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The anatomy of sovereign risk contagion

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Abstract

We analyze the channels for the cross-border propagation of sovereign risk in the international sovereign debt market. Identifying sovereign credit events as extraordinary jumps in CDS spreads, we distinguish between the immediate effects of such events and their longer term spillover effects. To analyze "fast and furious" contagion, we use daily CDS data to conduct event studies around a total of 89 identified credit events in a global country sample. To analyze "slow-burn" spillover effects, we apply a multifactor risk model, distinguishing between global and regional risk factors. We find that "fast and furious" contagion has been primarily a regional phenomenon, while "slow-burn" spillover effects can often be global in scope, especially the effects of the recent European debt crisis. The global risk factors are driven by investor risk appetites and debt levels, while the regional factors depend on economic fundamentals of countries within a region.

JEL: G15, F30, F31

Keywords: sovereign risk, credit event, contagion, spillover, credit default swap, debt crisis

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1. Introduction

The recent U.S. subprime crisis and the subsequent European sovereign debt crisis have had adverse consequences for sovereign borrowers around the world. Spreads on credit default swaps (CDS) written on sovereign names rose sharply and simultaneously, especially at the time of the Lehman default in September 2008 and again during the height of the Eurozone debt crisis in late 2011. This study seeks to examine the risk transmission mechanisms by which such credit crises spread to sovereign borrowers around the world. To do so, we distinguish between the "fast-and-furious" contagion mechanism and the "slow-burn" risk spillover mechanism, to use the adjectives applied by Kaminsky, Reinhart and Vegh (2003) to contagion and protracted spillover effects.

The literature distinguishes between two types of cross-border propagation of financial crises which are consistent with these two risk transmission mechanisms. Forbes and Rigobon (2002) see a contagion mechanism in which the realization of a shock to one country triggers a cascade of adverse reactions in other countries. Alternatively, Adrian and Brunnermeir (2011) and Ang and Longstaff (2013) amongst others focus on the contemporaneous effects across countries in response to major common shocks which lead to systemic risks. Bekaert et al. (2014) associate both mechanisms with financial crises. In this paper we examine both of these channels, using sovereign credit events to analyze the contagion channel and factor analysis to analyze the common shock channel. The latter leads to a risk spillover interpretation as we show that common risk factors load significantly on country-specific sovereign credit events and the effects were magnified during the European Sovereign Debt Crisis.

The growing empirical literature on the determinants of sovereign credit spreads suggests that after controlling for common global shocks, sovereign default risk is related to country

fundamentals (Hilscher and Nosbusch, 2010; Chiarella et al., 2015). It has been recognized that adverse economic fundamentals in individual countries have played a significant role during the European sovereign debt crisis (Caceres et al., 2010; Arghyrou and Kontonikas, 2012; Mink and De Haan, 2013) and this has been referred to as "wake up calls" or fundamental contagion. However, recent research also supports a role for regional contagion or cross-country links that are somewhat divorced from country-specific fundamentals. Such contagion seems to stem in part from correlated investor sentiment across the Eurozone (Beirne and Fratzscher, 2013; Beetsma et al., 2013; Chiarella et al., 2015; De Grauwe and Ji, 2013). Aizenman, Hutchison and Jinjarak (2013), De Grauwe and Ji (2013) and Fuertes, Kalotychou and Saka (2015) show that in 2010 Eurozone periphery CDS spreads were higher than those of non-Euro countries with similar fundamentals, suggesting a role for contagious pessimism and self-fulfilling dynamics of panic and fear leading to the European sovereign debt crisis. Aizenman, Hutchison and Jinjarak (2013) provides as an alternative explanation based on the effect of expectations on future fundamentals, which were expected to worsen due to the adjustment challenges faced. In another vein, Dieckmann and Plank (2012) and Brutti and Saure (2015) document risk transfers due to the exposures of national banking sectors to bad credit stemming from the US sub-prime and European sovereign debt sectors and the widespread expectation of government bailouts across multiple countries.

A parallel literature argues that sovereign credit spreads exhibit a strong degree of commonality that is unrelated to correlations in fundamentals. Instead the commonality can be traced to global financial market factors (for example, Ang and Longstaff, 2013; Geyer, Kossmeier and Pichler, 2004; Longstaff et al., 2011; Dieckmann and Plank, 2012; Mauro, Sussman and Yafeh, 2002). In particular, Longstaff et al. (2011) show that sovereign CDS spreads are explained and predicted by US equity returns, equity market implied volatilities and bond market risk premia. Remolona, Scatigna and Wu (2008) and Chiarella et al. (2015)

decompose the pricing of sovereign CDS contracts into what is attributed to fundamentals and what is due to non-fundamental forces like investor risk aversion and price momentum, with the latter components consistently accounting for the larger part of CDS spreads. Nonetheless, much of the focus in the literature has been on finding the determinants that explain credit spreads at the country level but not on the common pricing kernel for sovereign credit risks.

Our study speaks to the literature on cross-border sovereign risk propagation by exploring both the time dimension and the cross-country dimension of this phenomenon. We investigate the time dimension by distinguishing between "fast-and-furious" contagion and the subsequent "slow-burn" spillover effects that are found to arise from increasing common risks. We explore the cross-country dimension by distinguishing between regional risk propagation and global risk propagation. Furthermore, we investigate the driving forces behind these two major risk transmission channels in the international sovereign debt market.

To this end, we first use an event study approach to investigate the immediate impact of important sovereign credit events on other sovereign borrowers as reflected in extraordinary jumps in CDS spreads.[1] This immediate impact is what we call "fast-and-furious" contagion.[2] We specifically examine the geographical reach of such contagion over our sample period. Does it tend to be contained within the region where the shock first occurs or does it often have widespread global consequences?

[1] In recent work on measuring systemic risk within financial systems, Rodriguez-Moreno and Peria (2013) compare two groups of macro-based and micro-based measures and for both groups they find that measures based on market-determined credit default swap (CDS) spreads performed better and are more straightforward to use than alternative measures.

