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SEMINARIO PERMANENTE DE CIENCIAS SOCIALES

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SPCS Documento de trabajo 2016/16

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I.S.S.N.: 1887-3464 (ed. CD-ROM) 1988-1118 (ed. en línea)

Impreso en España – Printed in Spain.

SOVEREIGN CREDIT RISK CONTAGION IN EMERGING MARKETS[1]

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ABSTRACT

We document a framework for the analyses of contagion among sovereign credit risk markets concretely through sovereign CDS spreads of different emerging economies and regions during a period of prolonged financial distress. Following a Generalized VAR (GVAR) approach, we firstly observe a significant amount of commonality in emerging CDS portfolios over time that can be seen as previous signals of contagion. Secondly, we found a high degree of relationship between the events originated in the advanced economies and the total contagion in the CDS emerging markets. Third, we found a high degree of credit risk transfer among emerging economies, differentiating between transmitting and receiving risk portfolios. BRIC and CIVEST portfolios are net transmitters of credit risk to all others emerging portfolios during all the sample period. By contrast, Asian, Middle East Asian and African portfolios are mostly credit risk receivers from all other portfolios and Eastern European and American emerging portfolios are transmitters and receivers of contagion depending on the evolution over time. Finally, there is enough evidence of credit risk contagion to support the importance of this study.

Keywords: CDS spreads, emerging markets, spillover effects, GVAR

JEL codes: F30, G15, C32

[1] The authors would like to express their gratitude for the grant received from the Fundación Ramón Areces. A. González-Urteaga acknowledges financial support from ECO2012-35946-C02-01 and ECO2012-34268. We thank Óscar Carchano, Mª Paz Jordá, and Ana María Ibáñez for valuable comments and discussions on earlier drafts of this paper.

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1. INTRODUCTION

Following the collapse in September 2008 of Lehman Brothers, the fourth largest US investment bank, financial markets experienced tremendous distortions and credit spreads rose to unprecedented levels. This had important implications for the financial and sovereign system at international level, since financial institutions are closely interrelated through derivative contracts so the bankruptcy of one of them could cause losses to the counterparty, producing, as a result, new bankruptcies. This large interconnection has increased in recent years as credit derivatives have been trading in all financial markets, being the credit default swap (CDS hereafter) the most commonly used instrument for transfer credit risk. CDS is a contract in which the protection buyer makes a series of premium payments in exchange for the right to receive a payoff from the protection seller if the underlying debt defaults. The premium payment made by the protection buyer is called the CDS spread. CDS are quoted in basis points of the notional value of the underlying debt instrument, typically a corporate bond. In fact, CDS spreads theoretically reflect the credit quality of a particular country/firm and are considered a good proxy of credit risk and the probability of default, and they also reflect market perceptions about the financial health of a country.

The financial crisis not only affected the advanced economies. Emerging countries were also affected by this situation. Among other consequences, the GDP of the BRIC grew on average 7.25% in 2007 however in 2008, GDP grew 5.1% which means that these emerging economies reduced their GDP growth in a 29.66% due to the financial crisis that began in 2007 September. In addition, the most affected economies by the financial crisis were Brazil and Russia. The first, registered a GDP growth for 2009 of -0.2%, which means the first contraction in 18 years of the country's economy. While Russia's economy is more affected by the subprime crisis of 2008 as it recorded a GDP growth for 2009 of -7.8% . Also, at the end of 2008, the government rescued four of the largest banks in Kazakhstan; in March 2009, Arab banks had lost three billion dollars, reaching in September almost four billion dollars loss since the onset of the global financial crisis. In addition to the deteriorating economic conditions, it favored the emergence of mass protest movements in North Africa and the Middle East, even to government’s overthrown in some countries within these geographical areas that were traditional allies of the West.

Nowadays, emerging sovereigns are among the largest high-yield borrowers in the world; however, their nature is different to other high-yield obligors. Since rating agencies usually assign them the non-investment grade status, they are more likely to default. However, emerging countries in financial distress generally do not enter bankruptcy proceedings or ever liquidate their assets, but go through debt restructuring mechanisms, which allow them to exchange defaulted bonds for new longer maturity, lower yield debt instruments.

Using emerging market CDS spreads as indicators of sovereign credit risk, this paper aims to identify the transmission mechanism of risk in the emerging market during the prolonged crisis period. In this study, we define contagion as the change in the propagation mechanism when a shock occurs and we measure it in terms of return spillovers. We aim to shed some light on how contagion works among these economies, as this is the key to understanding the sovereign propagation of financial crises. Firstly, we employ a common approach to measure contagion using the correlation coefficients across markets. That way we test initial signals of credit risk contagion between emerging markets. Secondly, following a Generalized VAR (GVAR) approach (Diebold and Yilmaz, 2012) we estimate contagion, in terms of return spillovers, between CDS returns portfolios. In addition, the examination of the net directional return spillover measures enables us to identify emerging portfolios that can be seen as net transmitters and receivers of credit risk contagion. Unlike the majority of existing contagion studies look at a combination of developed and emerging countries, we focus exclusively on emerging markets, given the significant growth that their credit market has experienced in last years and the serious consequences for some emerging countries during the recent global financial crisis.

The large amount of data used and the existing heterogeneity between all the emerging countries considered could cause a significant diversity of spillover effects, which we will analyze in terms of portfolios. In particular, the data set consists of sovereign CDS for 45 emerging countries, which we use furthermore to construct seven emerging credit risk representative portfolios: BRIC, CIVEST, Eastern Europe, Asia, Middle East Asia, America and Africa. Moreover, given the advantages of CDS spreads

instead of bond spreads[3], we use them as a proxy of the sovereign credit risk, covering a large stability and crisis period from 2004 to 2015. To the best of our knowledge, this has not been investigated up to now.

This study may have useful applications and implications for regulators and policymakers as they provide an insight into country/region specific vulnerabilities and how these vulnerabilities are transmitted. The historical and current level of spillovers represent crucial information to understand the dynamics of international risk transmission and can assist the formulation of effective and coordinated policy initiatives.

The remaining part of this study is organized as follows. In the next section, we review the existing literature. Section 3 and 4 describe the data and the GVAR estimation methodology, respectively. Section 5 presents our empirical results and discusses their interpretation and we end with a brief conclusion in Section 6.

2. LITERATURE REVIEW

The concept of "contagion" is difficult to define and measure empirically, being however a very intuitive concept. Kaminsky *et al*. (2003), Bae *et al*. (2003) and Longstaff (2010) among others, define contagion as an episode in which there is a significant increase in cross-market linkages when a shock occurs. According to Forbes and Rigobon (2002) contagion exists if there is a significant increase in cross-market linkages after a shock to one country, whereas Bekaert *et al*. (2014) define contagion as the co-movement in excess of what can be explained by fundamentals taking into account their evolution over time. Pericoli and Sbracia (2003) review different definitions and related measures of contagion that are frequently used in the literature[4], concluding that all methodologies are drawn by limitations and caveats. In this study, we define contagion as the change in the propagation mechanism when a shock occurs

[3]See for instance, Blanco *et al*. (2005), Norden and Weber (2009) and Jorion and Zhang (2009), among others.

[4]They include changes in the probability of currency crises, volatility spillovers, Markov-switching models, correlation or co-movements, and changes in the transmission mechanism.

and we measure it in terms of return spillovers using the GVAR methodology of Diebold and Yilmaz (2012).

During the last decade, some studies have investigated the issue of contagion focusing their attention on emerging financial markets.[5]A first stand of the literature have focused on the analysis of contagion between the stock, bond and exchange markets for developed and emerging economies.

Chiang *et al*. (2007) analyze the relationship between the stock returns of various crisis-hit markets for nine Asian countries. They conclude that a contagion effect exist. Moreover, the paper identifies two phases of the 1997-1998 Asian crisis. In the first phase, the crisis displays a process of increasing correlations, while in the second phase, investor behavior converges and correlations are significantly higher across the Asian countries. Alouiet *et al*. (2011) investigates extreme interdependences of BRIC with the US market. They find evidence of extreme co-movement for all market pairs, while Brazil and Russia (commodity-price dependent countries) exhibit higher and more persistent dependency comparing with China and India (finished-product export-oriented markets). The results between emerging market pairs suggest that the dependence is smaller in bearish markets than in bullish ones, which might indicate a low probability of simultaneous crashes.

Samarakoon (2011) analyzes the transmission of shocks from US to emerging and frontier markets to delineate interdependence from contagion. It concludes that there exists an important interdependence and contagion in bi-directional terms and the interdependence is driven more by US shocks, while contagion is driven more by emerging market shocks. Tzeng and Tay (2014) evaluate the transmission of shocks during the US subprime crisis and the European sovereign debt crisis to sixteen emerging markets. The findings show that the stock market in the US has a significant effect on the transmission of emerging markets in the initial stage of the crisis and that there are an obvious link between the US mortgage crisis and the European sovereign debt crisis.

