having, on the day before the

[5] See "Comprehensive Capital Analysis and Review 2012: Methodology and Results for Stress Scenario Projections" on the Federal Reserve Board website at http://www.federalreserve.gov/newsevents/press/bcreg/bcreg20120313a1.pdf.

[6] See "2011 EU-wide stress test results" on the European Banking Authority website at http://www.eba.europa.eu/risk-analysis-and-data/eu-wide-stress-testing/2011/results.

announcement, a market capitalization above the median value across all intervened banks in our sample. Data on market capitalization is obtained from Bloomberg.

6. Large injection: Equals 1 on days when a large capital injection for a bank was announced. A large capital injection is defined as having a ratio of injection size to bank total assets (on the day before the announcement) that is above the median value across all intervened banks in our sample. Data on injection size is obtained from our interventions database, while data on total assets is obtained from Bloomberg.

7. Large *SRisk*: Equals 1 on days when capital injections were announced for a bank with a large *SRisk* value. A large *SRisk* is defined as having, on the day before the announcement, a value above the median value across all intervened banks in our sample. *SRisk* is a measure of systemic risk proposed by Brownless and Engle (2012) that depends on each bank's leverage, size, and marginal expected shortfall (MES). MES is calculated as the expected loss in the total value of a firm in the event of a substantial decline in the market, which is approximated by the S&P 500.

To investigate further what drives the differential effect of interventions by individual euro-area member states on each country's aggregated downside variance risk premium, we also collect information on a set of country-specific variables.[7] We collect data on 10-year sovereign bond yields and 5-year CDS spreads as financial measures of investors' perception of sovereign risk. 10-year sovereign yields are obtained from the Federal Reserve Board while CDS spreads are obtained from Bloomberg. We also calculate the ratio of government debt to GDP and government deficit to GDP to characterize each country's fiscal constraints, using data from Haver and from the Federal Reserve Board. Finally, using data from the European Central Bank, we calculate the relative size of each country's banking system as the ratio of total bank assets to GDP.

[7]Because option prices for bank indexes at the country level are not available for euro-area countries, a country-specific DCRP measure cannot be calculated.

3 DCRP and Bank Intervention Announcements

In this section, we examine the differences in the dynamics of DCRP between the U.S. and the euro area, and investigate the effect of government intervention announcements on our measures of downside variance and correlation risk premiums.

3.1 DCRP in the U.S. and the Euro Area

Figure 1 shows our measure of DCRP for the U.S. and the euro-area bank indexes. Figure 2 plots the two components of DCRP: the bank index's downside variance risk premium and the relative-volatility-weighted average of the downside variance risk premium of all banks within the index (see equation (3)). Table 1 reports the summary statistics for the DCRP and its components.

Individual options for banks in the U.S. KBW index are more expensive on average than options on the index. Therefore, as shown in Table 1, the implied volatility of individual banks' OTM options is higher than that of the index options (48 percent versus 39 percent). In addition, the volatility-weighted average of the downside variance risk premiums of the index's individual components is significantly higher than the downside variance risk premium of the bank index (255 versus -33). In unreported results, we confirm that this difference between the variance risk premium of the index and the aggregate variance risk premium of individual institutions holds irrespective of whether we use volatility-weighted or equal-weighted variance risk premiums in equation (3). As a consequence, the DCRP for U.S. banks is, on average, *negative* and significant. In fact, the U.S. DCRP is particularly negative around the Lehman Brothers episode (Figure 1), when most U.S. bank interventions were announced in our sample. The negative nature of the U.S. DCRP and the negative DCRP peak around the Lehman Brothers episode is in line with the evidence in Kelly et al. (2012), who show that, around the 2008 U.S. bank intervention announcements, the cost of insurance against extreme events for individual banks increased in comparison to the cost of insurance for the U.S. bank index.

The difference between the cost of insurance of the index and its components suggests that agents believe a simultaneous drop in the price of all bank stocks is less likely to occur as authorities demonstrate they are willing to prevent a collapse of the banking system by intervening in SIFIs. Similarly, we observe in panel (a) of Figure 2 that, after the bulk of the 2008 bank intervention announcements, the downside variance risk premium of both the bank index and individual banks dropped significantly, but it dropped less for individual banks. The different dynamics of the components of DCRP is consistent with the view that investors became less concerned about overall variance risk in light of the government interventions but *relatively* less concerned about the bank index's downside variance risk than about individual banks' downside variance risk.

In contrast to the evidence for the U.S., the downside variance risk premium of the euro-area bank index is larger on average than the relative-volatility-weighted average of the downside variance risk premiums of its individual components (1074 versus 780), as shown in panel (b) of Table 1. Thus, the DCRP for euro-area banks—the extra downside variance risk premium in the bank index that is not accounted for by its individual components—is on average positive (294) and significant at the 1 percent level. This evidence suggests that, on average, investors demand compensation for bearing the risk of large correlated drops in the euro-area banking system.

The euro-area DCRP display high volatility (905 percent) and deviate from the normal distribution, with relatively high kurtosis (17) and positive skewness (2.1). The euro-area DCRP spikes around the collapse of Lehman Brothers and is particularly large in the second half of 2011, at the peak of the European debt crisis, which coincides with the peak identified by the overall systemic risk measures in Black et al. (2013). As can be seen in panel (b) of Figure 2, during this period, the downside variance risk premium of the euro-area bank index increases much more than the average downside variance risk premium of the index components. In fact, most of the spikes in euro-area DCRP are closely linked to crisis-related news, especially in the last quarter of 2011. For instance, between September and December of 2011, concerns about economic growth in the euro area added to concerns about Greece's inability to meet its budget-cut targets and the country's increasing need for bailout loans. Other episodes of the European debt crisis had an impact on the DCRP, such as Spain's intentions to seek financial support for the country's banks between June and August 2012.

In an event study around DCRP spikes to disentangle news-related spikes from outliers, we find that a 1 percent winsorization of the options-implied volatility provides a good balance between excluding most of the outliers without excluding important news-related episodes of high DCRP.

Interestingly, the DCRP for U.S. banks often increases around news in the euro area that deteriorated global risk sentiment but did not directly involve U.S. banks. For instance, the U.S. DCRP spiked on November 2010 as markets grew concerned about Ireland's banking sector. Also, by the end of September 2011, stock markets worldwide fell significantly in reaction to weaker-than-expected euro-area economic data. Concerns about the crisis in Europe increased again at the beginning of October 2011 as European finance ministers began discussing plans to recapitalize the region's financial institutions.[8] The U.S. DCRP is slightly less volatile than the euro-area DCRP (721 percent) and also deviates from the normal distribution, with large kurtosis (28) and negative skewness (-3.6), mostly driven by the negative spike around the collapse of Lehman Brothers.

3.2 Effect of Bank Intervention Announcements

We now provide an explanation for the differences between the dynamics of the U.S. and the euro-area DCRP. In particular, we show that bank intervention announcements in the U.S. have a significant and economically meaningful effect in reducing the DCRP, while interventions in the euro area seem to have been unsuccessful in reducing DCRP. In Section 4, we show that interventions by U.S. authorities are successful, while, for the euro area, only interventions that involved multiple banks have a significant effect at reducing the DCRP.

The empirical framework we use to examine the effect of the announcement of government interventions into banks on our measures of downside variance and correlation risk premiums is

$$rp_{i,t+h} = \alpha_{i,h} + \beta_{i,h} D_{i,t} + s_{i,h} Surp_{i,t} + \epsilon_{t,h}, \tag{4}$$

[8] In unreported results, we show that the U.S. and the euro area DCRP are not Granger caused by industrial production nor unemployment rate in these areas, indicating that DCRP is not merely picking up real economy effects.

where $rp_{i,t+h}$ is one of the following h-days-ahead options-based risk premiums for country/region i: (a) the DCRP of the bank index, (b) the downside variance risk premium of the bank index, or (c) the relative-volatility-weighted average of downside variance risk premiums of individual banks in the index. Dummy $D_{i,t}$ is equal to 1 if there is a capital injection intervention announcement in country i at time t, and $Surp_{i,t}$ is Scotti (2013)'s macroeconomic surprise index.

Figure 3 reports the regression results for the U.S. Panel (a) reports the coefficient of government intervention announcements on the DCRP, and panels (b) and (c) report the effect on the downside variance risk premium of the index and on the average downside variance risk premiums of all individual banks within the index, respectively. The results suggest that bank interventions in the U.S. have a significant effect on DCRP. Specifically, announcements of government interventions in the U.S. reduce DCRP by approximately 950 squared percentage points—roughly one fourth of the DCRP around the Lehman Brother's episode—one day after the injection announcement, and this effect remains significant for nearly all 30 days in our horizon window. As pointed out previously, the significance of government interventions might explain the highly negative DCRP around the Lehman Brothers episode in Figure 1. The results in panels (b) and (c) show that intervention announcements are also significant at reducing both components of DCRP, where announcements have a larger impact on the U.S. bank index's downside variance risk premium, a measure of aggregate risk including correlation risk, than on the average downside variance risk premium of its components, a measure of aggregated bank-specific risk.

Our results for the euro area in Figure 4 stand in sharp contrast to those for the U.S. Notably, announcements of bank interventions by euro-area authorities do not have a significant effect on the DCRP among euro-area banks. The insignificant effect of these interventions might explain the average positive DCRP among euro-area banks, particularly during the latter half of 2011, as seen in Figure 1. The results in panels (b) and (c) of Figure 4 help us understand the lack of significance of bank interventions on the euro-area DCRP. In particular, intervention announcements in the euro area do significantly reduce both the index's downside variance risk premium and the average downside variance risk premiums of its components, but the effect is similar in magnitude across these two components. In addition, the impact of intervention announcements on the index's downside variance risk premium is only about half the magnitude in the euro area as it is in the U.S.