[2] There is a vast literature linking the financial crises that occurred in the 1990s and early 2000s to past episodes of financial contagion. See for example, Bae, Karolyi and Stulz (2003), Forbes and Rigobon (2002), Kaminsky and Reinhart (2000) and Kaminsky, Reinhart and Vegh (2003).

Second, we extract multiple global sovereign risk factors from the variance structure of CDS spread movements and estimate a multi-factor pricing model for our sample of 67 sovereign borrowers from five geographical regions around the world. The effect of credit events on individual sovereign spreads through the common global risk factors and regional risk factors is what we collectively interpret as "slow-burn" risk spillover effects. According to Kaminsky, Reinhart and Vegh (2003), these credit events pose shocks that may have gradual and protracted manifestations in the build-up of shared risks that could cumulatively impose major economic consequences. It is important to have an improved understanding of these risk transmission channels underpinning sovereign credit contagion.

Our analytical framework facilitates the testing of three related hypotheses. First, we hypothesise that contagion in the international sovereign debt market has an important geographical bias in that the effects are significantly more intense within regions than globally. This explains why De Grauwe and Ji (2013) find geographic clustering in spread changes that cannot be fully explained by fundamentals. The second hypothesis is that these region-specific episodes of sovereign credit contagion serve to gradually heighten global and regional risks. Third, these risk spillover effects can be reinforced by deteriorating economic fundamentals and/or global financial market forces.

Using a global sample of daily sovereign CDS spreads over 2002 to 2013, we find strong evidence of intra-regional credit contagion stemming from specific sovereign credit events. Occasionally credit events do lead to global contagion but "fast and furious" contagion appears to be by and large, a regional phenomenon. We find these episodes of regional contagion to be concentrated during 2002-2003 in Latin America with the onset of the Argentinian debt crisis and at the height of the more recent Eurozone sovereign debt crisis. The common global risk factors all increased progressively leading up to the European debt

crisis coinciding with the increased sovereign credit contagion. This is consistent with a mechanism for global spillover effects or common clustering of shocks, which escalates systematic sovereign credit risk.

We find that the global risk factors are predominantly driven by variables that tend to reflect global investor risk appetites and global indebtedness. On the other hand, the regional risk factors depend more on the fundamentals of all countries within the region. A deterioration in economic fundamentals captured by rising debt to GDP levels and downgrades in sovereign credit ratings increase regional sovereign credit risks.

The remainder of the paper is organized as follows. Section 2 describes the sovereign CDS data used. Section 3 introduces our methodological framework whilst Section 4 discusses the nature of sovereign credit contagion. Finally, Section 5 provides concluding remarks and some policy implications.

2. Data

The credit default swap (CDS) data used in this study are sourced from the Markit database.[3] Specifically, they are daily closing CDS spreads (ask prices) on five-year CDS contracts for 67 sovereign borrowers in five geographical regions. We use CDS spreads from the 5-year maturity segment as this is deemed to be the most actively traded of all maturities (Pan and Singleton, 2008). The sample of sovereigns is shown in Appendix Table A. All spreads are expressed in basis points and are notionally denominated in US dollars. The period studied spans January 2002 to March 2013, providing a maximum of 173490 country-day observations. This is the longest time period for which we have CDS data for a large cross-

[3] Markit provides the longest history and best country coverage for sovereign CDS spreads. Another data source for sovereign CDS spreads is Thomson Reuters but these are available for a much shorter time period. We find a large correspondence in the brief time period over which the two data sources overlap.

section of countries. According to the International Swaps and Derivatives Association (ISDA, 2013), the top 9 gross positions held in the CDS markets amounted to US$12.5 trillion, and were all referenced on sovereign names, with four of them coming from the European Union (Italy, Spain, France, Germany).

In Table 1, Panel A reports the summary statistics for the daily spreads, whilst Panel B reports the same for daily changes in spreads. In Panel A, the average spreads over the sample period vary widely across sovereign obligors. These averages range from 379 basis points (bps) for Latin America (LA), 197 bps for Middle East and North Africa (MENA), 172 bps for Eastern Europe (EEU), 152 bps for the Asia-Pacific (AP) and 110 bps for the rest of Europe (EU). Latin America has the highest mean and standard deviation of spreads (728 bps) reflecting the chequered debt history of this region and especially the effects of the Argentinean debt crises in the 1990s and early 2000s. On the other hand, continental Europe exhibits the narrowest average daily spreads for the entire sample period. The standard deviation in European CDS spreads of 471 bps shows considerable volatility but this is mainly due to the turmoil in the last few years of the sample period.

For investment horizons that are shorter than maturity, returns to CDS contracts are proportional to changes in spreads (but with the opposite sign). Hence, our analysis will be based largely on these spread changes. When it comes to daily changes in spreads, the full-sample averages are small. Panel B shows a relatively large average for Western Europe, with a mean daily spread change of 0.56 bps, indicating a valuation loss. These spread changes however, have been quite volatile, with a standard deviation of 60.68 bps. The Asia-Pacific and MENA regions saw small average daily reductions in spreads and experienced relatively low volatility in spread changes (with standard deviations of 16.64 and 9.31 bps, respectively). Eastern Europe experienced a mean spread increase of 0.0054 bps but the

volatility has been relatively low with a standard deviation of 14.86 bps. At the lower tail of the return distribution, exposures to sovereign borrowers in Latin America have suffered the heaviest losses, with a CDS spread change of 254.49 bps at the 99.9% quantile. This reflected the disruptive Argentinian crisis in 2002. The second largest losses at the 99.9% quantile has been experienced in Western Europe with a CDS spread change of 227.68 bps. The smallest tail loss has been for Eastern Europe, with a spread change of 106.6 bps at the 99.9% quantile.