Kenourgios and Padhi (2012) investigates the contagion of three emerging market crises focusing on financial markets of emerging and developed countries from

[5] See Appendix A for a detailed table of recent literature review results.

Asia (Hong Kong and Singapore) economies. Using stock and bond market data, the results show that during the subprime crisis there exist long and short run dynamics only among emerging markets during the Russian and the Asian crises, while the Argentine turmoil has no impact on any of the examined markets. Finally, Celik (2012) have focused on the analysis of contagion between currencies of emerging markets and developed countries during the US subprime crisis. The results show that there is evidence of contagion during the US subprime crisis for most of the advanced and emerging economies, however this contagion presented a higher influence on these latter economies.

However, these previous research has investigated financial contagion but not focusing exclusively on credit risk transmission. The most recent papers, that constitute the second strand in the literature, have used CDS spreads with this purpose. Cho *et al*. (2014) have investigated the interconnectedness and the contagion effect of default risk in Asian sovereign CDS markets during the global financial crisis. Firstly, they find significant co-movements in Asian sovereign CDS markets being larger between developing countries than between developed and developing countries. Moreover, the co-movements intra-regional nature are stronger than inter-regional nature. Secondly, they find evidence of contagion effects among six of them with the exception of Japan, affected more by cross-market spillovers than by their own-market spillovers. Kang and Suh (2015) examine whether emerging market financial turmoil in 2013-2014 can extend to advanced economies creating spillovers. The results suggest that the uncompromised policy surprise in advanced countries may spill back upon themselves through the financial tension in emerging countries. Moreover, the trade and economic linkage of advanced economies to emerging market is the important source of the transmission channel.

This paper contributes to the literature that investigates the contagion on the sovereign credit risk markets concretely through sovereign CDS spreads of emerging markets. In this sense, this paper is closely related with Cho *et al.* (2014). However, we differ from their paper in several ways. Related with the data, we analyze a more complete emerging market sample with 45 countries grouped in different portfolios (they only focus on seven Asian countries) and our sample period is longer, including the period before the global financial crisis. Following Diebold and Yilmaz (2012), we analyze not only the total credit risk contagion in a rolling framework but also we

determine which emerging CDS markets would be transmitters and receivers of such contagion. Nowadays, CDS spreads represent the direct prices of credit risk and therefore are the most suitable sources for such studies. Besides, the election of emerging sovereigns is basically due to the special nature of their default risk, and also because they are among the largest high-yield borrowers in the world. As far as we know, this is a pioneer study that not only complements but also deepens the literature on international information transmission across emerging economies via examining sovereign CDS contagion.

3. DATA DESCRIPTION

The sample consists of daily sovereign CDS spreads, collected from the Thomson Datastream (CMA), for 45 emerging countries. We consider US dollar denominated, senior tier and 5-year CDS quotes, since these contracts are the most traded maturity and the largest of the segment of the emerging economies' CDS market (Jorion and Zhang, 2007, Ismailescu and Kazemi, 2010 and Eichengreen *et al.*, 2012, among others). The CDS spread shows the periodic average premium (*premium mid spread*)[6] expressed in basis points (bps). The sample comprises a wide period from January 1, 2004 to March 4, 2015, with 114,587 unbalanced panel observations for 2,915 days. Our interest in sovereign emerging markets is twofold. Firstly, since rating agencies usually assign them the non-investment grade status, they are more likely to default. However, they do not fall into default in classical terms due to the special nature of their default risk.

The 45 emerging countries have been classified in seven representative portfolios[7], selected as follows. The first portfolio is the well-known BRIC portfolio (P1), which is comprised by Brazil, China, India and Russia. This is a sub-group of emerging countries with a remarkable strong development over the recent years. Secondly, CIVEST portfolio (P2) is constituted by Colombia, Egypt, Indonesia, South

[6]The arithmetic mean between CDS spreads offered (*premium bid spread*) and demanded (*premium ask spread*) by a group of contributors who report their prices daily to CMA.

[7] The use of portfolios provides an efficient way to summarize all the information included in individual countries CDS, with the advantage of smoothing the noise presents in the data, mainly due to transitory shocks in individual countries.

Africa, Turkey and Vietnam. These economies are considered very promising and they have been called the new BRICs. The remaining five portfolios are formed by geographical zone. Eastern Europe portfolio (P3) is formed by Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Poland, Romania, Slovakia and Slovenia. Asia portfolio (P4) is comprised by Kazakhstan, Pakistan, Philippines, Malaysia, Thailand, South Korea and Sri Lanka. Middle East Asia portfolio (P5) is constituted by Bahrain, Israel, Lebanon, Qatar and Saudi Arabia. America portfolio (P6) includes Argentina, Chile, Costa Rica, Dominican Republic, El Salvador, Guatemala, Mexico, Panama, Peru, Uruguay and Venezuela. Finally, Africa portfolio (P7) closes the list and is formed by Ghana, Morocco and Tunisia. The idea of building portfolios corresponds with the aim to reflect the country credit risk average in a particular economic and/or area portfolio.

Table 1 presents the descriptive statistics on the CDS data for each country and portfolio, while Figure 1 illustrates the daily time evolution of the mean CDS spreads through all the countries in the sample (Panel A), and the seven portfolios (Panel B).

CDS spreads differ substantially by country and portfolio[8]. The mean of CDS spreads range from 130.06 bps for Eastern Europe (with Czech Republic presenting the minimum mean of the sample) to 324.01 bps to America (with Argentina and Venezuela displaying the maximum means of the sample).

It is noticeable the sharp increase in the CDS premiums during 2008, which corresponds to the global financial crisis originated in US with the subprime crisis in mid-2007. In November 2008, following the bankruptcy of Lehman Brothers, CDS spreads of all the emerging portfolios began to grow to a large extent, with a greater impact in Asia and America portfolios. They exhibit the maximum values in the sample with 1,652.64 bps (due to Pakistan and Sri Lanka) and 1,066.99 bps (due to Venezuela and Argentina), respectively. Moreover, these portfolios have the highest volatility of the entire sample as they have a standard deviation of 199.7 and 190.4, respectively.

[8] Since the 45 emerging countries considered in the study represent a very heterogeneous sample, the significant differences between the descriptive statistics are not unexpected.

From that date, the CDS spreads start to decrease, the October 3, 2008 due to the approval of the bailout plan proposed by the Bush administration to combat the economic crisis, it consisted of investments of 700 billion dollars from the Treasury Department to clean up banks' balance sheets "toxic" assets, in addition in 2009 created the South Bank, composed of seven Latin American countries, which include Argentina, Paraguay, Venezuela and Uruguay. To this must be added the rescue to four major Asian banks in late 2008 and the creation of ASEAN–China Free Trade Area (ACFTA), being the world's largest regional emerging market.

Overall, after 2010 all portfolios display a quite stable pattern, but still exceeding the values they had before the crisis. Besides, America has experienced a considerably intense rise after 2012, reflecting the Argentine and Venezuelan credit risk troubles. Moreover, to police Argentina crisis that passed to a social crisis armed, a Mw 8.2 earthquake that rocked northern Chile and generated a tsunami of 2.55m, the death of Venezuelan President Hugo Chavez and the falling price of oil, made relevant as countries that make up the portfolio America are oil exporters and in the period between 2012 and 2015 the price of Brent fell approximately 46%. All this has led[9], as previously mentioned, to reach the end of January 2015 the maximum CDS spread exceeding of 1.000 bps, which translates into an increase of 240% during this period.[10]

4. METHODOLOGY

As a first step we first calculate log-returns in order to obtain a stationary series:

$$CDS_t = log\left(\frac{CDS\ spread_t}{CDS\ spread_{t-1}}\right) \quad (1)$$

This way, the resulting series, named hereafter CDS, captures the relative variation of emerging portfolio's credit risk.

[9] The CDS spreads for the individual countries are available upon request.

[10] See Appendix B for a timeline of key events during 2004-2015 sample period.

The return spillover effects are obtained following the Generalized Vector Autoregressive framework (GVAR) methodology developed by Diebold and Yilmaz (2009, 2012), which is a VAR-based spillover index particularly suited for the investigation of systems of highly interdependent variables. In particular, we will apply the GVAR approach to the seven portfolios previously built ($N = 7$). Spillovers are measured from a particular variance decomposition associated with an *N*-variable vector autoregression framework, which allow us to parse the forecast error variances of each variable into parts which are attributable to the various system shocks. One of the main advantages of this approach is that it eliminates the possible dependence of the results on ordering, in contrast to the traditional Cholesky factorization[11].