Until now, we have assumed in our regressions that announcements of capital injections have similar characteristics and come as a complete surprise to the market, with all of the changes in DCRP being attributed to our dummy variable on intervention announcements (after controlling for macroeconomic surprises). Because certain intervention announcements may have come as more of a surprise than others, we construct an alternative to our dummy variable, which takes a value between 0 and 1 for an announcement in country i at time t. $P_{i,t}$, our p-value intervention variable, represents the likelihood that the capital injection announcement was a surprise to the market. The construction of $P_{i,t}$ is described in Section 2.2. Our new regression framework is then

$$rp_{i,t+h} = \alpha_{i,h} + \beta_{i,h} P_{i,t} + s_{i,h} Surp_{i,t} + \epsilon_{t,h}. \tag{5}$$

As shown in Figure 5, accounting for the surprise component of intervention announcements does not alter our primary findings for the U.S. and the euro area in Figures 3 and 4, respectively. In particular, capital injection surprises still reduce U.S. banks' DCRP (panel (a)). Interestingly, the estimated effect of intervention surprises by U.S. authorities is considerably larger than the effect of the intervention dummy (1600 versus 950 squared percentage points) and is significant for all 30 days in our horizon window. For the euro area, accounting for capital injection surprises still does not significantly reduce euro-area banks' DCRP (panel (b)). Moreover, the insignificant effect of euro-area interventions on DCRP does not seem to be driven by overall *less-surprising* interventions in the euro area. If anything, euro-area interventions come, on average, more as a surprise than U.S. interventions—the average $P_{i,t}$ is 0.49 and 0.53 for the U.S. and the euro area, respectively. Moreover, we do not find evidence that the magnitude of announcement surprises changes substantially between the global and the European sovereign debt crisis.

In sum, our results show that investors do demand significant compensation to bear downside correlation risk among banks in the euro area. Our results also show that interventions by euro-area authorities do not significantly reduce this DCRP, as these interventions do not have a sufficiently large differential effect on the downside variance risk premium of the index and its components. The results for the euro area stand in sharp contrast to those for the U.S., where the DCRP is on average negative, and interventions do have a significant and economically meaningful alleviating effect on DCRP.

3.3 Additional Tests

In this section, we investigate whether our benchmark results for the differential effect of intervention announcements on the U.S. and the euro-area DCRP in Section 3.2 are robust to the sample period considered, to potential liquidity and informational-content concerns of individual options, to different magnitudes of downside events (degrees of options moneyness considered), and to categories of bank interventions other than capital injections. We also explore the effect of interventions into banks on the difference between the option-implied variance of the index and the average option-implied variance of its components, the risk-neutral component of DCRP. The results for the robustness tests are summarized in Figures 6 and 7 for the U.S. and the euro area, respectively. Some results in this section are left unreported to save space and are available, upon request, from the authors.

Our full sample period runs from 2008 to 2013. Because the original BIS database ends in 2011, and because most bank intervention announcements occurred by the end of 2011, we repeat the regression in equation (4) for DCRP for the 2008-2011 subsample period. The results are consistent with those for our full sample period. Specifically, intervention announcements in the U.S. significantly reduce DCRP for nearly all 30 days after the announcement (Figure 6 panel (a)), while announcements in the euro area are ineffective at alleviating DCRP (Figure 7 panel (a)).

We also address two common concerns when dealing with options, especially at the firm-level: their liquidity and informational content. As a robustness test, we only include the 10 largest banks in each bank index when calculating the value-weighted average of the downside variance risk premiums, as large banks are less likely to be subject to these concerns. We then recalculate the DCRP as the difference between the downside variance risk premium of the index and the alternative value-weighted average of the variance risk premiums. As of December 2013, the 10 largest banks account for 86 and 76 percent of the total market capitalization of all banks in the U.S. KBW and the euro-area Eurostoxx bank index, respectively. The results in panel (b) of Figure 6 show that bank intervention announcements still have a significant alleviating effect on DCRP among the largest U.S. banks. Panel (b) of Figure 7 presents the corresponding results for the largest euro-area banks. Consistent with our benchmark results in Figure 4, intervention announcements in the euro area do not significantly reduce DCRP.

We now test whether our results hold for alternative magnitudes of downside risk events. Our benchmark measure of DCRP is calculated based on options with an 80 percent degree of moneyness. Because these options provide a hedge against downside risk, DCRP measures investors' compensation for bearing the risk of correlated price drops of 20 percent or more in bank stock prices. We acknowledge, however, that a price drop of 20 percent for the index might be a much more drastic event than a price drop of the same magnitude for an individual bank. Thus, we examine whether our results still hold under a scenario where the hedge in the price drop for the bank index is less than the hedge in the price drop for its components. In particular, panel (c) in Figures 6 and 7 show the coefficients associated with our dummy intervention variable, where DCRP is calculated using options prices with a 90 percent degree of moneyness for the bank index—which hedge against price drops of 10 percent or more within the next month—and with an 80 percent degree of moneyness for individual banks in the index. For the U.S., intervention announcements still reduce DCRP, although the magnitude and significance are much higher than for our benchmark results—intervention announcements reduce the alternative DCRP by almost 1200 squared percentage points, while they reduce the benchmark DCRP by 950 squared percentage points. The results for the euro area still indicate that intervention announcements do not alleviate DCRP; in fact, the coefficient is positive and weakly significant for some horizons.

In unreported results, we also confirm that our results are robust to considering all five categories of central bank interventions: capital injections, deposit insurance, debt guarantees, asset relief measures, and credit market interventions. All intervention announcements have a significant effect at reducing the U.S. DCRP, while they are unsuccessful at reducing the euro-area DCRP.

Finally, we calculate the difference between the implied variance of OTM options on the bank index and the (equally-weighted or relative-volatility-weighted) average implied variance of its components. While DCRP is a measure of the compensation demanded for bearing correlation risk, the implied-variance is the risk-neutral component of DCRP, which is closer in nature to the cost-of-insurance measure in Kelly et al. (2012). Our results highlight the differences between these two measures. Specifically, we show that, in line with the results in Kelly et al. (2012), intervention announcements in the U.S. are successful at reducing the implied-volatility difference. However, in contrast to our results for DCRP for the euro area, intervention announcements are also successful at reducing the euro-area implied-variance difference.[9]

4 Characteristics of Interventions into Banks

Our results so far suggest that while the U.S. DCRP is, on average, negative, the euro-area DCRP is positive and significant. Moreover, there are significant differences in the effectiveness of bank interventions at reducing DCRP between the U.S. and the euro area. In this section, we extend our investigation to explore the characteristics of successful interventions at reducing DCRP. In the first part of the section, we construct the conditional intervention dummies described in Section 2.2 to understand which intervention characteristics are more effective at alleviating DCRP. In the second part, we center our attention on the euro area, and explore whether the country-specific variables defined in Section 2.2 explain the heterogeneous effectiveness of country-specific interventions at reducing the aggregated downside variance risk premium for each euro-area country.

4.1 Characteristics of Successful Interventions

To examine the effect of intervention announcements with particular characteristics on the DCRP, we propose two regression frameworks. The first framework is the following univariate

[9]The results for the risk-neutral component of the DCRP also hold when we consider the option-implied volatility instead of the variance. These results are also left unreported to save space and are available, upon request, from the authors.

(with control variables) regression setup:

$$DCRP_{i,t+h} = \alpha + \beta_{c,i,h} D^c_{i,t} + s_{i,h} Surp_{i,t} + \epsilon_{t,h}, \tag{6}$$

where $D^c_{i,t}$ is one of the seven conditional intervention dummies defined in Section 2.2 and only takes a value conditional on days when capital injections are announced. The second framework is a multivariate (with control variables) regression setup that allows us to isolate the *additional* effect of each type of intervention announcement:

$$DCRP_{i,t+h} = \alpha_{i,h} + \beta^*_{c,i,h} D^c_{i,t} + \beta^*_{int,i,h} D_{i,t} + s_{i,h} Surp_{i,t} + \epsilon_{t,h}, \tag{7}$$

where $D_{i,t}$ is the intervention dummy used for the benchmark results in Section 3.2.

Table 2 reports the estimated effect, β_c, and the additional effect, β^*_c, of intervention announcements with particular characteristics. Our results for the U.S. show that intervention announcements have a negative and significant effect on the DCRP across all seven characteristics (β_c). Moreover, the estimated effect for interventions with these characteristics is higher than the overall effect of interventions ($\widehat{\beta_{US}} = -950$ in figure 3). The magnitude of the estimated effect is much larger for interventions that involved more than one bank ($\widehat{\beta_c} = -1747$), interventions into banks involved in the Federal Reserve's stress tests ($\widehat{\beta_c} = -1680$), and interventions into banks in the U.S. KBW bank index ($\widehat{\beta_c} = -1339$). In fact, the results show that interventions into banks involved in the stress test or into one of the banks in the bank index have an additional relieving effect on the DCRP among U.S. banks—β^*_c is negative and significant. Interestingly, there is a disconnect between the definition of SIFIs according to the stress test and that according to $SRisk$ because interventions into banks with relatively large $SRisk$ do not have a significant additional alleviating effect—β^*_c is insignificant. Our evidence also suggests that interventions into banks not included in the bank index is the only type of intervention with an insignificant effect on the U.S. DCRP—β^*_{int} is not significant. Interestingly, however, two thirds of the dates with intervention announcements involved at least one of the banks in the index.

In contrast to the results for the U.S., the results for the euro area suggest that only interventions that involved multiple banks are somewhat successful in alleviating the DCRP;

that is, $\widehat{\beta}_c = -558$ and is significant at the 10 percent confidence level. All other types of interventions have an insignificant effect (and additional effect) on the DCRP. In fact, the estimated effect and additional effect is, in some cases, positive, although only significant for large relative injections—$\widehat{\beta_c^*} = 994$ and is significant at the 10 percent confidence level.