[Insert Table 1 here]

3. Empirical Methodology

Our empirical analysis of systemic risk in the international sovereign debt market is divided into two main parts. The first part focuses on measuring the geographical extent of "fast-and-furious" contagion and determining whether it tends to be regional or global in nature. The second part focuses on measuring "slow-burn" global spillover effects.

3.1 Measuring "fast-and-furious" contagion

We measure the geographical extent of contagion using an event study approach. First, we identify sovereign credit events in each of our five geographical regions (outside of North America).[4] We follow the approach of Jorion and Zhang (2007), who measure contagion in the US corporate debt market by relying on extreme jumps in CDS spreads to identify credit events. In our case, we define a regional sovereign credit event as the case where

$$\Delta S_{it} \geq k \qquad (1)$$

[4] We do not investigate sovereign credit events emanating in the U.S. as our period of analysis includes the Global Financial Crisis (GFC) and the inclusion of these credit events are likely to bias our findings on systemic sovereign risks.

where ΔS_{it} is the one-day change in the CDS spread for sovereign *i* from day *t-1* to day *t*, and the threshold *k* is the 99.9% region-specific upper quantile of the historical daily sovereign CDS spread change distribution reported in Table 1. We detect extreme sovereign CDS spread movements relative to other countries in the region as there are large variations in the magnitude of jumps at the 99.9 percentile observed across regions in Table 1. For this reason, we do not use global nor arbitrary region-specific thresholds to detect credit events. This strategy is also consistent with past financial crises being largely regional in scope and contained in East Asia, Latin America and more recently Europe. To pinpoint the exact onset of a given credit event, all consecutive events within each region are identified but only the first observation within a 5-trading-day window is kept. This approach identifies 89 credit events, arising from 20 individual countries over the 2002-2013 sample period.

Having identified the events, we construct for each event two sovereign credit portfolios, a regional portfolio and a global one. The regional portfolio is an equally weighted portfolio of CDS contracts for all the sovereign borrowers in the region in which the event took place (excluding the event country). The global portfolio is an equally weighted portfolio of CDS contracts for the United States and all the other sovereign borrowers in the four regions outside the one in which the event took place. We then measure CDS portfolio returns for various narrow time windows around each event. We look at the one-day return on each portfolio for each day starting with the second day before the event and ending with the second day after the event and also multi-day cumulative portfolio returns within this 5-day window of each credit event.

In the case of the regional portfolio, for each day *t* in the event window [t_1, t_2] we construct the cross-sectional Average CDS Spread Change Index (*ACDXC*) as

$$ACDXC_t = \frac{1}{N}\sum_{i=1}^{N} CDXC_{it} \qquad (2)$$

where *CDXC* is the change in the regional CDS portfolio spread and N = 89 credit events. We then compute the Cumulative Average *CDXC* (*CACDXC*) over the event window as

$$CACDXC[t_1, t_2] = \sum_{t_1}^{t_2} ACDXC_t \qquad (3)$$

In order to circumvent biases in the variance estimation caused by ignoring cross-section-dependence we adopt the portfolio time series approach advocated by Brown and Warner (1980). Thus, we control for cross-sectional dependence induced by possible event clustering by computing the variance of the average CDS spread change across events, $Var(ACDXC_0)$, over the 60-day pre-event window [-70, -11]. In this framework, the event-day corrected (for cross-sectional dependence) *t*-statistic is

$$\frac{ACDXC_t}{\sqrt{Var(ACDXC_0)}}, \qquad t = -2,\ldots,0\ldots,2 \qquad (4)$$

and the corresponding *t*-statistic for the Cumulative Average *CDXC* over [t_1, t_2] is

$$\frac{CACDXC[t_1,t_2]}{\sqrt{(t_2-t_1+1)Var(ACDXC_0)}} \qquad (5)$$

Similarly, to assess the international reach of regional sovereign credit events we evaluate of the effects on the global portfolio around each sovereign credit event by conducting the above calculation using changes in CDS spreads for the United States and for other sovereign borrowers in regions outside that of the credit event. We also report measures of regional responses that are adjusted for global credit risk levels by computing the risk-adjusted spread change of each sovereign in excess of spread changes in the global CDS portfolio (as defined for the global contagion analysis).

3.2 Measuring "slow-burn" spillover effects

The second part of our analysis focuses on measuring spillover effects across international debt markets. We first extract multiple underlying common global risk factors based on a

generalized principal component analysis (PCA) of the panel of sovereign CDS spreads.[5] Then we estimate a multifactor asset pricing model for the whole cross-section of sovereigns in our sample and treat the residuals as country-specific idiosyncratic risks. These country-specific risks are those that are not explained by the global risk factors. Hence, we compute the equally-weighted averages of these country-specific risks for sample countries within regional portfolios to generate the regional risk factors. Within a regional portfolio, the country-specific risks are diversified away, leaving only the common region-specific risk component.

Our approach captures the main sources of common global risks in the international sovereign debt market as well as the sources of region-specific risks. This allows us to consider whether sovereign credit events load on and thus works to affect the multiple global risk factors or regional risk factor driving spread changes. An analysis of the global and regional risk factors underpinning spread movements provides a different perspective on the commonalities in the dynamics of sovereign CDS spreads compared to the systemic risk measure based on default intensities implied from a term structure of sovereign CDS spreads (Ang and Longstaff, 2013). The advantage of our factor-based approach is that it is not benchmarked on individual major world economies like the U.S. and Germany and provide a more comprehensive picture on the different sources of risk within the global sovereign credit market over time. This allows us to assess the specific risk channels through which sovereign credit events affect multiple countries during episodes of sovereign credit contagion.