In addition to that it includes directional contagion indicators from/to a particular series, not only the total spillovers[12]. This enables us to measure not only the total contagion across all the portfolios, TS^{G}, given by (C.4), but also the net directional contagion from a particular portfolio *i* to all the others, $NDS^{G}_{i\rightarrow all}$, given by (C.5), as well as the net directional contagion among each pair of portfolios *i* and *j*, $NPS^{G}_{i\rightarrow j}$, given by (C.6). That way, the examination of net directional contagion measures enables us to identify groups of portfolios that can be seen as net transmitters and receivers of contagion.

Besides, since we do estimate the GVAR in a rolling framework (using a 200-day rolling windows)[13], we are able to analyze the evolution of the different measures of contagion over time and during a number of phases of market instability.

[11]This problem is circumvented by exploiting the generalized VAR framework of Koop *et al.* (1996) and Pesaran and Shin (1998), among others.

[12] For a more in deep explanation of the GVAR methodology and construction of contagion measures, see Appendix C.

[13] At each rolling window, the lag *p* of the GVAR model is determined using the likelihood ratio test and the Akaike information criterion, which confirms that *p* varies over time. The forecast horizon H=10is selected using the *total return spillover* index of the GVAR. This forecasting horizon is commonly used in similar studies (see for example Ballester *et al.*, 2014).

5. EMPIRICAL RESULTS

5.1 Preliminary rolling correlation analysis

Table 2 presents several statistical tests for CDS log-returns in the countries and portfolios. The Jarque-Bera test (Panel A) rejects the normality of all the series, due to excess kurtosis and skewness. These results are indicative of non-normal distributions and fat tails, which are common features in financial series. Finally, test both Dickey and Fuller (1981) Augmented (ADF) and Phillips and Perron (1988) (PP) (Panel B) that reject the null hypothesis of unit root of all series, being stationary.

As a preliminary analysis to understand contagion we explore the pair-wise correlations[14] between the log-returns of CDS spreads for emerging portfolios in the sample. Figure 2 shows the correlation coefficient evolution results for all the portfolios. The preliminary rolling correlation analysis indicates that the pair-wise correlations between the emerging CDS portfolios are mostly positive and they change over time.

In general, we observe a significant increasing trend in the correlations coefficients between portfolios since 2005 reaching maximums with the global financial crisis. It is remarkable for all portfolios except for Eastern Europe, Middle East Asia and Africa with increasing correlations levels with others portfolios started in 2008. After this moment, it is noted that correlations between all portfolios decreases three times: in mid-2009, in 2011 and 2013, except between BRIC and CIVEST portfolios whom maintain their correlations in the same levels than during the global crisis. It seems that this portfolios exhibit the highest correlation levels, close to 0.9 between late 2007 and mid-2011, and above 0.8 until 2014, and moreover this correlation is independent of the financial crisis.

In summary, the results are consistent with the idea that during periods of international financial crises, correlations between assets and markets are higher and this is a key element in the underestimation of risk in stress periods. Figure 2 indicates that there is a significant amount of commonality in emerging CDS portfolios that can be seen as signals of contagion.

[14] We perform the correlation analysis with a rolling sample framework using 200-day rolling windows in order to investigate the correlation pair-wise between emerging portfolios over time.

In order to measure the credit risk contagion between among emerging countries, we analyze the returns spillover effects between the different emerging CDS portfolios. More specifically, we examine, firstly the *total return spillover index*, which indicates the percentage of the forecast error variance in all the series that comes from spillovers, and secondly the *net directional and net pairwise return spillover indices*, which measures the spillover transmitted by portfolio *i* to all others and then, if *i* is a net transmitter (receiver) of return spillovers to (from) *j* respectively.

5.2. Total return spillovers

Once we have established high co-movement in emerging CDS portfolios, the next step is to evaluate if contagion occurred. We measure the *total return spillover* index using the variance decomposition approach of Diebold and Yilmaz (2012). Figure 3 present the evolution over time of the return spillover measure, corresponding to the total contagion between the credit risk of the seven CDS portfolios, for the whole period from January 2004 and March 2015.

It can be seen that the index started on late 2004 with a level of contagion, on average for this year, of 11.91%. A gradual growth of contagion is observed from that date until the end of 2006 leading the index to be at 47% on December 15 due to the slowdown in the second half of the US economy, a significant decline in oil prices in that month, the increase of geopolitical tensions in the Middle East (outbreak of hostilities between Israel and Lebanon) and the rise in current account shortfalls in some of the emerging Europe economies. Since January 2007 we observe a decrease in the contagion, which could be due to the increase in the emerging countries domestic consumer and the increase in the price and amount of oil exportations, reaching the contagion at level of 33.75% on June 13.

On August 2007, with the global financial crisis, a progressive growth of contagion levels is observed and this measure is augmented by the bankruptcy of Lehman Brothers in September 2008. This event had a significant impact between emerging countries with the highest levels of contagion during the last quarter of 2008 and until mid-2009 peaking 70.99% of contagion on July 16, 2009. After mid-2009, the contagion experienced a decline to stand at 42.96% on April 16, 2010 due to the

recovery in the global economy and the fact that the exposure of these economies to the crisis were limited.

After the first Greek bailout in May 2010, the contagion started a new growth rising on average 67.47% in the last quarter of 2010. In 2011, the index started to decline due to several reasons. Firstly, the countries forming the BRIC portfolio be part of the IMF[15] member countries. Secondly, the rapid economic recovery in the emerging economies due to the solid fiscal and financial policies causing an increase in the domestic demand and the level of exportations. And finally, the 38% of increase in the Brent price comparing with 2010, situates contagion on average at levels of 43.12%.

In late 2011 started a new growth due to the reduction of the exportations from emerging economies, the uncertainty environment and the increasing tensions in financial markets due to the sovereign debt crisis in the euro area, leading the contagion, on average, 66.66% during the second quarter of 2012. The third significantly decrease in the index was on May 21, 2013 with a minimum value of 40.29%. During this year the emerging economies benefit from the advanced economies economic recovery and the injection of US$104.600 million to Mexico and Poland and US$6.200 million to Morocco from the IMF.

From the end of May 2013 occurs the last significant increase in the level of contagion leading the index during the first quarter of 2014 an average value of 63%. This date marks the starting point of the most significant decline in the level of contagion for the entire period analyzed, reaching on average the index for the 2nd and 3rd quarter at a value of 22.28%.Finally in late 2014 begins a new growth of contagion among emerging countries, but more moderately than previously, and the index is situated to 30% of contagion in early 2015.

5.3. Net Directional Spillovers and Net Pairwise Return Spillovers

The next step of the analysis is to compute directional information. To this end, we calculate the *net directional return spillover* index, which is presented in Figure 4. This index will enable us to identify the net transmitters and receivers of contagion. In addition we compute the *net pairwise return spillovers* indices between two

[15]IMF: International Monetary Fund.

emerging CDS portfolios and consider the time evolution of the pair-wise relationships as shown in Figure 5.[16] Looking at Figures 4 and 5, we can see that contagion appear to have been present in all emerging CDS portfolios being giving and receiving ends of the credit risk net transmissions during the sample.

We observe that BRIC (P1) and CIVEST (P2) portfolios play a role of absolute net transmitters of contagion to all the portfolios due to the positive net directional spillover observed. They are credit risk net transmitters to all others emerging CDS portfolios during all the sample period. If we observe the net pairwise spillovers we could distinguish that BRIC (P1) portfolio are transmitter to all others with values higher than 3% except for CIVEST (P2) portfolio, however CIVEST (P2) is mostly transmitter only to Asian (P4) and Middle East Asian (P5).

Asian (P4), Middle East Asian (P5) and African (P7) portfolios present in general the opposite behavior. These three emerging portfolios are mostly credit risk receivers from all other portfolios with negative net directional spillovers. In this sense, we could observe that Middle East Asian (P5) portfolio has the highest receptor behavior, assuming credit risk from BRIC (P1), CIVEST (P2) and Eastern European (P3) portfolios. We also remark the transmission from American (P6) to African (P7) portfolio.

Finally, Eastern European (P3) and American (P6) emerging portfolios are transmitters and receivers of contagion depending on the evolution over time. Moreover, we observe a peak in all the net transmissions among portfolios in mid-2009 of 40% (except for American portfolio that is 20%) when the World Bank announces (June, 22) that the global production for 2009 would fall by 2.9%, the first decline since the Second World War.