4.2 Country-specific Bank Interventions in the Euro Area

To shed further light on our empirical results for the euro area, we examine the differential effects of country-specific bank interventions. Our results allow us to identify particular countries within the euro area whose capital injection announcements might have a greater effect at reducing the region's DCRP or, at least, the aggregated downside variance risk premium of banks within the country intervening. Furthermore, decomposing the euro-area intervention dummy into country-specific dummies allows us to disentangle country-specific effects, as multiple announcements for different countries often occur on the same day.

We first explore the following regression framework to examine the effect of country-specific bank interventions on the DCRP in the euro area:

$$DCRP_{t+h}^{euro} = \alpha_{i,h} + \sum_i \beta_{i,h} D_{i,t} + s_{euro,h} Surp_{euro,t} + \epsilon_{t,h}, \tag{8}$$

where we decompose the euro-area capital injection dummy in equation (4) into eight countries/regions: Belgium, France, Germany, Greece, Italy, the Netherlands, Spain, and the rest of the euro area (Austria, Finland, Ireland, Luxembourg, and Portugal).

Figure 8 plots the estimated coefficients $\beta_{i,h}$ for $h = 1$ to 30 days after a capital injection announcement for the regression framework in equation 8. Our results suggest that, in general, interventions by euro-area member countries do not have an economically meaningful effect on the euro-area DCRP. French interventions (panel (b)) are weakly significant in reducing the euro-area DCRP up to 4 days after an intervention. Italian and Dutch bank interventions are only significant 13 and 5 days after an intervention, respectively, and the effect is short-lived (panels (e) and (f)). For the remaining countries, the results indicate that country-specific interventions do not reduce DCRP among euro-area banks, in line with our results for all interventions in Figure 4. In unreported results, we show that the coefficients from regressing on each country-specific intervention dummy separately ($DCRP^{Euro}_{t+h} = \alpha_{i,h} + \beta_{i,h} D_{i,t} + s_{Euro,h} Surp_{Euro,t} + \epsilon_{t,h}$) are essentially the same as the coefficients from the joint regression with all countries.

We then use the following panel-data regression setup to investigate which country-specific characteristics explain the differential effect of interventions by euro-area member states on the country-level aggregated downside variance risk premium:

$$DVRP^i_{t+h} = \alpha_i + (\beta_{0,h} + \beta_{1,h} * X_{i,t-1}) D_{i,t} + s_h Surp_{euro,t} + \epsilon_{t,h}, \tag{9}$$

where $DVRP^i_t = \sum_{i \in index} l_i VRP^i_t$ (see equation 3) and $X_{i,t-1}$ is one of the following country-specific characteristics: a dummy that controls for the purely domestic effect of interventions (within country), the 5-year CDS spread, the 10-year sovereign bond yield in each country, the ratio of government deficit to GDP, the ratio of government debt to GDP, and the ratio of total bank assets to GDP. The coefficients in equation 9 are estimated using ordinary least squares (OLS) where the coefficients associated with intervention announcements and the interaction between these announcements and the country-specific characteristics, $\beta_{0,h}$ and $\beta_{1,h}$, respectively, are restricted to be homogeneous across countries.

Figure 9 shows the results for the panel-data setup in equation 9. The results in panel (a) suggest that, overall, intervention announcements are successful at reducing the country-level aggregated downside variance risk premium, in line with the results for the euro-area DVRP in figure 4. However, the effect seems to be much stronger on the average downside variance risk premium of banks within the country intervening, as suggested by the large negative coefficient associated with the dummy that controls for the purely domestic effect of interventions (panel (b)).

The effectiveness of interventions on the country-level aggregated downside variance risk premium is significantly lower in countries with large CDS spreads, as suggested by the positive and significant coefficient in panel (c). Although the coefficient associated with 10-year sovereign yields is also positive, it is not significant at any standard confidence level (panel (d)). The effect of government interventions is also less effective at reducing the downside variance risk premium in more fiscally constrained countries, as suggested by the positive coefficient associated with the ratios of government deficit and government debt to GDP (panels (e) and (f), respectively)—significant only for the former.

Interestingly, the coefficient associated with the ratio of banks' total assets to GDP is negative and significant (panel (g)), which suggests that interventions are more effective at reducing the country-level aggregated downside variance risk premium in countries with relatively larger financial systems. This may seem counterintuitive, as the ability of governments to intervene banks and rescue the financial system should be more credible for relatively smaller banking systems. However, for the euro area, the ratio of banks' assets to GDP is highly negatively correlated with all the previous variables that tend to increase as the vulnerability of a country to a financial system collapse increase.

In sum, our results suggest that interventions by U.S. authorities have a significant alleviating effect on DCRP, except for interventions that involved only banks that are not in the bank index. Interventions into U.S. banks in the KBW bank index or into banks involved in the Federal Reserve's stress tests have an additional relieving effect on the U.S. DCRP. This evidence suggests that interventions by U.S. authorities appear credible to investors, who reduce the compensation they demand for bearing the risk of large correlated drops.

In contrast, for the euro area, only intervention announcements involving multiple banks are marginally successful in reducing the region's DCRP. All other types of interventions, including country-specific intervention announcements, have an insignificant effect on the region's DCRP, often with the opposite sign. Our evidence suggests that the lack of success of intervention announcements by euro-area authorities is, at least in part, due to investors' fragmented view of interventions into financial institutions, where interventions appear to have a stronger effect on the country-specific risk component of the region's DCRP. Moreover, the effectiveness of interventions on the country-specific aggregated downside variance risk premium is relatively weaker for countries whose sovereign debt is perceived as riskier, countries that are more fiscally constrained, or countries with relatively smaller financial systems.

5 Conclusion

In this paper, we propose a measure of downside correlation risk premium (DCRP) in the banking system to investigate the effect of central bank intervention announcements on the compensation that investors demand for bearing the risk of large correlated drops in banks' stock prices. Our measure of DCRP is calculated as the difference between the downside variance risk premium of the major bank index and the volatility-weighted average of the downside variance risk premiums of individual banks within the index. We show that there are significant differences in the unconditional level of DCRP in the U.S. and the euro-area banking sectors. In particular, DCRP is, on average, negative for banks in the U.S. and positive for euro-area banks, especially around key events of the European debt crisis. We hypothesize that the main driver of this difference in the unconditional level of DCRP between the U.S. and the euro area is investors' beliefs in how effective central bank interventions are at preventing a system-wide failure.

Exploiting a novel dataset on central bank interventions, we find that intervention announcements by U.S. authorities are successful in reducing DCRP. In contrast, intervention announcements by euro-area authorities have an insignificant effect on DCRP, except for those involving several banks. We also document evidence that investors view interventions in euro-area countries as fragmented. While country-specific interventions are unsuccessful in reducing DCRP for the region as a whole, interventions are successful at reducing the average downside variance risk premium, especially for banks domiciled in the country of intervention. The effectiveness of interventions on the country-level aggregated downside variance risk premium is smaller when the sovereign debt of the country intervening is perceived as riskier or when the country is more fiscally constrained.

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Table 1: Variance and correlation risk premiums, summary statistics

This table reports the summary statistics for the DCRP and its component for the U.S. and the euro-area bank indexes. Columns 1 and 2 report the options-implied volatility of the bank index and the equal-weighted (EW) average of the implied volatility of individual banks in the index, respectively. Implied volatility is calculated using options with 80 percent degree of moneyness. Columns 3 and 4 report the downside variance risk premium of the bank index and the relative-volatility-weighted (VW) average of the downside variance risk premium of individual banks in the index, respectively. The downside variance risk premium is calculated as the difference between the (80 percent moneyness) options-implied variance and the expected realized variance, as described in Section 2.1. Column 5 reports the downside correlation risk premium (DCRP), which is calculated as the difference between columns 3 and 4 (see equation(3)). Units for implied volatility are in percentage points, while units for variance and correlation risk premium are in percentage squared points. *** indicates significance at the 1 percent level.

Panel (a) U.S. bank index (KBW)

	(1)	(2)	(3)	(4)	(5)
	Implied volatility		**Variance risk premium**		
	Index	Banks (EW)	Index	Banks (VW)	**DCRP**
Mean	38.8	48.3	-32.7	254.6***	-287.3***
Median	32.7	41.6	271.7	466.8	-117.9
St. Dev.	22.1	27.6	1,336.1	1,068.0	720.8
Skew.	1.4	1.7	-4.1	-3.5	-3.6
Kurt.	4.8	5.7	28.7	19.5	28.4

Panel (b) Euro-area bank index (Eurostoxx)

	Implied volatility		**Variance risk premium**		
	Index	Banks (EW)	Index	Banks (VW)	**DCRP**
Mean	51.9	61.7	1074.3***	780.1***	294.2***
Median	48.9	60.1	976.0	768.7	231.3
St. Dev.	13.2	13.9	1,341.5	1,362.8	904.7
Skew.	0.9	0.6	-1.4	-6.4	2.1
Kurt.	3.2	2.8	16.3	60.6	17.3

Table 2: Intervention characteristics and DCRP

This table shows the estimated coefficients from the following regressions:

$$DCRP_{i,t+h} = \alpha + \beta_{c,i,h} D^c_{i,t} + s_{i,h} Surp_{i,t} + \epsilon_{t,h}$$

and

$$DCRP_{i,t+h} = \alpha + \beta^*_{c,i,h} D^c_{i,t} + \beta^*_{int,i,h} D_{i,t} + s_{i,h} Surp_{i,t} + \epsilon_{t,h},$$

where DCRP is the downside correlation risk premium for the U.S. or the euro area. Dummy D^c_t is one of the following types of interventions defined in Section 2.2: (1) involving multiple countries (defined only for the euro area), (2) involving multiple banks, (3) to banks involved in stress tests, (4) to one of the banks in the benchmark bank index, (5) to relatively large banks, (6) relatively large capital injections, or (7) relatively large $SRisk$ (see Brownless and Engle, 2012). $Surp_{US,t}$ is a measure of macroeconomic news surprises (see Scotti, 2013). Standard errors are corrected using Newey and West (1987) with 10 lags. We report only the coefficient for the day following the intervention announcement, h=1. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

	U.S.			**Euro Area**		
	β_c	β_c*	β_{int}*	β_c	β_c*	β_{int}*
Type of intervention						
Multiple country				-377	-303	-79
Multiple bank	-1747*	-1118	-657***	-558*	-743	192
Involved in stress test	-1680**	-1190*	-505**	-131	-51	-82
In bank index	-1339**	-1098*	-243	202	467	-278
Large bank	-1069*	-275	-814***	885	1257	-394**
Large injection	-963**	-69	-919**	590	994*	-422*
Large $SRisk$	-1143**	-456	-704***	714	1179	-489**

Figure 1: U.S. and euro-area DCRP

The figure plots the downside correlation risk premium (DCRP) for the euro area (the bold line) and the U.S. (the dashed line) from 2008-2013. DCRP is computed as the difference between the downside variance risk premium of the bank index and the relative-volatility-weighted average of the downside variance risk premiums of its individual components (see equation (3)). To facilitate the visualization of the series, we reduce their frequency to monthly by averaging across all days within each month.