To extract the global risk factors, we follow the dynamic factor approach proposed by Forni et al. (2005) to perform a generalized principal component analysis (GPCA). This approach allows us to explicitly account for the cross-sectional correlations between individual

[5] See Forni et al. (2005) for further details on the generalized PCA implemented. The generalized PCA cannot handle missing observations so when CDS spreads are missing due to infrequent trading we assume that the spreads stay constant until the next reported spread.

countries' sovereign CDS spread movements. Our core sample for extracting global risk factors following this approach consists of CDS spreads for 19 sovereign obligors - Brazil, Colombia, Mexico, Venezuela, Austria, Belgium, Spain, Italy, Turkey, China, Philippines, Russia, Thailand, Bulgaria, Poland, Qatar, Japan, Malaysia and Croatia. These countries have the longest time history of sovereign CDS spreads and are representative of the developed and emerging markets across the main geographical regions in the world with the exception of North America.[6] As in Forni et al. (2005), we estimate the covariance matrices of common and idiosyncratic components. The eigenvalues are calculated based on a frequency domain principal component which allows for efficient aggregation of the variables and minimization of idiosyncratic errors. The eigenvalues from our initial GPCA are illustrated in Figure 1. It can be seen that the first ten principal components explain 96.1% of the total variation in daily sovereign CDS spreads, with the first component alone explaining 43.9% of these variations.[7] This analysis supports the use of a multifactor asset pricing framework for explaining co-movements in sovereign CDS spreads. We interpret these principal components as the set of common global sovereign risk factors that are priced into sovereign CDS spreads.

[Insert Figure 1 here]

Hence, we regress the ten multiple global sovereign risk factors extracted as principal components onto individual sovereign CDS spread changes as follows:[8]

[6] We do not include the United States in this core group from which we extract generalized principal components as sovereign CDS data was not available consistently for the US until the beginning of 2008.

[7] This is comparable with the PCA performed by Longstaff et al. (2011) from which they found the first principal component (PC) of monthly sovereign CDS spread changes could account for 31.7% of the spread variations over the years from 2000-2007. Our generalized PCA is performed at a higher (daily) frequency and accounts for a larger proportion of the total spread variations.

[8] This multifactor asset pricing framework is similar to that used by Pukthuanthong and Roll (2009) in their global stock market integration study. They also used the first ten principal components, which they found to be sufficient to explain approximately 90% of the total variations in all country stock returns.

$$\Delta S_{i,t} = \sum_{m=1}^{10} \beta_{i,m} PC_{m,t} + \varepsilon_{i,t} \quad (6)$$

where ΔS_{it} represents the change in country *i*'s sovereign CDS spread between day *t*-1 and day *t* and $PC_{m,t}$ represents the m^{th} principal component for day *t* estimated from the panel of sovereign CDS spread changes on day *t*-1.

Market reactions observed during the European sovereign debt crisis suggest that international sovereign debt markets have become more closely interconnected on a regional as well as global scale. The revelation of budgetary problems in Greece in late 2009 and subsequent revelations in neighbouring countries in Southern Europe reverberated throughout all European debt markets (Beirne and Fratzscher, 2013; Kalbaska and Gatkowski, 2012). Hence, we also account for regional risk to aid our investigation into global credit risk spillovers.

Our *regional* risk factor is computed by taking the cross-sectional average of the estimated residuals obtained from equation (6) for countries within specific regions:

$$Region_Risk_{j,t} = \frac{1}{N} \sum_{i=1}^{N} \varepsilon_{i,t} \quad (7)$$

where $Region_Risk_{j,t}$ is the regional sovereign risk factor for all countries $i = 1,\ldots, N$ within a given geographical region $j \in \{LA, EU, EEU, MENA, AP\}$ at time *t*.

3.2.1 Determinants of global and regional spillovers

In the final part of our empirical analyses, we explore the mechanisms behind the global and regional spillover of sovereign credit risk by looking separately at the behaviour of: 1) the individual global sovereign risk factors and 2) the regional risk factors. Since there are a large number of variables that could be potentially related to sovereign credit risk, we rely on prior research on sovereign credit risk to narrow down our selection of determinants (Ang and

Longstaff, 2013; Longstaff et al., 2011). We focus on a parsimonious set of financial variables and economic fundamentals for explaining separately the two underlying risk channels through which sovereign credit risk can spread to multiple countries. These variables are described below.

The time series regressions that we estimate are of the form:

$$SovRisk_Channel_t = \alpha + \Gamma Creditevent_t + XControls_t + \varepsilon_t \quad (8)$$

where Sov*Risk_Channel*$_t$ is either one of the global sovereign risk factors {PC1, PC2..PC4, PC5} or the regional risk factors (*Region_Risk*). *Creditevent*$_t$ is a matrix comprising indicators for either all credit events or region-specific credit events detected and their interactions with an *EU_Crisis* dummy. The dummy takes a value of 1 from 2009 and 0 before to capture the specific effects of the European sovereign debt crisis, which is dated based on the sequence of events detailed in BIS (2011) in the lead up to that crisis. *Controls*$_t$ is a matrix of global market-based and country fundamentals-based explanatory variables. However, only the latter are used to explain regional sovereign risks given that global financial market forces are by definition more relevant for global sovereign risks.

In our set of global market variables, we have the following: returns on the S&P 500 stock market index (Stock_return) which serves as a broad indicator on global financial conditions; the change in the VIX, the implied volatility index on the S&P 500 (VIX), serves as a proxy for global risk appetite; and the CDX North American Investment Grade index of CDS spreads (Corp_Sprds) is included to capture corporate credit conditions. These global financial market variables have been shown to account for much of the commonalities in sovereign CDS spread movements internationally (Ang and Longstaff (2013) and Longstaff et al. (2011)).