6. CONCLUSIONS

Using emerging market CDS spreads as indicators of sovereign credit risk, this paper aims to identify the transmission mechanism of risk in emerging economies

[16]To summarize the main results, Figure 5 shows only the overall net pairwise return spillovers relationships. Graphs relating to the time evolution of *net pairwise return* indices are not presented to conserve space but are available upon request.

during 2004-2015. We define contagion as the change in the propagation mechanism when a shock occurs and we measure it in terms of return spillovers.

Firstly, we test initial signals of credit risk contagion between emerging markets using the correlation coefficients across markets. Secondly, following a GVAR model (Diebold and Yilmaz, 2012) we estimate contagion, in terms of return spillovers, between CDS portfolios. Moreover, we analyze the net directional and pairwise return spillover measures to identify portfolios that can be seen as net transmitters and receivers of credit risk contagion. Unlike the existing contagion studies that look at a combination of developed and emerging countries, we focus on emerging markets, given the significant growth that their credit market has experienced in last years and the serious consequences for some emerging countries during the global financial crisis.

The rolling correlation analysis shows that there is a significant amount of commonality in emerging CDS portfolios that can be seen as signals of contagion. The results are consistent with the idea that during periods of international financial crises, correlations between assets and markets are higher and this is a key element in the underestimation of risk in stress periods. We observe that the total contagion between the credit risk of the CDS portfolios vary over time and how the events occurred in advanced economies affect increasing credit risk transmission among emerging economies, in addition to the actions taken to help the advanced economies eventually also affect to emerging economies. Therefore, there is a high degree of relationship, in terms of credit risk transmission between both economies which primarily affects the advanced economies, subsequently transferred to emerging economies.

Furthermore, the results show that not all emerging economies have the same degree of credit risk transmission. BRIC and CIVEST portfolios are net transmitters of credit risk to all others emerging CDS portfolios during all the sample period. Asian, Middle East Asian and African portfolios present the opposite behavior. These portfolios are mostly credit risk receivers from all other portfolios. We observe that Middle East Asian portfolio has the highest receptor behavior, assuming credit risk from BRIC, CIVEST and Eastern European portfolios. Eastern European and American emerging portfolios are transmitters and receivers of contagion depending on the evolution over time.

An understanding of the dynamics of international risk transmission is key to regulators and policy makers who need put in place framework for the prevention of contagion in financial markets. Also, studies of the transmission of return and volatility shocks from one market to another as well as studies of the cross-market correlations are essential in finance, because they have many implications for international asset pricing and portfolio allocation. As an interesting further research, we propose to extend our paper analyzing the contagion effects of the same emerging economies CDS portfolios but distinguishing between the systematic and the idiosyncratic contagion. To do that, the idea is to follow the recent paper of Ballester *et al.* (2014) in order to see if the contagion effect is linked to global emerging factors (systematic contagion) or linked to emerging specific factors (idiosyncratic contagion).

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APPENDIX A. Recent literature review of contagion in the emerging market (2007-2015)

Paper	Sample	Methodology	Market	Objective	Results
Chiang *et al*.(2007)	1990-2003	Dynamic conditional-correlation (DCC) model	Stock markets 9 Asian countries	Analyze the correlation-coefficient of nine Asian daily stock-return data to measure the evidence of a contagion effect	The empirical evidence confirms a contagion effect. By analyzing the correlation-coefficient series, we identify two phases of the Asian crisis. The first shows an increase in correlation (contagion);the second shows a continued high correlation (herding). Statistical analysis of the correlation coefficients also finds a shift in variance during the crisis period, casting doubt on the benefit of international portfolio diversification. Evidence shows that international sovereign credit-rating agencies play a significant role in shaping the structure of dynamic correlations in the Asian markets.
Aloui *et al.* (2011)	2004-2009	Copula approach	Stock markets BRIC and US	Examine the extent of the current global crisis and the contagion effects by conductingan empirical investigation of the extreme financial interdependences of some selected emerging markets with the US.	Evidence of extreme co-movement for all market pairs both in bearish markets and bullish markets. The results suggest that dependency on the US is higher and more persistent for Brazil and Russia (commodity-price dependent countries), than for China and India whose economic growth is largely influenced by finished- products export-price levels. The extreme dependence between emerging market pairs is found to be generally smaller in bearish markets than in bullish markets, which might indicate a low probability of simultaneous crashes.
Samarakoon(2011)	2000-2009	VAR model	Stock markets 22 Emerging &40 frontier countries and US	Analyzethe transmission of shocks between the US and foreign markets to delineate interdependence from contagion of the US financial crisis by constructing shock models for partially overlapping and non-overlapping markets.	There exists important bi-directional, interdependence and contagion in emerging markets, with important regional variations. Interdependence is driven more by US shocks, while contagion is driven more by emerging market shocks. Frontier markets also exhibit interdependence and contagion to US shocks. There is no contagion from US to emerging markets (except for Latin America), but there iscontagion from emerging markets to the US.
Kenourgios&Padhi(2012)	1990-2007	Cointegration and vector error correction analysis	Stock and bond markets 9 Emerging countries and US	Investigate financial contagion of three emerging market crisesfocusing on financial markets of emerging and developed economies.	Long and short run dynamics only among emerging stock markets during the Russian and the Asian crises, for both stock and bond markets during the subprime crisis, while the Argentine turmoil has no impact on any of the examined markets. Evidence on the global impact of the Russian default, the contagion effects of the subprime crisis, the regional aspect of the Asian crisis and the isolated nature of the Argentine turmoil.
Celik(2012)	2005-2009	DCC-GARCH model	Exchange market 10 Emerging and 9 developed countries	Test the existence of financial contagion between foreign exchange markets of several emerging and developed countries during the U.S. subprime crisis.	Evidence of contagion during US subprime crisis for most of the developed and emerging countries. The analysis of the pattern of the conditional correlation coefficients provides no evidence in favor of contagion effects in foreign exchange markets of Japan, South Africa, Switzerland and Thailand. Emerging markets seem to be the most influenced by the contagion effects during US subprime crisis.
Tzeng&Tay(2014)	2003-2013	GARCH model	Stock markets 16 Emerging countries and US	Evaluate the transmission of shocks during the US subprime crisis and the European sovereign debt crisis to sixteen	The US stock market has a significant transmission effect on emerging markets at the early stage of the crises. The stock markets in emerging market tried to loosen their ties or reduce the connection with the Dow Jones after the bankruptcy of Lehman Brothers. Most emerging

				emerging markets.	markets also attempted to moderate the effects of the crises and loosened their relationship between their local currencies and stock markets.
Cho *et al.*(2014)	2005-2013	DCC model and GVAR	Asian sovereign CDS market	Investigate the interconnectedness and the contagion effect of default risk in CDS markets since the global financial crisis.	There are significant co-movements in Asian sovereign CDS markets; that such co-movements tend to be larger between developing countries than between developed and developing countries; and that in the co-movements intra-regional nature is stronger than inter-regional nature. They find evidence of contagion effects among six of them; Japan is the exception. In addition, we find that these six countries are affected more by cross-market spillovers than by their own-market spillovers.
Kang & Suh (2015)	2013-2014	Panel Fixed Effects Model and Granger Causality	Emerging CDS market	Examine whether emerging market financial turmoil in 2013–2014, caused mainly by the expectation of future US monetary policy tightening, created such spillover.	Emerging market financial instability reduces portfolio fund flows to advanced economies and increases their sovereign CDS premium. In addition, Granger causality network analysis indicates that the influence of emerging market economies in the global financial network significantly increased during the period of interest.

APPENDIX B. Timeline with selected key events.

This table shows the most important events, sorted by date, that have happened during the sample period from January 2004 to March 2015.