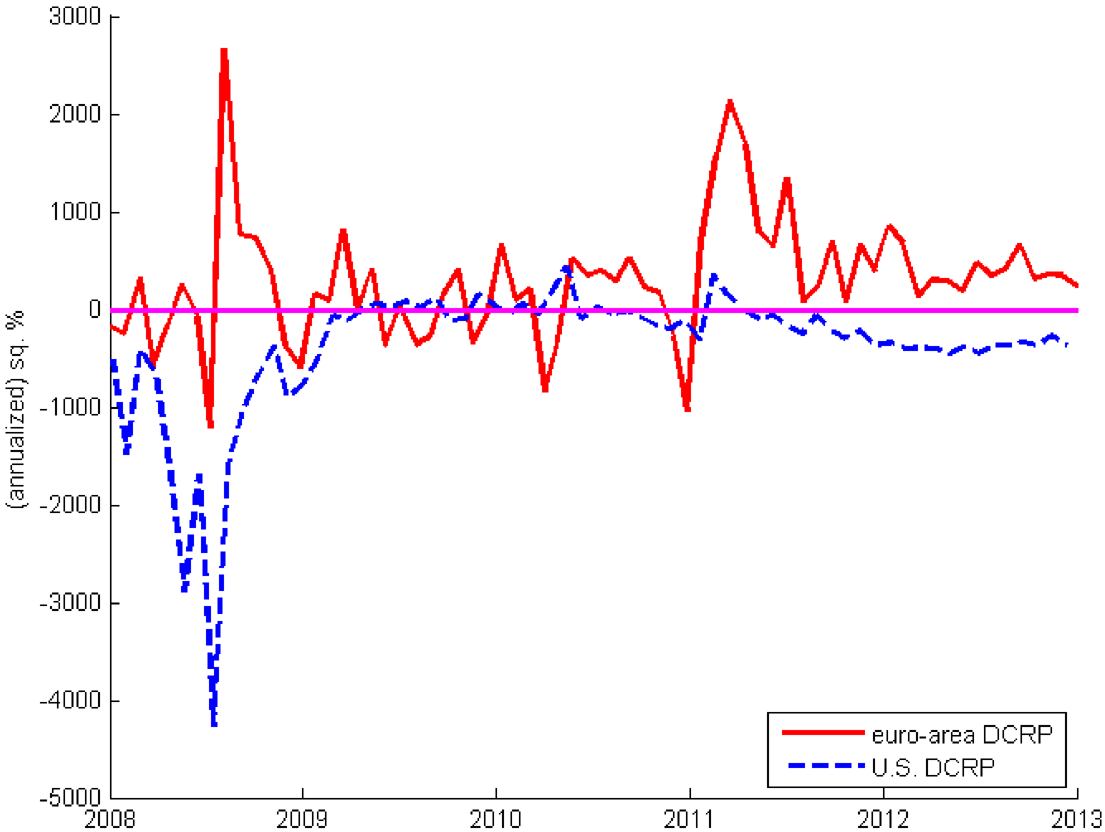
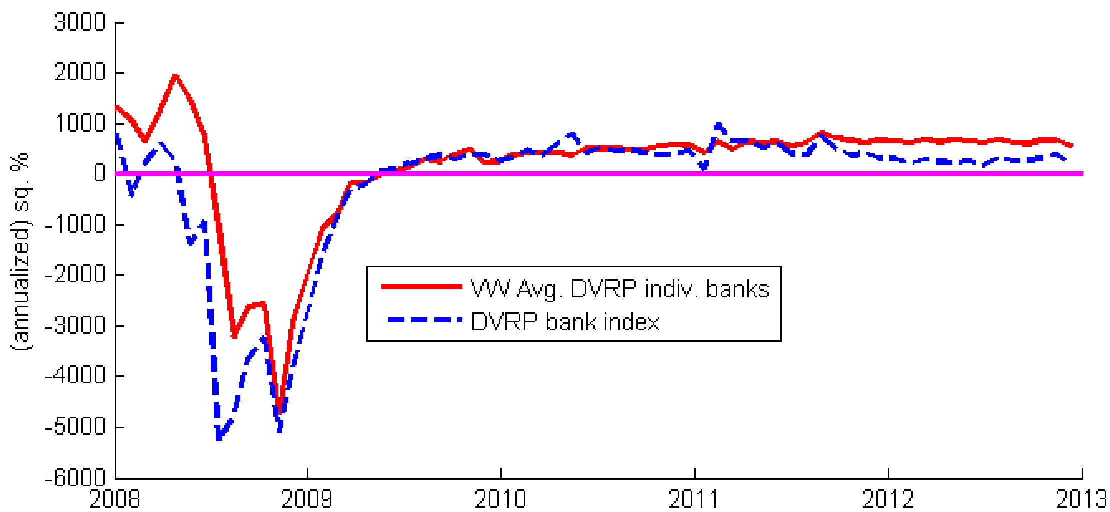


Figure 2: **DCRP components**

The figure plots the components of the downside correlation risk premium (DCRP) for the U.S. and the euro area in panels (a) and (b), respectively. The components are the downside variance risk premium (DVRP) of each region's bank index (dotted line) and the relative-volatility-weighted (VW) average of the DVRPs of individual banks in the bank index (solid line). DCRP (plotted in figure 1) is defined as the difference between the dotted and solid lines (see equation 3). To facilitate the visualization of the series, we reduce their frequency to monthly by averaging across all days within each month.

(a). U.S.



(b). Euro Area

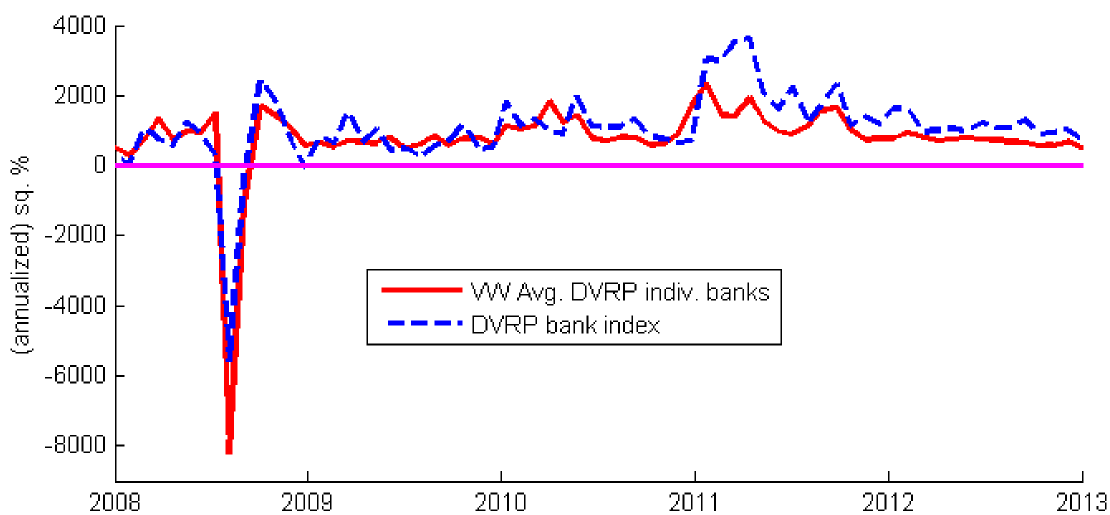


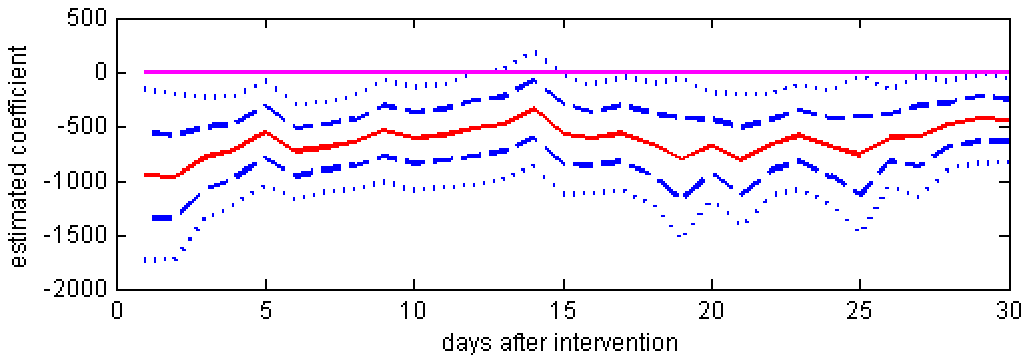
Figure 3: Effect of intervention announcements on the U.S. DCRP

This figure plots the estimated coefficient $\beta_{US,h}$ from the following regression:

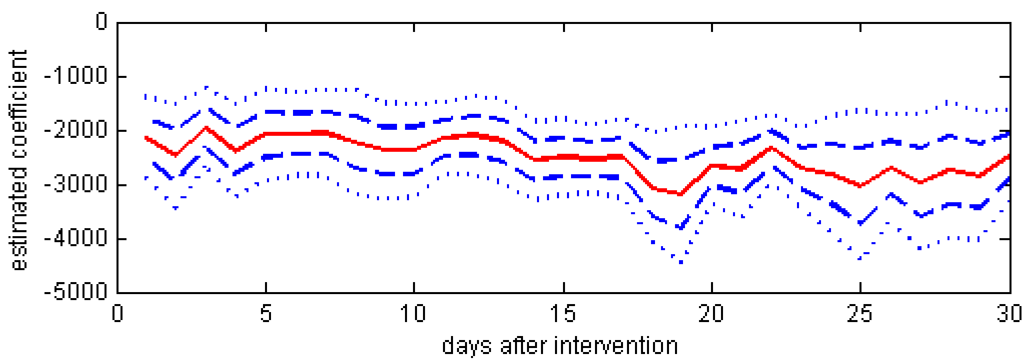
$$rp_{US,t+h} = \alpha_{US,h} + \beta_{US,h} D_{US,t} + s_{US,h} Surp_{US,t} + \epsilon_{t,h},$$

for $h = 1$ to 30 days after the announcement of a capital injection to a bank in the U.S. The dependent variable is one of the following options-based risk premium measures: (a) downside correlation risk premium (DCRP) for U.S. banks, (b) downside variance risk premium (DVRP) of the U.S. bank index (KBW), or (c) relative-volatility-weighted (VW) average of the DVRPs of individual banks in the bank index. Dummy $D_{US,t}$ is equal to 1 if there is a capital injection announcement in the U.S. at time t and $Surp_{US,t}$ is a measure of macroeconomic news surprises (see Scotti, 2013). The dotted blue lines represent one and two standard error deviations. Standard errors are corrected using Newey and West (1987) with 10 lags.

(a). DCRP



(b). DVRP of bank index



(c). VW average of DVRPs of individual banks

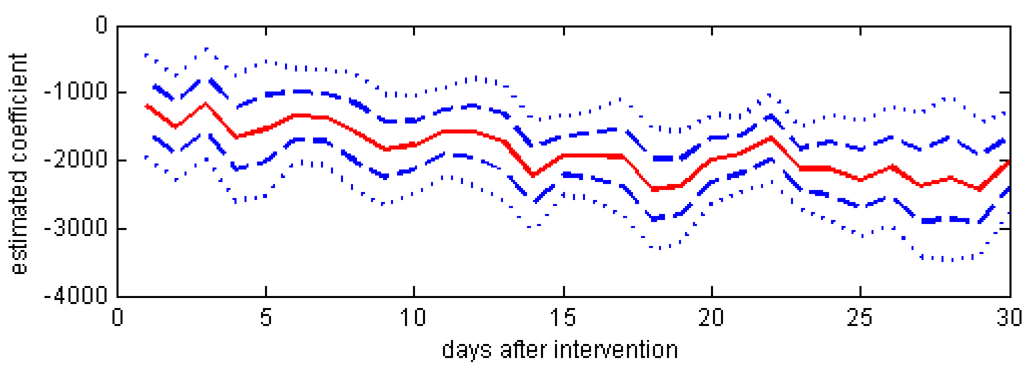


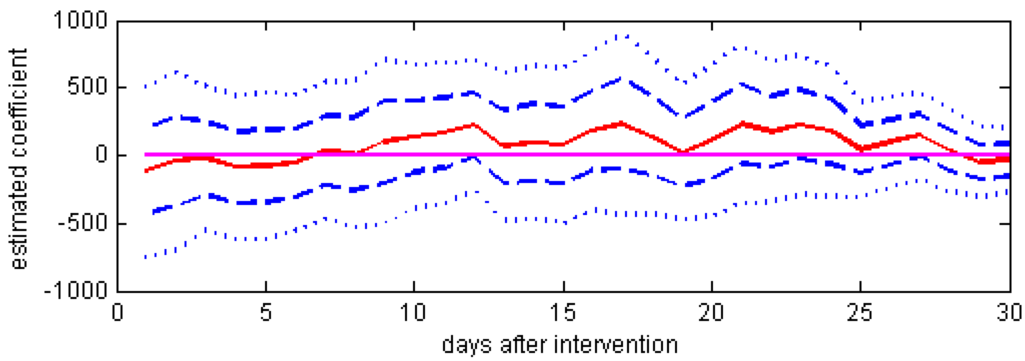
Figure 4: Effect of intervention announcements on the euro-area DCRP

This figure plots the estimated coefficient $\beta_{Euro,h}$ from the following regression:

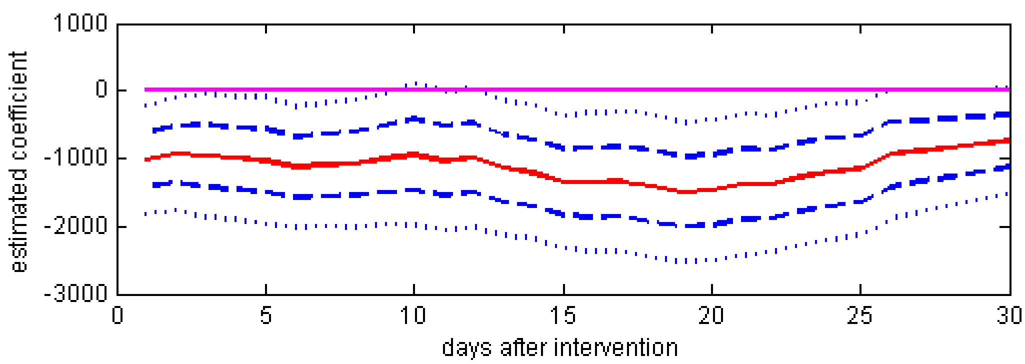
$$rp_{Euro,t+h} = \alpha_{Euro,h} + \beta_{Euro,h} D_{Euro,t} + s_{Euro,h} Surp_{Euro,t} + \epsilon_{t,h}$$

for $h = 1$ to 30 days after the announcement of a capital injection to a bank in the euro area. The dependent variable is one of the following options-based risk premium measures: (a) downside correlation risk premium (DCRP) for euro-area banks, (b) downside variance risk premium (DVRP) of the euro-area bank index (Eurostoxx), and (c) relative-volatility-weighted (VW) average of the DVRPs of individual banks in the bank index. Dummy $D_{Euro,t}$ is equal to 1 if there is a capital injection announcement in the euro area at time t and $Surp_{Euro,t}$ is a measure of macroeconomic news surprises in the euro area (see Scotti, 2013). The dotted blue lines represent one and two standard error deviations. Standard errors are corrected using Newey and West (1987) with 10 lags.

(a). DCRP



(b). DVRP of bank index



(c). VW average of DVRPs of individual banks

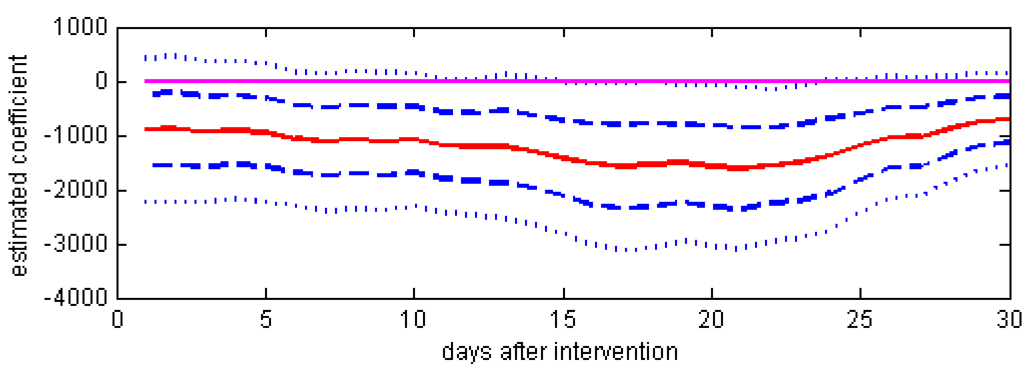


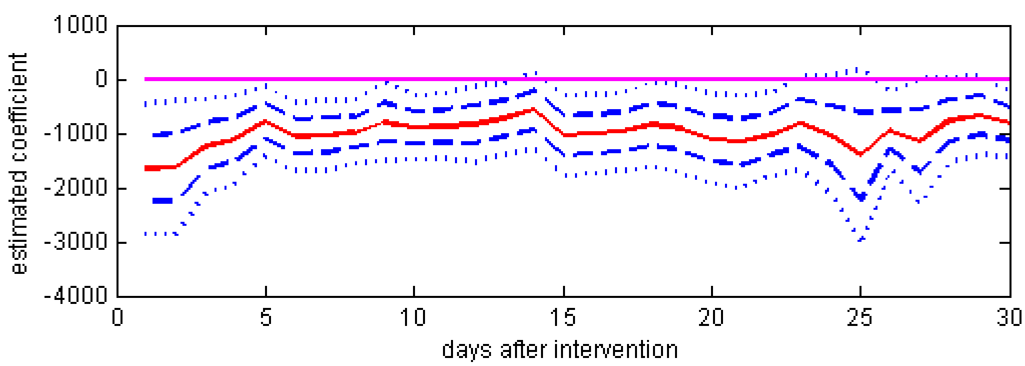
Figure 5: Effect of intervention surprises on DCRP

This figure plots the estimated coefficient β_h from the following regression:

$$DCRP_{t+h} = \alpha_h + \beta_h P_t + s_h Surp_t + \epsilon_{t,h},$$

for $h = 1$ to 30 days after the announcement of a capital injection to a bank in the U.S. (panel (a)) or in the euro area (panel (b)). DCRP is the downside correlation risk premium calculated as the difference between the downside variance risk premium of the bank index and the relative-volatility-weighted average of the downside variance risk premiums of its individual components (see equation (3)). P_t represents the likelihood that a capital injection announcement was a surprise to the market. This surprise announcement measure is calculated as 1 minus the p-value that results from comparing the return of the intervened bank stock in the day following the announcement with a normal distribution of daily returns for the full sample. If stocks of an intervened bank are not publicly traded, the intervention surprise measure is calculated based on the impact of the intervention on the bank index of the country where the bank is domiciled. $Surp_t$ is a measure of macroeconomic news surprises (Scotti, 2013). The dotted blue lines represent one and two standard error deviations. Standard errors are corrected using Newey and West (1987) with 10 lags.