For the set of economic fundamentals, we focus on two variables that indicate the ability of a sovereign to service and repay its foreign debt. Our first variable is based on sovereign credit ratings assigned by the three major international credit rating agencies – Standard and Poors, Moodys Investor Services and Fitch Ratings – and we take the average changes in sovereign ratings across rating agencies (Sov_rating_chg). The sovereign credit ratings on long-term sovereign debt denominated in foreign currencies are first converted into linear scores following the approach of Gande and Parsley (2005). Ismailescu and Kazemi (2010) previously documented that sovereign CDS spreads react significantly to changes in sovereign credit ratings. For our second variable, we consider the ratio of Debt to GDP (Debt_GDP) to account for the relationship between a country's level of indebtedness relative to the size of its economy and its ability to service its financial obligations (Reinhart and Rogoff, 2010). When we conduct the risk spillover analysis at the regional level using time series regressions, we take the average of the above variables across all countries within each regional group. However, to assess the global risk spillovers we take averages of these country-specific variables across all countries in our global sample.

Lastly, we construct a variable of special interest. This variable is a credit event indicator (Reg_creditevent) that takes a value of one when there is a regional sovereign credit event as defined by equation (1). Our a priori assumption is that episodes of intra-regional credit contagion would spillover over a longer period to affect multiple countries' sovereign credit market either through the global sovereign risk factor or the regional sovereign risk factor over time. To understand the spillover effects beyond the region of origin, we also examine a global indicator, Other_ creditevent, which indicates whether a credit event has taken place in one of the other four (non-North American) regions in the sample. We expect the

Other_creditevent variable to be generally less important than the region-specific ones in affecting the regional risk spillovers within geographical regions.

The data for these variables are obtained from the Bloomberg system and Thomson Reuters Datastream. The only exception is the gross level of general government debt to GDP, which is obtained from the International Monetary Fund's World Economic Outlook database.

4. Main Findings

4.1 Fast-and-furious contagion: regional and global

The sovereign credit events detected in each sample year are shown in Table 2. Over the full sample period there were 89 credit events involving 20 sovereign countries. The average size of the spread jumps (at the threshold level k = 99.9%) was 228 basis points, the maximum jump was 1216 basis points (for Uruguay in 2003) and the smallest jump was 43 basis points (for Ireland in 2010). Sovereign credit events occurred in every region and involved a wider cross-section of sovereigns over time. Table 2 indicates how prevalent sovereign credit problems have been over the last decade. Within Europe, the sovereign credit events involved Iceland, Ireland, Greece, Portugal, Italy and Cyprus over the period from 2008 to 2013; in Eastern Europe, they involved Russia and Ukraine in 2008; in Latin America, they involved Argentina, Brazil, Ecuador, Venezuela and Uruguay; in the Middle East and North Africa, they involved Lebanon, Bahrain and Turkey; and in the Asia-Pacific region, they involved Indonesia and Pakistan.

Several interesting observations can be made. First, while such extreme jumps in sovereign spreads used to be larger in magnitude and were confined to a handful of emerging market sovereigns, the period since the global subprime debt crisis of 2008 saw credit events

involving a larger number of sovereigns but spread jumps of smaller magnitudes. Since 2008, the sovereign credit events have involved advanced countries as well as emerging markets – marking a new phenomenon in international sovereign debt markets. Second, the frequency of sovereign credit events increased dramatically over time. Out of the 89 credit events identified, 71 of them were concentrated in the 2008-2013 period. There were no sovereign credit events during 2004 and 2007, and only one event occurred during 2005 (specifically, Ecuador). In all other years, there were multiple sovereign credit events. The number of sovereign credit events peaked in 2008 at 23 during the subprime debt crisis and the events were spread across all the regions. The fallout from the subprime debt crisis continued into 2009-2010, with major sovereign credit events involving Iceland and Ireland, two countries with banking sectors that were heavily exposed to risky mortgage debt. The bailout of troubled banks by national governments led to sovereign debt problems as highlighted by Acharya, Drechsler and Schnabl (2014) and Dieckmann and Plank (2012). Subsequently, sovereign credit events occurred in Greece, Italy, Portugal and Cyprus, marking the European sovereign debt crisis from 2009-2013. Upon closer examination of the economic news behind the credit events since the GFC in Appendix Table B (sourced from Eurostat and the Federal Reserve System), we find two distinct phases within our full sample period. In the earlier period during 2008, credit events corresponded closely to the news on policies and actions made by the Federal Reserve Bank to inject liquidity into the US but subsequently the triggers for the detected credit events from late 2008 switched to macroeconomic news concerning the health of the EU.

[Insert Table 2 here]

The event study on regional sovereign credit portfolios shows that sovereign credit events have immediate and significant effects on other sovereigns within the same geographical region. These results are presented in Table 3 for the full period and for two sub-periods, the post-GFC period of 2007-2013 and the shorter post-European debt crisis period of 2009-2013. The intra-regional responses are both statistically and economically significant. Over 2002-2013, on average a sovereign credit event increases the CDS spreads of other sovereign obligors in the region by 26 basis points on the same day (t=0). The cumulative impact is smaller for the two-day window [0,1] at 18 basis points, suggesting an initial degree of mean-reversion on the day after the credit event. The effect on the second day after the credit event, however, reinforces the effect on the event day, leading to an average cumulative impact of 32 basis points over the three-day window [0, 2]. These regional credit portfolio reactions are all highly significant at the 1% level. In addition, there are no significant reactions prior to the events, which suggest that sovereign credit events tended not to be anticipated. These results vindicate a form of contagion that is indeed "fast and furious" as characterized by Kaminsky, Reinhart and Vegh (2003).

The same-day contagion results remain robust for the more recent crisis sub-periods of 2007-2013 and 2009-2013, during which 80% of our credit events occurred, but the day-after and second day responses disappear after 2007. If contagion had been "fast and furious" before 2007, it has become even more so since then. Our pre-2007 event sample is predominantly characterized by the Latin American crisis, whereas the post-2007 sample is dominated by events in the Eurozone periphery countries. Our findings reveal that, despite the financial crisis and volatility of financial markets, the price discovery process functions efficiently for sovereign CDS, i.e. recent CDS spread changes cannot be predicted with past CDS spread changes. The size of the sovereign CDS market has increased noticeably since 2008 facilitating the correct pricing and efficiency of sovereign credit markets. The post-2008

surge likely relates to the need to hedge derivative counterparty credit risk exposure that had to be more fully disclosed under new accounting rules that came into effect in 2006. Our findings are in line with Gündüz and Kaya (2013) who document informational efficiency in the Eurozone sovereign CDS market and lack of long memory behaviour in the period post-2007. On the other hand, they show significant persistence in the volatility of CDS spread changes in Eurozone periphery countries, which is linked to heightened sovereign risk premia.