Event´s Date	Key Events
January, 2004	The Bital Bank and its branch network are renamed with the initials of its majority shareholder, HSBC UTD. Mexican States
April, 2004	Bulgaria, Slovakia, Slovenia, Lithuania and Romania are associated with NATO as full member.
May, 2004	Slovakia, Slovenia, Estonia, Hungary, Lithuania, Poland and Czech Rep joins the European Union
July, 2004	The government implemented aggressive reforms between 2004 and 2008 in order to attract foreign investment and stimulate growth
December, 2004	The South American Community of Nations is created
December, 2004	Venezuela and Cuba founded the ALBA
January, 2005	The Turkish lira was replaced by the new Turkish lira, eliminating national currency 6 zeros
December, 2005	The Central Bank of Brazil on the loan the IMF
June, 2006	The Colombia Stock Exchange suspended operations at 12:45 local time (17:45 GMT) by more than 10% decline and closed the day with losses 10.45%
July, 2006	Lebanon War 2006: Israel invades Lebanon without the approval of the international community under the pretext of rescuing two soldiers kidnapped by Hezbollah. During the invasion the city of Tyre, the ancient Phoenician port is destroyed.
July, 2006	The Mexican Stock Exchange recorded its second best year profit to rise 5.22%
August, 2007	Begins the global economic crisis.
November, 2007	Confirmation of existing fields in the Santos Basin
December, 2007	The wreck of the tanker Hebei Spirit Hong Kong Ocean poured over 10,000 tons of oil off the coast of natural Taeanhaean South Korea Park.
September, 2008	Quiebra el cuarto banco de inversiones del mundo, el estadounidense Lehman Brothers, con el mayor pasivo de la historia: 550.000 millones de dólares. Afecta a unas cien mil entidades financieras y desata el pánico ante la amenaza de un crash financiero mundial. El Banco Central Europeo y la Reserva Federal de los EE.UU. inyectaron liquidez en los mercados para contener las caídas bursátiles y el Bank of America amortiguo el caos con la compra del banco de inversión Merrill Lynch por 50.000 millones de dólares.
October, 2008	The House of Representatives of the US approves the bailout plan proposed by the Bush administration to combat the economic downturn. It is to invest 700,000 million from the Treasury Department to clean up bank balance sheets of "toxic" assets tainted by subprime mortgages
December, 2008	Bernard Madoff, former chairman of the Nasdaq technology market on Wall Street, has defrauded about 37,500 million Euros through a Hedgefund: Major financial swindle in history is discovered.
2008	Kazakhstan: Four major banks were bailed out by the government in late 2008
2009	Indonesia emerges as the fourth fastest growing G20 (grew at a rate of 5.8%)
2009	Creation of the South Bank, composed of seven Latin American countries,

	which include Argentina, Paraguay, Venezuela and Uruguay
January, 2009	The Turkish lira, again became the country's currency
February, 2009	Of Goyler & McNaughton, Netherland Sewell and Ryder Scott certified that the complex Chicontepecontien comparable to half of the reserves in Saudi Arabia reserves, which would put UTD. Mexican States in third countries with more oil reserves after Saudi Arabia and Canada
2nd quarter of 2009	The increase in commodity prices and demand, as well as fiscal and monetary stimulus began to support economic recovery.
May, 2009	In May 2009 United Nations report of a drop in foreign investment in the Arab World.
March, 2009	In March 2009 it was reported that, following the crisis, the Arab world lost three billion dollars
2009	Following the crisis, the World Bank predicted a tough year in 2009 in many countries árabes.24 Deteriorating economic conditions favored the emergence of mass protest movements in North Africa and the Middle East, particularly in Tunisia, Libya, Egypt and Syria. In the first three to traditional Western allies it was toppled autocratic governments.
April, 2009	The leaders of the 20 largest economies, meeting in London, decided to create a fund of a billion dollars to assist countries with the greatest difficulties to the crisis
September, 2009	It is reported that Arab banks have lost nearly $ 4 billion since the beginning of the global financial crisis
September, 2009	Argentina, Brazil, Paraguay, Uruguay and Venezuela: South Bank, composed of seven Latin American countries is.
January , 2010	Free trade area Ansa-China was founded and is the world's largest regional emerging market.
February , 2010	A Mw 8.2 earthquake that rocked northern Chile and generated a tsunami of 2.55m
May , 2010	First Greek bailout
October, 2010	Begins the "Arab Spring": Refers to a series of popular uprisings in Arab countries occurred from 2010 to the present. Countries like Tunisia, Morocco, Egypt
December, 2010	The Tunisian Revolution begins: Self immolation of Mohamed Bouazizi; protest demonstrations in the streets; nationwide protests; attacks on party offices in government and in some police stations.
December, 2010	The countries forming the BRIC portfolio be part of the IMF member countries
January, 2011	Fall of the government of Ben Ali.
January, 2011	After elections held Islamic government is overthrown court a military coup in 2013 was established
February , 2011	Immolations. The February 20 movement claims the King Mohamed VI "equality, social justice, employment, housing, education and higher wages."
August, 2011	The credit rating agency Standard & Poor's downgraded the credit rating of the United States.
August, 2011	Debt ceiling crisis in the United States: the Senate approved the agreement to raise the ceiling of public expenditure in the country, preventing the government from the first economic power in the world went into receivership
January , 2012	Begins the political crisis in Paraguay, 2012, also called by many critics, politicians and media: "Parliamentary Coup", that erupted following the politics trial of the president of Paraguay, Fernando Lugo, initiated by the Chamber of Deputies the same country. This parliamentary body accused the elected leader in 2008 for poor performance of functions. Subsequently, a majority of the Senate decided to remove him from office
October , 2012	Pemex reported that they had found two new large oil fields in the Gulf of UTD. Mexican States, specifically in Tamaulipas, Dechas reserves and ensure economic stability in oil for at least 30 years

May, 2013	Death of Venezuelan President Hugo Chavez
December , 2013	Argentina enters police crises especially in the interior, the coast and the Chaco due to wage claims by police, who one by one in all provinces adhere to the strike, leaving unobstructed urban areas, resulting in the invasion of spoilers, and an impromptu defense of citizens, opening a social crisis armed ending the lives of eighteen people.
2013	the injection of US$104.600 million to Mexico and Poland and US$6.200 million to Morocco from the IMF
June, 2014	The President of the European Central Bank Mario Draghi announced a plan to revive the European economy, weakening the euro against other currencies and deal with the risk of deflation. The favorable market response was immediate.
July, 2014	Russia's parliament condones 90% of the debt contracted with the former Union Cuba Soviética and amounting to 35,000 million. The remaining 10% will be dedicated to investments in the island.
September,2014	ECB President Mario Draghi announced a series of measures to eliminate the risk of deflation in the euro zone.

APPENDIX C. Generalized Vector Autoregressive (GVAR) model

The GVAR methodology developed by Diebold and Yilmaz (2009, 2012) consists of two steps. First, a stationary *N*-variable VAR(*p*) is considered:

$$CDS_t = \sum_{i=1}^{p} \phi_i \, CDS_{t-i} + \varepsilon_t \tag{C.1}$$

where$\varepsilon \sim (0, \Sigma)$ is a vector of independently and identically distributed disturbances and CDS_t denotes a $N = 7$ -variable vector of emerging CDS log-returns portfolios. To ease the analysis the model is written as the moving average representation $CDS_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i}$, where the $N \times N$ coefficient matrices are estimated by $A_i = \phi_1 A_{i-1} + \phi_2 A_{i-2} + \cdots + \phi_p A_{i-p}$, with A_0 being the identity matrix and $A_i = 0$ for $i < 0$.

In a second step, we calculate the variance decompositions. The variance shares defined as the fractions of the *H*-step-ahead error variances in forecasting x_i that are due to shocks to x_j, for $H = 1,2, \ldots$, are given by

$$\theta_{j \to i}^{G}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)}, \text{ for } i, j = 1,2, \ldots, N \tag{C.2}$$

whereσ_{jj} is the standard deviation of the error term for the j^{th} equation, i.e. the squared root of the diagonal elements of the variance-covariance matrix Σ and e_i is the vector with one as the i^{th} element and zeros otherwise. As the shocks to each variable are not orthogonalized, the row sum of the variance decomposition is not equal to 1. Thus, each entry of the variance decomposition matrix can be normalized by the row sum as

$$\tilde{\theta}_{j \to i}^{G}(H) = \frac{\theta_{j \to i}^{G}(H)}{\sum_{j=1}^{N} \theta_{j \to i}^{G}(H)} \times 100, \text{ for } i, j = 1,2, \ldots, N \tag{C.3}$$

where the multiplication by 100 is expressing the result in percentage terms. Note that, by construction $\sum_{j=1}^{N} \tilde{\theta}_{j \to i}^{G}(H) = 100$and $\sum_{i,j=1}^{N} \tilde{\theta}_{j \to i}^{G}(H) = N \times 100$.

Note that return spillovers show the degree of variation in CDS log-returns of portfolio *i* which is not due to the historical information of the CDS log-returns of portfolios *i* and *j* but to shocks (innovations) in CDS log-returns of portfolio *j*. This

indicator takes higher values as the intensity of the contagion effect, caused by the specific shocks of *j*'s CDS log-returns, increases. In the extreme case in which there are no spillovers from one series to the other, the indicator is equal to zero.

Using the above normalized variance contributions we can then construct some different spillover measures. The *total return spillover* index, which measures the contribution of spillovers of log-return shocks across all *N* series to the total forecast error variance is given by:

$$TS^{G} = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}^{G}_{j \to i}(H)}{N} \qquad \text{(C.4)}$$

It indicates on average the percentage of the forecast error variance in all the series that comes from spillovers (from contagion due to shocks).