(a). U.S.



(b). Euro Area

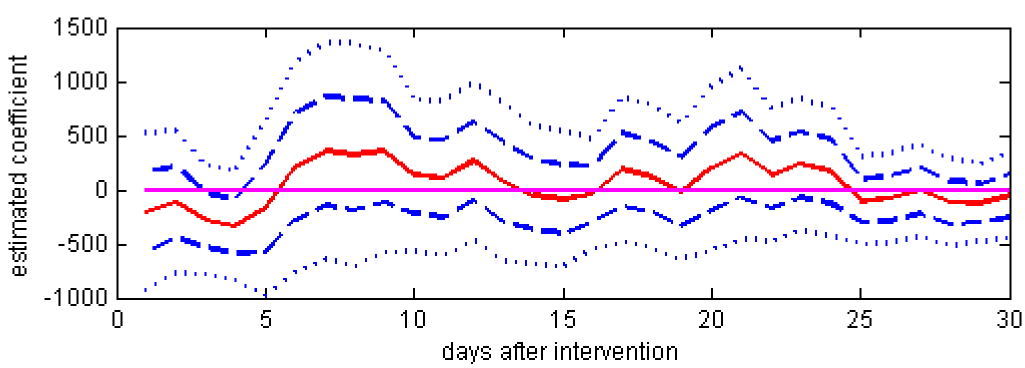


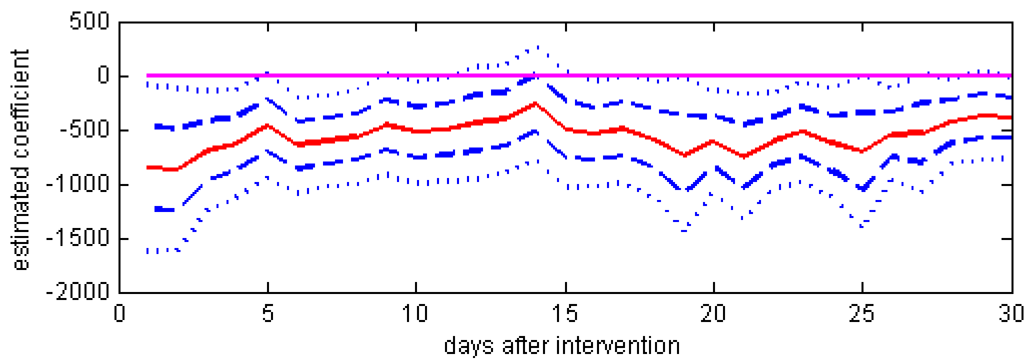
Figure 6: Robustness tests on U.S. DCRP

This figure plots the estimated coefficient $\beta_{US,h}$ for alternative specifications of the following regression:

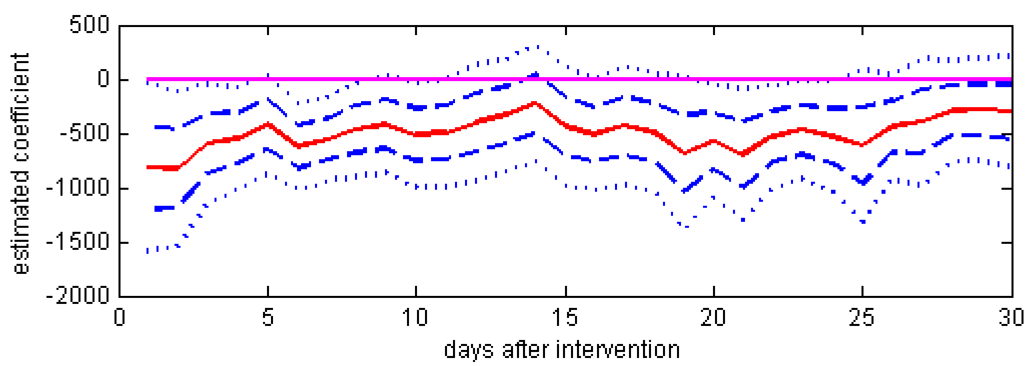
$$DCRP_{US,t+h} = \alpha_{US,h} + \beta_{US,h} D_{US,t} + s_{US,h} Surp_{US,t} + \epsilon_{t,h},$$

for $h = 1$ to 30 days after the announcement of a capital injection. DCRP is the downside correlation risk premium for U.S. banks and dummy $D_{US,t}$ is equal to 1 if there is a capital injection announcement in the U.S. at time t. $Surp_{US,t}$ is a measure of macroeconomic news surprises (Scotti, 2013). The dotted blue lines represent one and two standard error deviations. Standard errors are corrected using Newey and West (1987) with 10 lags. Panel (a) shows the results for the 2008-2011 subsample. Panel (b) shows the results for a specification where DCRP is calculated using only the 10 largest U.S. banks. Panel (c) is a specification where the downside variance risk premium of the bank index is calculated using options with a 90 percent degree of moneyness, while the downside variance risk premiums of the index's components are calculated using options with an 80 percent degree of moneyness.

(a). Subsample period: 2008-2011



(b). Largest banks



(c). DCRP (90,80)

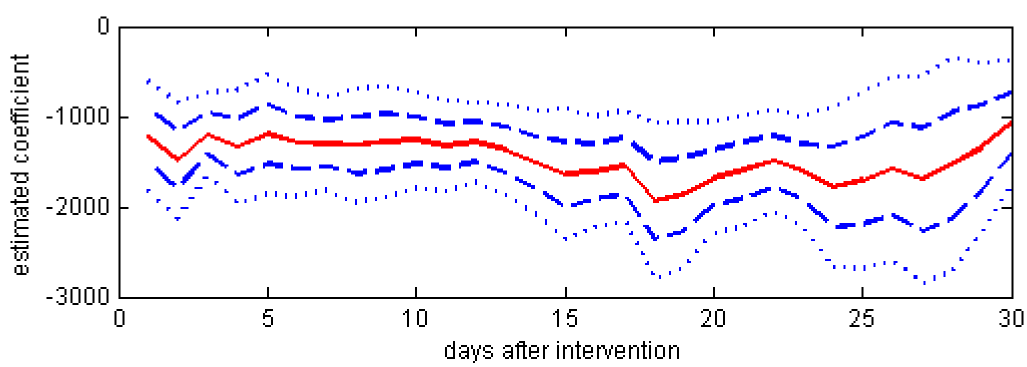


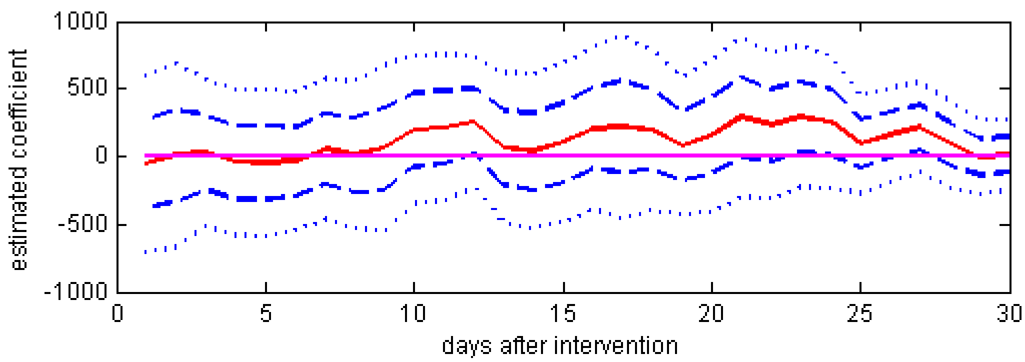
Figure 7: Robustness tests on euro-area DCRP

This figure plots the estimated coefficient $\beta_{Euro,h}$ for alternative specifications of the following regression:

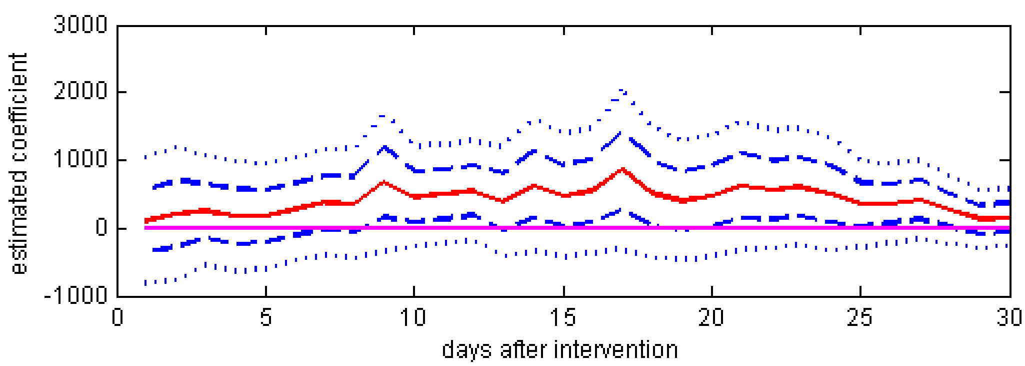
$$DCRP_{Euro,t+h} = \alpha_{Euro,h} + \beta_{Euro,h} D_{Euro,t} + s_{Euro,h} Surp_{Euro,t} + \epsilon_{t,h},$$

for $h = 1$ to 30 days after the announcement of a capital injection. DCRP is the downside correlation risk premium for euro-area banks and dummy $D_{Euro,t}$ is equal to 1 if there is a capital injection announcement in the euro area at time t. $Surp_{Euro,t}$ is a measure of macroeconomic news surprises (Scotti, 2013). The dotted blue lines represent one and two standard error deviations. Standard errors are corrected using Newey and West (1987) with 10 lags. Panel (a) shows the results for the 2008-2011 subsample. Panel (b) shows the results for a specification where DCRP is calculated using only the 10 largest U.S. banks. Panel (c) is a specification where the downside variance risk premium of the bank index is calculated using options with a 90 percent degree of moneyness, while the downside variance risk premiums of the index's components are calculated using options with an 80 percent degree of moneyness.