Lastly, the event study results show a credit contagion effect that is larger in magnitude over the full sample than in the recent sub-sample periods for post-GFC and post-EDC. This is an artefact of the lower CDS spreads in the European region where the latter credit events are concentrated and does not go to suggest that the earlier crises in Latin America and East Asia were economically more significant.

[Insert Table 3 here]

With respect to the global portfolio, the results suggest that credit contagion often spreads beyond the regional bounds of the credit event, although the effect is not as strong as that on the region of origin. Panel B of Table 3 presents these results. Similar to the regional results, there is no evidence of any anticipation of the event. As before the same-day reaction (t=0) is the strongest, however it is the only day that is statistically significant even for the full sample period. This same-day reaction of the global portfolio averages 6 basis points, which is only about a quarter of the size of the reaction of the regional portfolio. The immediate global response from credit events is surprisingly weak during the European debt crisis sub-period indicating this was largely a region specific concern. The average impact during the 2009-2013 sub-period was only 3 basis points, statistically significant at the 10% level.

Finally, Panel C of Table 3 reports the results of the regional analysis after adjusting the reaction of the regional credit portfolio for the global change in credit risk. The results are qualitatively similar to those shown in Panel A. The regional effects remain strongly significant even after adjusting for global credit risk levels. This is particularly the case for the event day, for which the regional response to sovereign credit events is 20 basis points over the full sample and about 7 or 8 basis points in the recent sub-sample crisis periods.

4.2 The slow-burn global spillover of sovereign risk

To understand the slow-burn global spillover of sovereign credit risk, we look at the two main sources of systematic risk behind the comovement of sovereign CDS spreads, namely, changes in the global risk factor and changes in the regional risk factors which market participants are exposed to. We then analyze separately the impact of sovereign credit events on these two risk transmission channels.

4.2.1 A first look at the global risk factors

We start by looking at the behaviour of the predominant global sovereign risk factors over our full sample period. The peaks in global sovereign risk cycles have coincided with the occurrence of sovereign credit events. As can be seen in Figure 2, the first five principal components extracted (PC1,..PC5) vary dramatically over time. Yet, they follow similar cyclical patterns in their movements and the peaks coincide with the Latin American debt crises in the early 2000s and then with the height of the international financial crisis before the onset of the European debt crisis that was triggered by Greece's growing budgetary problems from 2009. Global sovereign credit risk was at the lowest levels from 2006-2007,

before the global risk factors rose sharply from September 2008. This is the period that immediately followed Lehman Brother's Bankruptcy. This is also a period that coincides with the high concentration of sovereign credit events identified from our event study.

[Insert Figure 2]

Global sovereign credit risk levels particularly that captured by PC4, remained relatively elevated, albeit lower than the peak, marking the onset of the entire 2008-2013 sub-period in which there is an intense clustering of credit events. A downward trend in the global risk factor started in 2011, coinciding with the time that the European Central Bank (ECB) launched its Long-Term Refinancing Operations (LTROs) to ease the European sovereign debt crisis. Through this market intervention, the ECB provided almost €1 trillion in 3-year loans to European banks, which not only served to push down money market interest rates across Europe but also lowered sovereign bond yields for Italy and Spain. The intervention helped to reduce fears in global financial markets that banks might collapse and bring down the public finances of other countries in the EU like Italy and Spain. Clearly, variations in global sovereign credit risk levels map closely to our detected sovereign credit events and in turn the real-life news events that triggered the corresponding spread jumps (see Appendix Table B). Hence, we conduct parallel regression analyses on the variations in the global risk factor to provide a more complete investigation on the contagious spread of the country-specific sovereign credit events that have already been identified. Table 4 provides the summary statistics of the first ten principal components representing time-varying global sovereign risk factors.

[Insert Table 4]

In Table 4, it can be observed that the first four global sovereign risk factors are the highest on average with means ranging from 132.05 bps (PC3) to 806.59 bps (PC4) and also vary the most with standard deviations ranging from 80.33 bps (for PC3) to 603.37 bps (for PC1). We expect these first few global risk factors would relate most closely to the spread jumps underpinning the credit events that we have identified. We formally test this in subsequent regression analyses.

4.2.2 A first look at the regional risk factors

We now turn to the other common risk factor that is likely to affect sovereign credit spreads across countries, namely regional sovereign risk (Region_risk). Recall that our estimates of the time-variations in region-specific sovereign risks are based on the cross-sectional averages of the residual risks from our country-level multi-factor asset pricing models shown in equation (6). Table 5 provides the summary statistics of these regional risk factors, and Figure 3 shows their dynamics.

[Insert Figure 3] & [Insert Table 5]

In Table 5, it can be observed that the regional risk factors are on average very close to zero as they are estimated as the cross-sectional averages of residual (idiosyncratic) risks for countries within geographical regions. We find that the Asia-Pacific region is perhaps the least globally integrated with other sovereign debt markets in the world as the mean regional risk is the largest in magnitude at -0.093 bps corroborating with the low correlation in sovereign risks previously documented for Asia with the rest of the world by Remolona, Scatigna and Wu (2008). Furthermore, we find that regional risk factors for Latin America and Western Europe have been the most volatile with the standard deviations of 15.64 bps

and 13.90 bps, respectively consistent with the distinct clustering of regional risks shown in Figure 3 during the Latin American debt crises in the early 2000s and in 2011 during the most recent European sovereign debt crisis. These episodes of regional risk clustering correspond closely to the timing of spread jumps underpinning the credit events that we have identified. We formally test this in subsequent regression analyses.