The *net directional return spillover* indices measure the spillover transmitted by portfolio *i* to all others

$$NDS^{G}_{i \to all} = \sum_{\substack{j=1 \\ i \neq j}}^{N} \tilde{\theta}^{G}_{i \to j}(H) - \sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}^{G}_{j \to i}(H), \text{ for } i = 1,2,\dots,N \qquad \text{(C.5)}$$

This is the difference between the gross return shocks transmitted by *i*to all other portfolios and those received by *i* from all other portfolios. Positive (negative) values of the NDS index indicate that portfolio *i* is a transmitter (receiver) of return spillover effects, in net terms.

Finally, the *net pairwise return spillover* indices between series *i* and *j* are defined as

$$NPS^{G}_{i \to j} = \tilde{\theta}^{G}_{i \to j}(H) - \tilde{\theta}^{G}_{j \to i}(H), \text{ for } i,j = 1,2,\dots,N \qquad \text{(C.6)}$$

It is simply the difference between the gross return shocks transmitted from *i* to *j* and those transmitted from *j* to *i*. Hence, it is positive (negative) when the impact of *i*'s shocks is higher (lower) than vice versa, indicating that *i* is a net transmitter (receiver) of return spillovers to (from) *j*.

TABLE 1: Descriptive statistics of daily CDS spreads for all the countries and portfolios

This table presents the descriptive statistics for the sovereign CDS spreads for all the 45 emerging countries and 7 portfolios, expressed in basis points. The sample period is from January 1, 2004 to March 4, 2015.

Portfolio / Country	Obs.	Min.	Max.	Mean	Std. Dev.
Brazil	2,915	61.10	900.20	199.59	138.38
China	2,915	9.00	296.70	68.18	45.24
India	2,539	31.00	218.50	73.79	28.47
Russia	2,797	37.00	1,116.70	185.64	147.98
BRIC (P1)	2,915	35.53	546.40	138.55	79.58
Colombia	2,915	64.70	655.90	185.00	113.83
Egypt	2,181	68.50	843.54	356.76	196.92
Indonesia	2,717	91.40	1,256.70	215.04	125.76
South Africa	2,915	23.80	683.30	142.54	85.60
Turkey	1,671	109.82	835.01	212.69	86.47
Vietnam	2,624	51.90	982.90	235.83	112.38
CIVEST (P2)	2,915	62.16	851.75	217.37	92.99
Bulgaria	2,915	13.00	698.16	164.10	131.15
Czech Republic	2,912	4.30	350.00	60.20	54.39
Estonia	2,366	1.00	736.80	121.01	134.30
Hungary	2,915	9.20	729.89	204.43	170.68
Lithuania	2,543	1.00	849.90	178.07	160.13
Poland	2,915	6.80	417.58	91.32	79.61
Romania	2,915	17.20	780.78	199.93	149.30
Slovakia	2,912	4.00	306.01	71.83	71.36
Slovenia	2,915	3.80	488.58	114.33	123.97
Eastern Europe (P3)	2,915	10.63	540.96	130.06	105.95
Kazakhstan	2,490	33.30	1,646.32	220.61	206.99
Pakistan	2,712	146.20	5,105.70	782.05	624.49
Philippines	2,901	79.47	870.00	213.15	127.16
Malaysia	2,915	12.00	520.20	82.32	56.15
Thailand	2,915	24.00	524.20	96.45	58.10
South Korea	2,913	14.00	700.00	86.79	77.14
Sri Lanka	1,728	282.81	3,000.00	578.90	492.47
Asia (P4)	2,915	32.50	1,652.64	260.42	199.67
Bahrain	1,745	96.20	714.50	253.46	99.31
Israel	2,822	15.00	285.41	95.37	56.71
Lebanon	2,915	166.27	955.50	385.75	91.37
Qatar	2,885	7.80	379.60	75.09	55.80
Saudi Arabia	1,741	43.30	335.00	96.24	49.45

Middle East Asia (P5)	2,915	74.19	496.74	180.26	61.78
Argentina	2,758	1.50	4,961.65	1,035.10	1,025.47
Chile	2,915	4.50	315.00	69.33	49.04
Costa Rica	1,867	115.00	381.10	228.32	71.44
Dominican Republic	1,322	0.00	475.52	375.16	53.08
El Salvador	2,380	24.33	548.78	305.21	156.69
Guatemala	1,868	122.96	304.77	209.92	37.68
Mexico	2,915	28.70	606.70	115.95	68.71
Panama	2,915	61.90	613.80	152.04	78.61
Peru	2,835	59.90	611.20	160.71	89.00
Uruguay	1,782	120.82	264.00	165.64	27.97
Venezuela	2,823	118.67	8,588.31	938.62	933.81
America (P6)	2,915	65.50	1,066.99	324.01	190.43
Ghana	1,229	28.67	656.17	373.83	170.60
Morocco	1,884	70.00	500.00	190.42	59.26
Tunisia	2,915	17.96	455.10	173.36	118.46
Africa (P7)	2,915	17.96	409.59	177.48	120.15
Average	2,915	55.09	784.40	215.72	117.97

TABLE 2: Statistical test of daily CDS spreads for all the countries and portfolios

This table presents statistical tests for the sovereign CDS spreads for all the 45 emerging countries and 7 portfolios, expressed in basis points. Panel A shows the asymmetry test, excess kurtosis and Jarque-Bera normality. Panel B shows ADF and PP test for the unit root tests of Dickey and Fuller (1981) and Phillips and Perron (1988) for 10 lags. The sample period is from January 1, 2004 to March 4, 2015. ***, ** and *indicate significance at the level of 1%, 5% and 10% respectively.

	Panel A			Panel B	
Portfolio / Country	Skewness	Ex.Kurtosis	Jarque-Bera	ADF	PP
Brazil	0.47***	12.92***	20376.06***	-17.37***	-49.27***
China	1.02***	16.86***	35025.79***	-17.36***	-53.25***
India	-0.21***	6.52***	4519.76***	-14.85***	-45.85***
Russia	0.24***	58.00***	391967.22***	-16.60***	-53.81***
BRIC (P1)	0.59***	10.84***	14437.41***	-16.98***	-46.04***
Colombia	0.88***	18.99***	44146.56***	-17.19***	-48.25***
Egypt	1.13**	30.44***	84641.29***	-13.98***	-49.89***
Indonesia	0.74***	13.03***	19472.40***	-16.05***	-47.71***
South Africa	0.67***	14.09***	13945.72***	-16.30***	-36.24***
Turkey	-0.05	178.80***	3881790.38***	-17.11***	-68.17***
Vietnam	0.13***	550.82***	33158900.90***	-17.72***	-74.00***
CIVEST (P2)	1.28***	26.50***	86045.64***	-16.71***	-49.85***
Bulgaria	-0.18**	154.55***	2900156.47***	-16.15***	-62.22***
Czech Republic	0.20***	19.57***	46475.87***	-16.63***	-59.17***
Estonia	0.64***	214.18***	4520722.83***	-18.08***	-71.54***
Hungary	0.45***	22.27***	60305.79***	-17.12***	-50.97***
Lithuania	-0.79***	63.66***	429541.79***	-22.30***	-83.09***
Poland	0.82***	21.71***	57560.55***	-16.49***	-53.88***
Romania	0.28***	14.28***	24807.37***	-15.24***	-49.53***
Slovakia	0.17***	17.82***	38543.77***	-15.97***	-57.19***
Slovenia	-1.42***	72.43***	638000.82***	-18.80***	-74.29***
Eastern Europe (P3)	-0.52***	37.36***	169560.34***	-16.45***	-57.97***
Kazakhstan	0.67***	17.98***	33724.73***	-14.65***	-41.90***
Pakistan	-2.98***	107.24***	1303036.46***	-16.40***	-56.03***
Philippines	0.17***	9.68***	11338.85***	-17.67***	-50.63***
Malaysia	0.22***	10.36***	13043.56***	-17.97***	-51.03***
Thailand	-1.03***	40.84***	203052.39***	-17.96***	-53.89***
South Korea	0.20***	9.64***	11297.12***	-16.96***	-51.67***
Sri Lanka	3.89***	286.66***	5917283.66***	-15.60***	-44.71***
Asia (P4)	13.67***	491.32***	29399763.62***	-15.80***	-52.37***