(a). Subsample period: 2008-2011



(b). Largest banks



(c). DCRP (90,80)

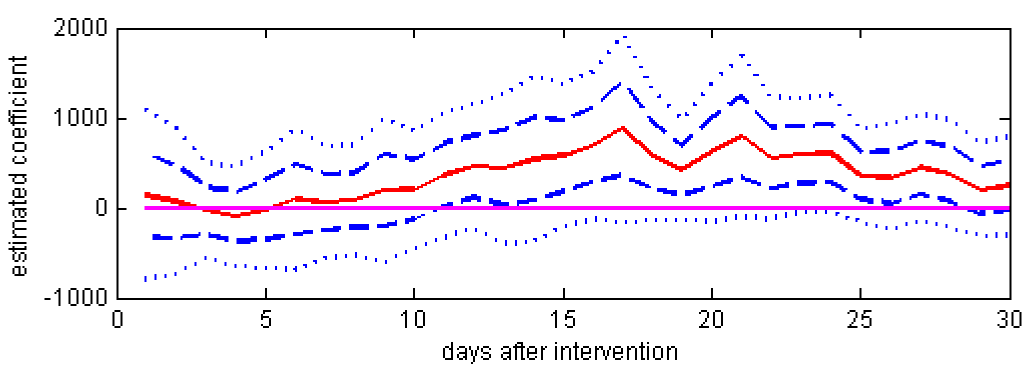


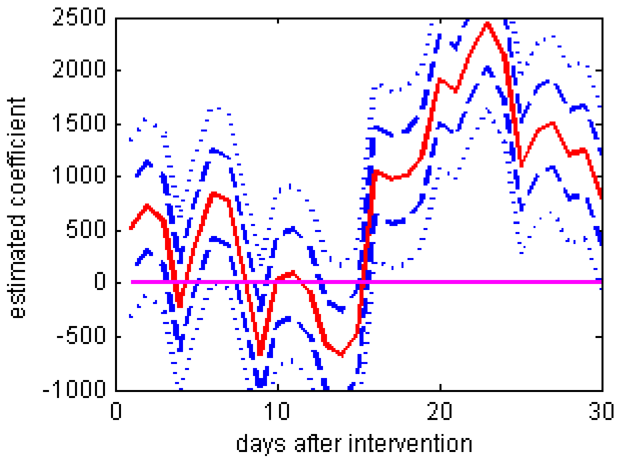
Figure 8: Effect of country-specific bank interventions on euro-area DCRP

This figure plots the estimated coefficients $\beta_{i,h}$ from the following regression:

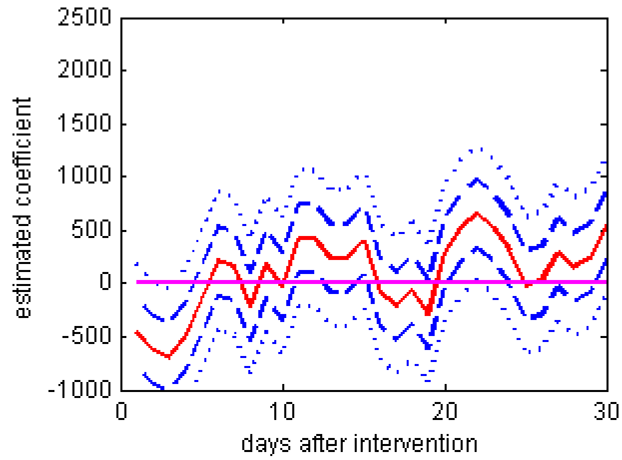
$$DCRP_{t+h}^{Euro} = \alpha_{US,h} + \sum_{i} \beta_{i,h} D_{i,t} + s_{Euro,h} Surp_{Euro,t} + \epsilon_{t,h},$$

for $h = 1$ to 30 days after an intervention announcement, where i is each one of the following euro-area member states: Belgium, France, Germany, Greece, Italy, the Netherlands, Spain, and the rest of the euro area (Austria, Finland, Ireland, Luxembourg, Portugal). The dependent variable is the euro-area DCRP, dummy $D_{i,t}$ is equal to 1 if there is a capital injection announcement in country i at time t, and $Surp_{Euro,t}$ is a measure of macroeconomic news surprises in the euro area (Scotti, 2013). The dotted blue lines represent one and two standard error deviations. Standard errors are corrected using Newey and West (1987) with 10 lags.

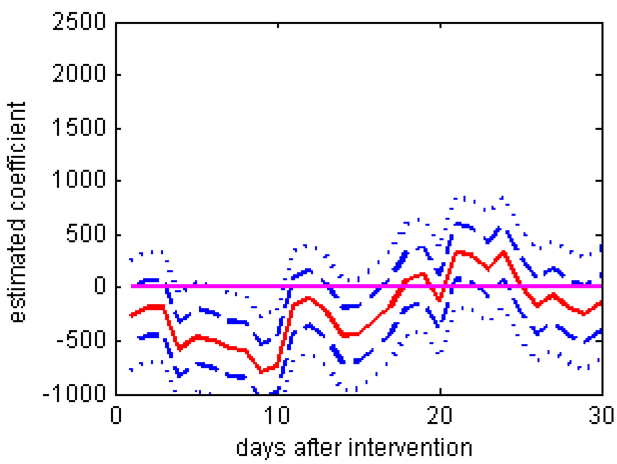
(a) Belgium



(b) France



(c) Germany



(d) Greece

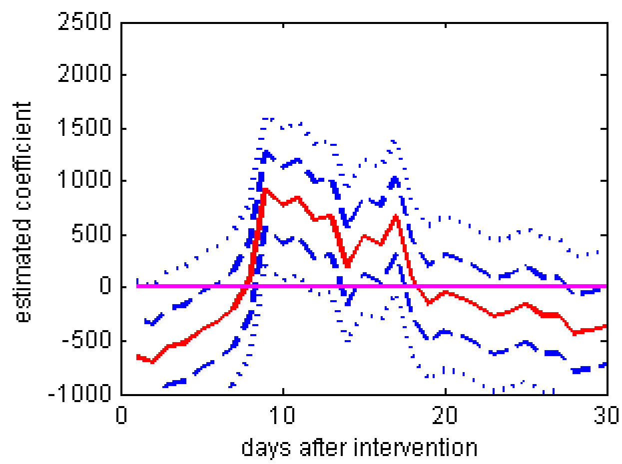


Figure 8: Effect of country-specific bank interventions on euro-area DCRP, continued