4.3 Explaining the sovereign risk spillover channels

Can we explain what lies behind the global risk factors and the regional risk factors for different sovereign borrowers? Bekaert, Hodrick and Zhang (2009) suggest that the time-variations in the underlying risk factors can account for a large proportion of the movements of asset prices. In the analysis below, we separately analyze the time-variation in the main global risk factors and the regional risk factors, primarily focusing on the protracted effects of sovereign credit events while controlling for financial market variables and economic fundamentals.

4.3.1 Do credit events affect the global risk factors?

We turn first to the global risk factors. In Table 6, we report time-series regression results for the first five principal components previously extracted to represent the most dominant global sovereign risk factors as dependent variables in equation (8).[9] To examine whether country-specific credit events may have global spillover effects, we regress each common global risk factor on the credit event indicator (Creditevent) which takes on a value of 1 in the periods when there are credit events in any of the sampled countries and zero otherwise and also its interaction with a time dummy marking the European debt crisis (EU_crisis). We also control

[9] We only report the regression estimates for the first five PCs as they already account for 86.4% of cumulative eigenvalues. We do not find the sovereign credit events have a significant loading on subsequent PCs. Results are available upon request.

for a set of global financial market and economic fundamental variables. Specifically, we capture global financial market performance using U.S. stock market index returns on the S&P 500 (Stock_return) and changes in its implied volatility index (VIX) and corporate credit risk conditions, measured as changes in the CDX Investment Grade corporate CDS index. Macroeconomic fundamentals are proxied by sovereign credit rating changes and by debt to GDP levels both computed as averages for all countries.

[Insert Table 6]

We highlight four main results. Firstly, prior to the Eurozone sovereign debt crisis, country-specific credit events were inversely related to global sovereign risks as they presented diversification benefits that reduced the global sovereign credit portfolio risks. Changes in individual country sovereign CDS spreads that are idiosyncratic in nature and are not correlated with other sovereign obligors' CDS spread movements present an effective risk-reduction benefit for the global portfolio of sovereign CDS. This is evident in the significant and negative effect of the creditevent variable on PC1 and PC5. The estimated coefficients indicate that when there is a significant country-specific credit event, global risk falls by between 24.7 and 46.3 basis points.

Secondly and most strikingly, during the Eurozone debt crisis, interaction terms for the credit events exerted significant protracted risk spillover effects and worked to heighten the global sovereign risks contributed by PC1, PC2 and PC5 in the order of 58.4, 41.9 and 27.5 bps, respectively. This indicates that global risk spillovers became a new risk transmission channel in the Eurozone debt crisis and was the mechanism through which European troubles spread around the global financial system. We note that the EU crisis loads significantly on

all PCs shown in Table 6. Taken together, the first two results suggest that sovereign credit events are usually harmless if they occur sporadically in isolation. However, during the EU crisis, when these credit events became clustered closely together, they rapidly spilled over and contributed to the global sovereign risk transmission channel and the debt crisis quickly became a global fiasco.

Thirdly, the global risk factors are all heavily influenced by U.S. financial market variables. These control variables behave in the expected manner. US stock market returns load significantly and negatively onto the first five PCs indicating that stronger financial market performance lowers global sovereign credit risks. The significant and positive loadings on the VIX and Corp_sprds suggests that heightened risk aversion is what is largely behind increases in the global risk factor. The results corroborate the explanatory power of U.S. market-based variables for sovereign CDS spreads and its comovements documented in prior studies (Ang and Longstaff (2013), Longstaff et al. (2011), Dieckmann and Plank (2012)).

Finally, we find that the dominant global risk factors load heavily on debt to GDP levels across all sample countries. PC3 is the only global risk factor that loads significantly onto sovereign credit rating changes. However the effect is economically small as a single notch increase in average sovereign credit ratings reduces global risk by 9 bps. This suggests that common global movements in sovereign credit spreads predominantly reflect global risk appetites and a wake up to indebtedness around the world. This is consistent with the findings of Ang and Longstaff (2013) and Longstaff et al. (2011) and the recent work of Rey (2015) revealing that the pattern of capital flows follows a global financial cycle which is synchronized with fluctuations in world market risk aversion and uncertainty as proxied by

the VIX. The strong loading on debt to GDP levels resounds strongly with the debt threshold effects highlighted by Reinhart and Rogoff (2010).

4.3.2 Do credit events affect the regional risk factors?

We now turn to assess what determines the variations in the regional risk factors. In Table 7, we report time-series regressions for explaining different regions' own sovereign risk, as captured by the cross-sectional average of estimated residuals for countries within geographical regions. As expected, credit events that take place outside the specific region (Other_ creditevent) have insignificant impacts on the regional risk factors whilst intra-regional credit events usually have consistently positive spillover effects on neighboring countries within the same region. Intra-regional contagion is stronger within the Asia-Pacific and Latin America suggesting greater regional integration in these sovereign credit markets. Sovereign credit shocks within these two regions are the most economically significant and work to increase regional risks in the Asia-Pacific by 50.1 bps and across Latin America by 44.1 bps, respectively. Interestingly, cross-regional credit contagion remained insignificant even during the EU debt crisis, based on the interactions between other_creditevent and the EU crisis indicator variables. The EU debt crisis has increased regional risk in Western Europe by 9.87 bps over other periods in our full sample. Thus, whilst there is usually a clear distinction between the influence of credit events on the global risk factors and regional risk factors as risk spillover mechanisms, in the recent European sovereign debt crisis both became additional channels of sovereign credit contagion within Europe and globally. However, the Asia-Pacific sovereign credit markets are unique in that during the European debt crisis their region-specific credit events had a lesser impact on increasing regional risk with a combined impact of 17 bps compared to the usual 50 bps suggesting that sovereigns in

the Asia-Pacific were perceived to be relatively less risky and a safer bet during the European debt crisis.