Bahrain	1.76***	32.74***	78775.45***	-12.35***	-42.03***
Israel	0.56***	15.94***	30018.91***	-18.27***	-53.10***
Lebanon	0.11**	48.89***	290271.70***	-16.82***	-67.65***
Qatar	0.30***	102.27***	1256904.18***	-18.50***	-53.46***
Saudi Arabia	5.45***	93.44***	641653.28***	-11.94***	-44.32***
Middle East Asia (P5)	-0.78***	48.55***	286512.72***	-15.17***	-60.43***
Argentina	-1.83***	107.99***	1341291.67***	-23.06***	-73.95***
Chile	1.47***	315.70***	12102101.04***	-17.15***	-55.43***
Costa Rica	-3.89***	116.67***	1062957.33***	-14.04***	-47.93***
Dominican Republic	0.51***	25.52***	35847.65***	-11.18***	-38.58***
El Salvador	3.77***	92.59***	855393.41***	-16.17***	-57.59***
Guatemala	-0.42***	28.34***	62544.15***	-16.64***	-44.97***
Mexico	0.86***	21.54***	56672.22***	-16.99***	-50.68***
Panama	0.61***	16.01***	31286.08***	-16.21***	-52.34***
Peru	0.75***	18.89***	42397.68***	-16.35***	-47.06***
Uruguay	0.24***	20.21***	30322.32***	-14.62***	-60.10***
Venezuela	0.70***	783.66***	72211090.17***	-17.19***	-79.99***
America (P6)	1.13***	63.85***	495540.51***	-15.72***	-52.24***
Ghana	11.93***	429.36***	9461493.75***	-10.51***	-35.04***
Morocco	5.82***	228.75***	4116185.80***	-13.32***	-42.97***
Tunisia	-0.09*	69.00***	578086.45***	-21.89***	-84.26***
Africa (P7)	0.03	72.30***	634732.45***	-21.24***	-80.76***

FIGURE 1: Daily time evolution of CDS spreads

This figure represents the daily time evolution of the emerging market average CDS spreads (Panel A), calculated as the average CDS spreads of all 45 emerging countries, and the daily time evolution of the 7 portfolios' CDS spreads (Panel B), calculated as average of all emerging countries' CDS spreads that are included in the same portfolio. The sample period is from January 1, 2004 to March 4, 2015.

Panel A: Emerging market Average CDS spreads

Panel B: Emerging portfolios CDS spreads

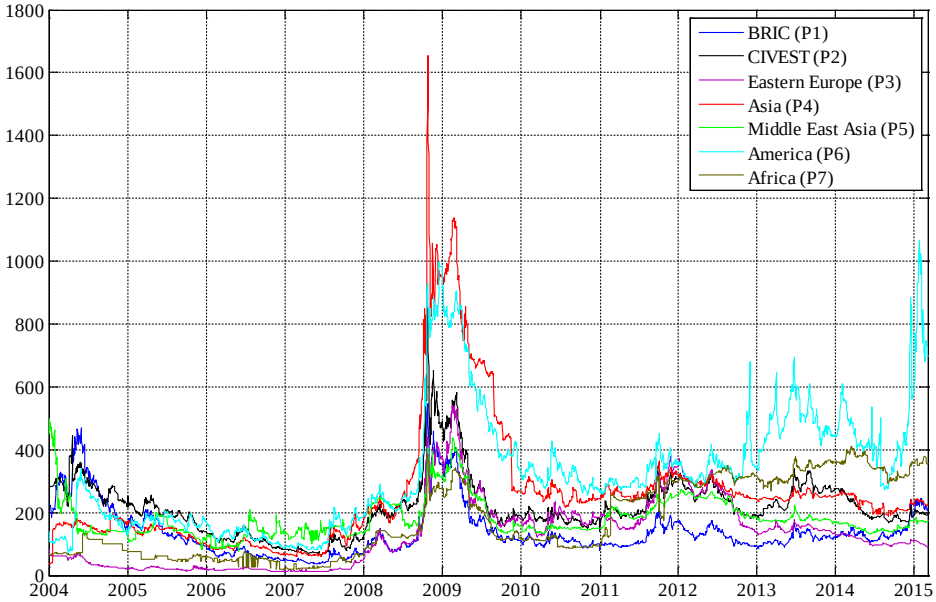
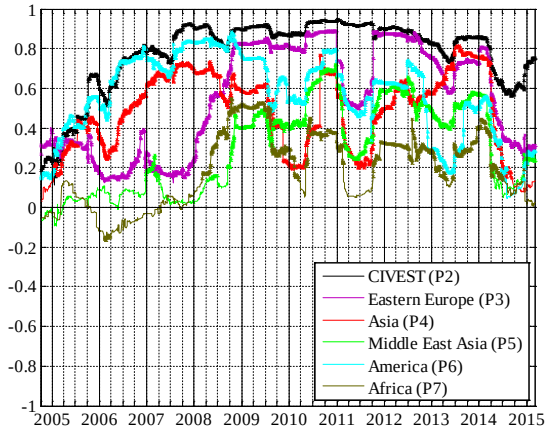


FIGURE 2: Daily time evolution of the correlation coefficient

This figure represents the daily time evolution correlation coefficient of the 7 emerging portfolios' CDS spreads, using 200-day rolling windows. The sample period is from January 1, 2004 to March 4, 2015. The correlation coefficient are highlight when the coefficient is statistically significant at 5%.

Panel A: BRIC (P1) Panel B: CIVEST (P2)



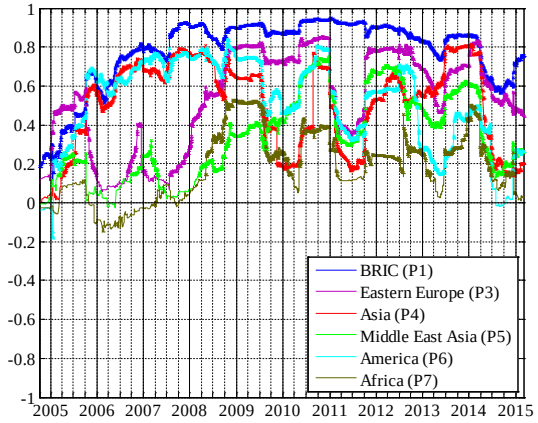
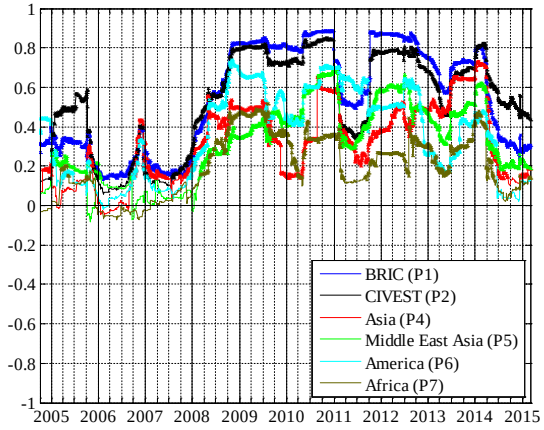
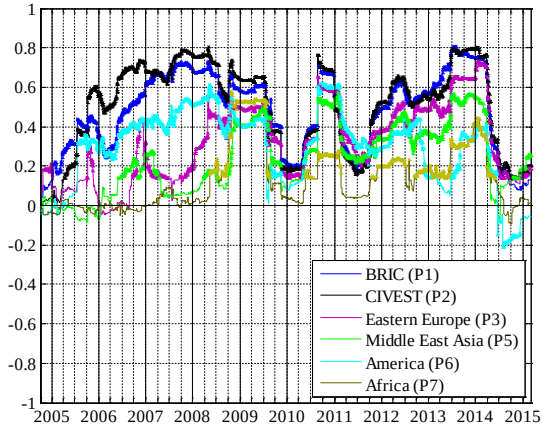


FIGURE 2 (*continued)*

Panel C: Eastern Europe (P3)

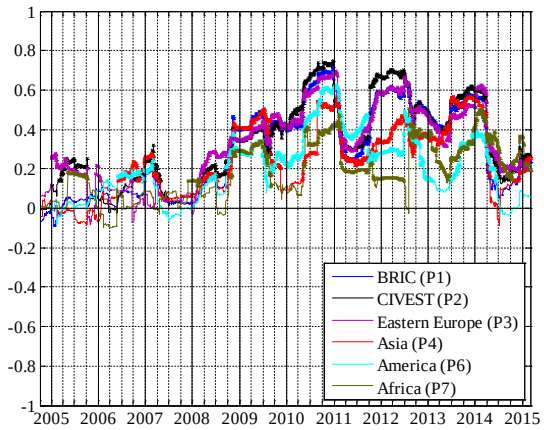
Panel D: Asia (P4)