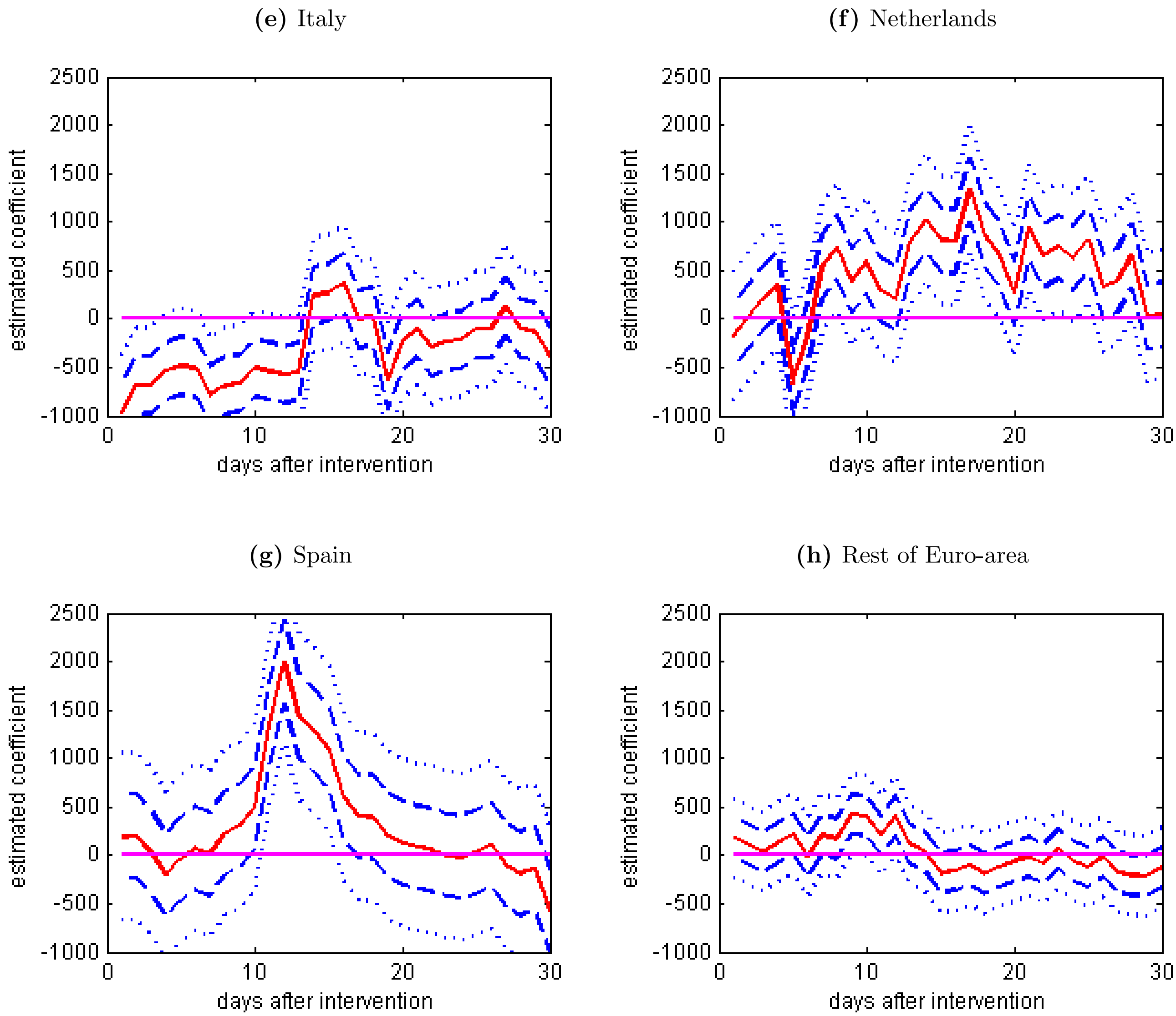


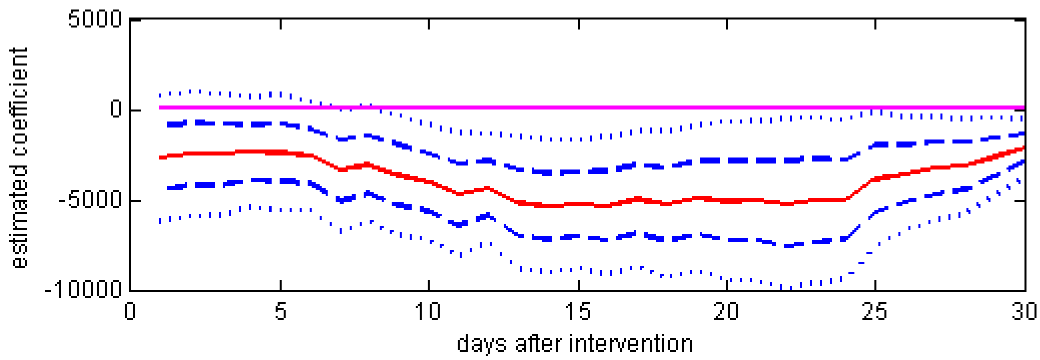
Figure 9: Effect of country-specific characteristics on aggregated DVRP

This figure plots the estimated coefficients from the following regression:

$$DVRP^i_{t+h} = \alpha_i + (\beta_{0,h} + \beta_{1,h} * X_{i,t-1})D_{i,t} + s_h Surp_{euro,t} + \epsilon_{t,h},$$

for $h = 1$ to 30 days after an intervention announcement, where i is each one of the following euro-area member states: Belgium, France, Germany, Greece, Italy, the Netherlands, Spain, and the rest of the euro area (Austria, Finland, Ireland, Luxembourg, Portugal). $DVRP_i = \sum_{j \in index, j \in i} l_j VRP^j_t$ represents each country's aggregated downside variance risk premium. Dummy $D_{i,t}$ is equal to 1 if there is a capital injection announcement in country i at time t and $Surp_{Euro,t}$ is a measure of macroeconomic news surprises in the euro area (Scotti, 2013). Panel (a) reports $\beta_{0,h}$ when we do not include a country-specific characteristic; that is, when $\beta_{1,h} = 0$, while panels (b) to (g) report the estimated $\beta_{1,h}$, the coefficient associated with the interaction between the intervention announcements and one of the following country-specific characteristics: a dummy that controls for the purely domestic effect of interventions (within country), the 5-year CDS spread, the 10-year sovereign bond yield, the ratio of government deficit to GDP, the ratio of government debt to GDP, and the ratio of total bank assets to GDP. The dotted blue lines represent one and two standard error deviations. Standard errors are corrected using Newey and West (1987) with 10 lags.

(a). Capital Injections Dummy



(b). Within-country

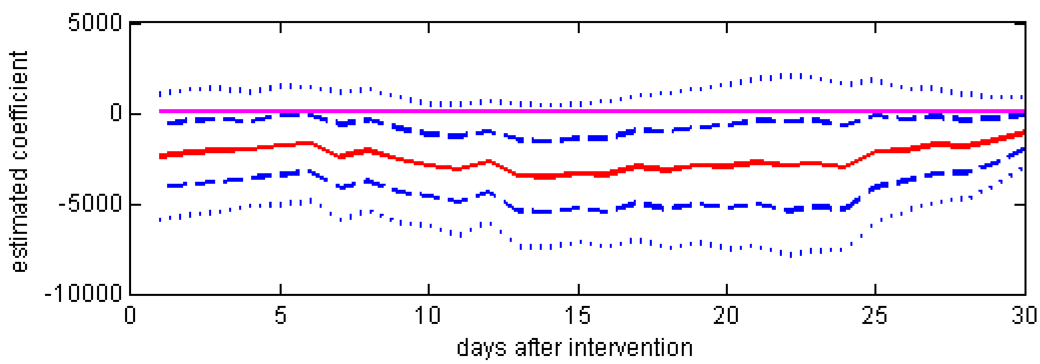
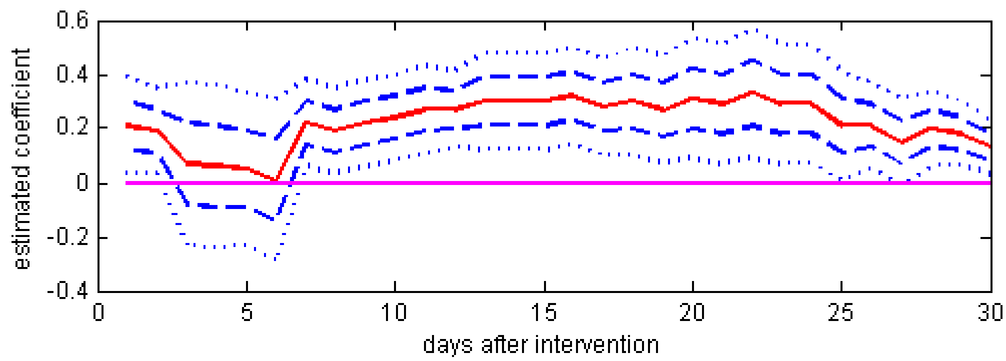
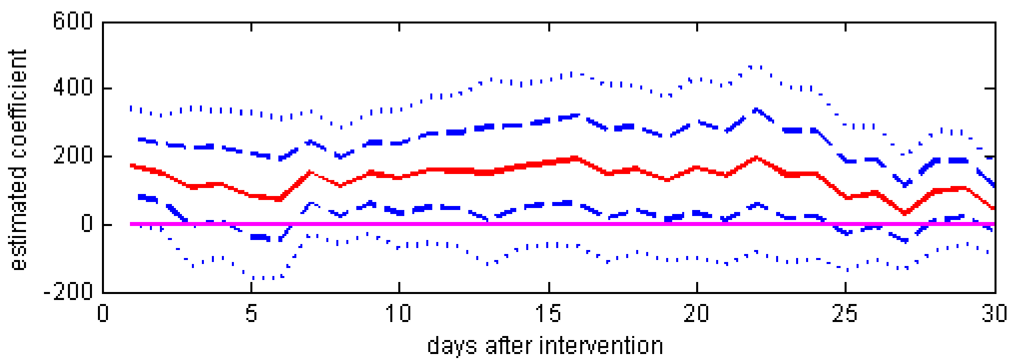


Figure 9: Effect of country-specific bank characteristics on aggregated DVRP, continued

(c). 5-year CDS Spread



(d). 10-year Sovereign Spread



(e). Government Deficit to GDP

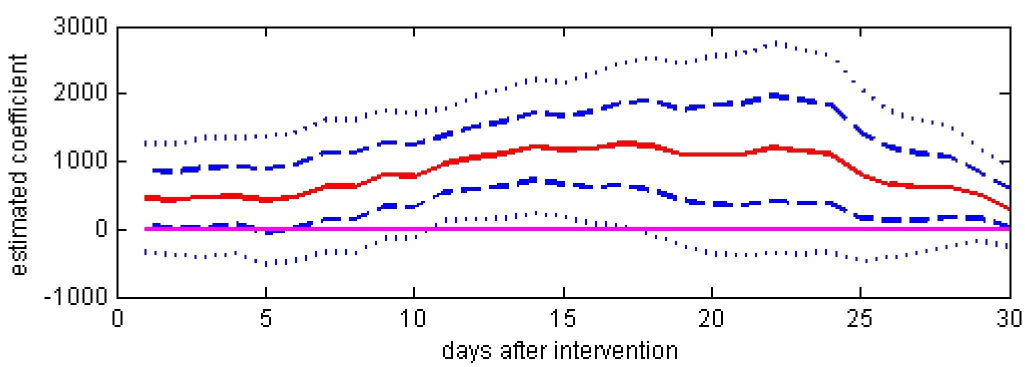
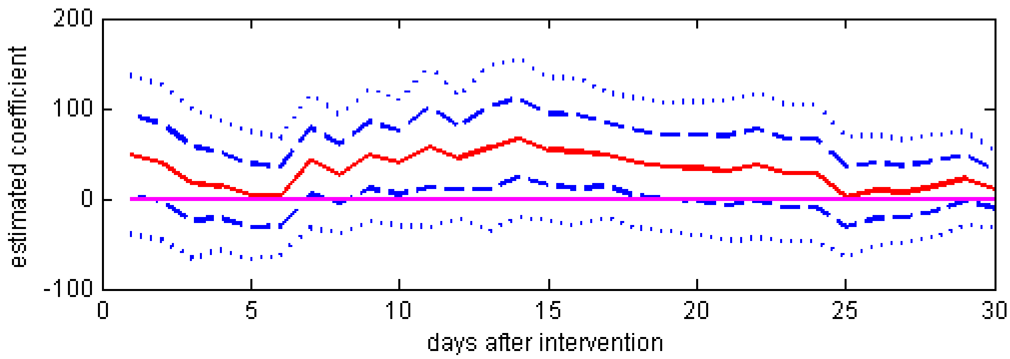


Figure 10: Effect of country-specific bank characteristics on aggregated DVRP, continued

(f). Government Debt to GDP



(g). Bank assets to GDP