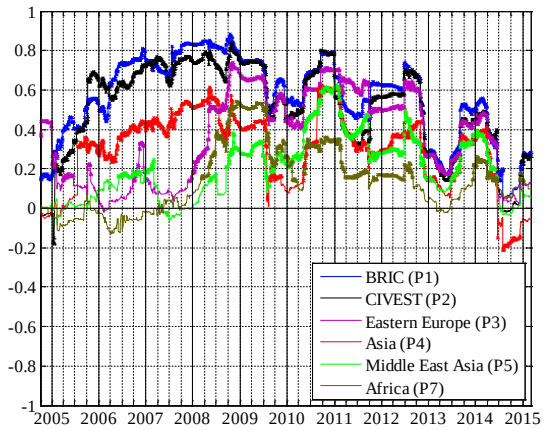




Panel E: Middle East Asia (P5)

Panel F: America (P6)





Panel G: Africa (P7)

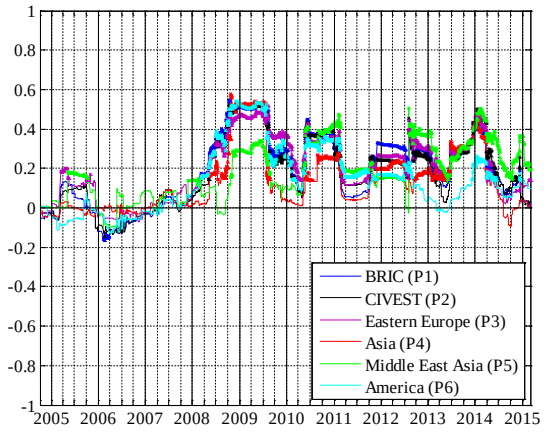


FIGURE 3: Total return spillover index

This figure reports the time evolution of the *total return spillover* index for the 7 emerging portfolios' CDS spreads. It measures on average the percentage of the forecast error variance in all the portfolios series that comes from contagion due to shocks. The sample period is January 2004 to March 2015, but the index starts on October 2004 since a 200-day rolling window is used to get the evolution over time.

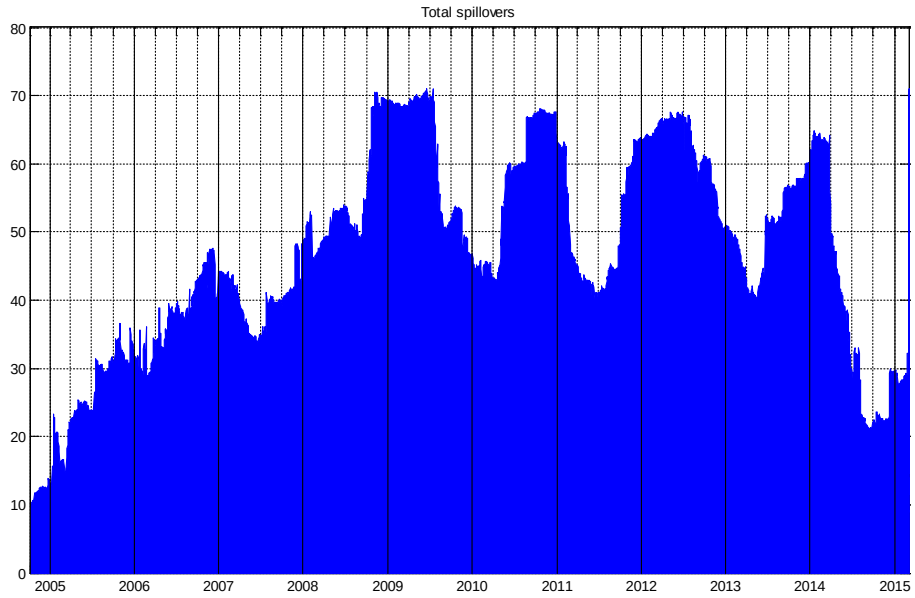
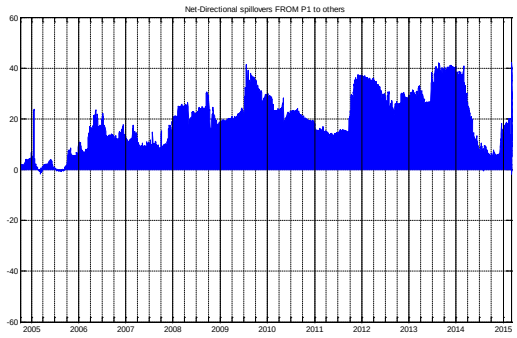


FIGURE 4: Net directional return spillover indices

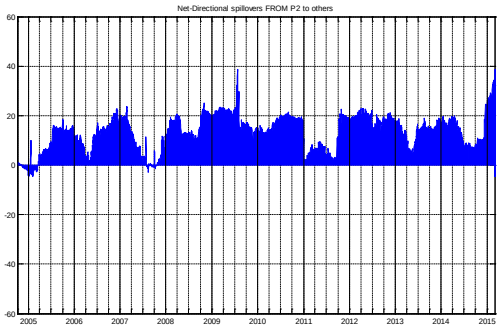
This figure reports the time evolution of the *net directional return spillover* indices for the 7 emerging portfolios' CDS spreads. They measure the spillover due to shocks (in percentage terms) transmitted by each portfolio to all others. Positive (negative) values indicate that the corresponding portfolio is in net terms a transmitter

(receiver) of return spillover effects to all others. The sample period is January 2004 to March 2015, but the index starts on October 2004 since a 200-day rolling window is used to get the evolution over time.

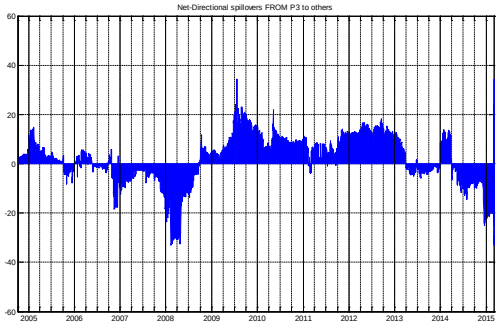
Panel A: BRIC (P1)



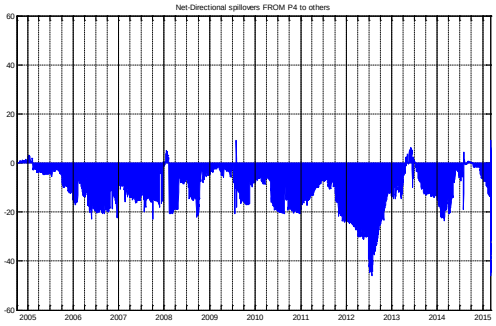
Panel B: CIVEST (P2)



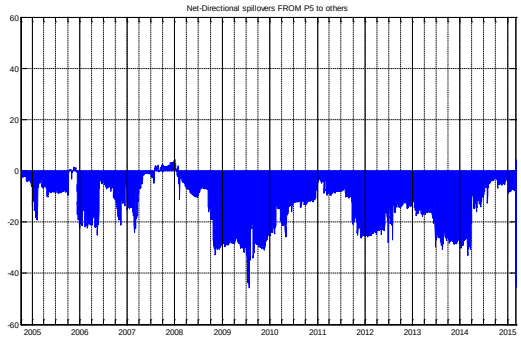
Panel C: Eastern Europe (P3)



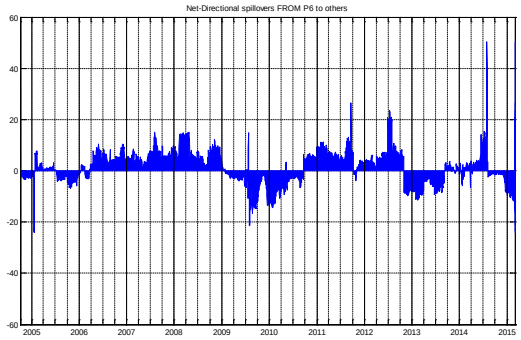
Panel D: Asia (P4)



Panel E: Middle East Asia (P5)



Panel F: America (P6)



Panel G: Africa (P7)

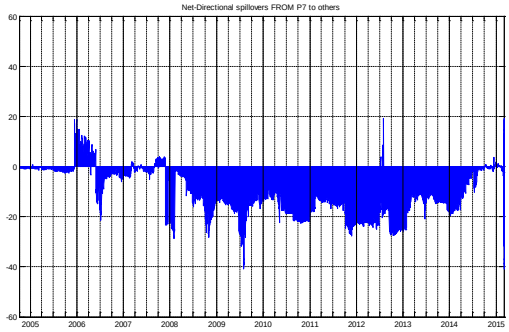


FIGURE 5: Credit risk contagion relation among portfolios

This figure reports the time evolution of the *net pairwise return spillover indices* relationships for the 7 emerging portfolios' CDS spreads. They measure the net spillover due to shocks (in percentage terms) transmitted between each pair of portfolios. Arrows indicate the level and direction of contagion: the fattest arrows indicate further contagion, the dashed arrows indicate that portfolios act as transmitters and receivers of risk for some period.