[Insert Table 7]

In regressions for explaining the time-variations in regional risk factors, only economic fundamentals that are specific to countries within geographical regions are averaged and used as controls. We find that both Sov_rating_chg and Debt_GDP tend to exert significant influence on regional risk factors and they enter with the expected negative and positive signs, respectively. Sovereign creditworthiness assessed by credit rating agencies and reflected in sovereign credit ratings are more significant in explaining regional risks in those emerging market regions that are more prone to political instability like Eastern Europe and MENA. Interestingly, fundamentals are insignificant determinants of regional risk in Latin America suggesting that they are still plagued by their chequered debt history and market participants are not even pricing credit risks conveyed by their economic performance. These results corroborate Beirne and Fratzscher‘s (2013) detection of a ‘wake up’ contagion in sovereign yield spreads to economic fundamentals in recent years. We extend current knowledge by showing that the ‘wake up’ to fundamentals occurred via the pricing of both global and regional sovereign credit risks.

In sum, we find that the global spillover of sovereign risks was escalated by sovereign credit events occurring during the recent European sovereign debt crisis. The transmission of sovereign credit risk was reinforced by rising global risk aversion in major financial markets and by escalating debt to GDP levels around the world, as national governments provided bailouts for troubled banking sectors. On the other hand, credit event spillovers within

regions depends more on economic fundamentals. These findings provide new evidence on the risk transmission mechanisms for sovereign credit contagion.

5. Conclusions

This paper investigates the regional and global propagation of sovereign credit risk by distinguishing between two propagation mechanisms, “fast and furious” contagion and “slow burn” spillovers. We first examine “fast and furious” contagion through an event study to assess the immediate geographical impact of major sovereign credit events, identified as extraordinary jumps in daily sovereign CDS spreads. The resulting sovereign credit events are mostly clustered during the post-subprime and European sovereign debt crisis periods. The findings suggest that although some sovereign credit events exert immediate effects that are global in reach, the effects of most credit events are limited to the region of origin. Fast-and-furious contagion seems to be largely a regional phenomenon.

We then look at “slow burn” risk spillovers by analyzing the variations in a global risk factors extracted from a generalized principal component analysis and then construct regional risk factors as the regional averages of the residual risks in a multi-factor pricing model. These can be conceptualized as two distinct slow burn risk spillover channels to neighboring countries or to the rest of the world. Most strikingly, in separately analyzing the determinants of the most dominant global risk factors and the regional risk factors, we find that sovereign credit events became systemic problems and significantly amplified global risk factors during the recent European debt crisis. In other times, country-specific credit events only have spillover effects within the region and usually present diversification benefits for global sovereign credit portfolios. We find that U.S. financial market variables and debt to GDP

levels load heavily on the global risk factors while sovereign credit ratings matter more for the residual risks in regions with greater political risks.

Our results support two risk channels for the propagation of sovereign credit risk. First, a major sovereign credit event has an immediate impact on the risk premia of neighbouring countries, although occasionally the impact is also global. Second, there is a slower process by which such an event builds up regional and global risk factors, with the latter fuelled by both global investors' risk aversion and the wake up to rising debt to GDP levels. Our research provides a better understanding of how seemingly country- or region-specific sovereign debt problems can proliferate widely to induce financial instability around the world as witnessed over the 2008-2013 period. For future research in this area, there is scope to delve into the specific sectors or types of firms through which sovereign risk contagion is most readily transmitted across national borders.

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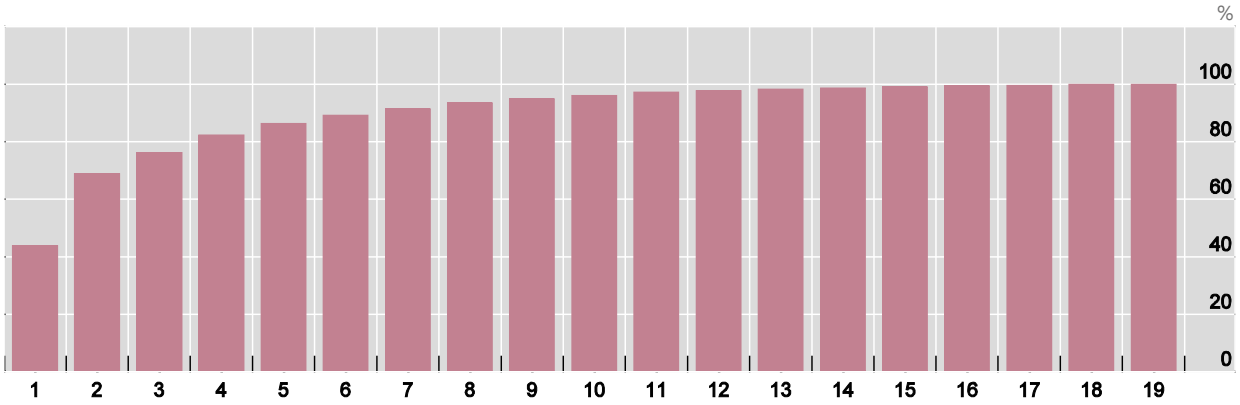
Figure 1. Eigenvalues for sovereign CDS spreads 2002-2013

This figure shows the average cumulative percentage of variance explained by sorted eigenvalues. The variance decomposition is calculated based on principal components extracted from a generalised principal components analysis on a group of 19 core countries with the longest history of sovereign CDS spreads over all sample years. Eigenvectors are computed and sorted from the largest to the smallest eigenvalue. We retain the first 10 general principal components to proxy global sovereign risk factors, as they account for 96.1% of cumulative eigenvalues.

Eigenvalues for sovereign CDS spreads 2002-2013

Cumulative percentage of variance explained Graph 1

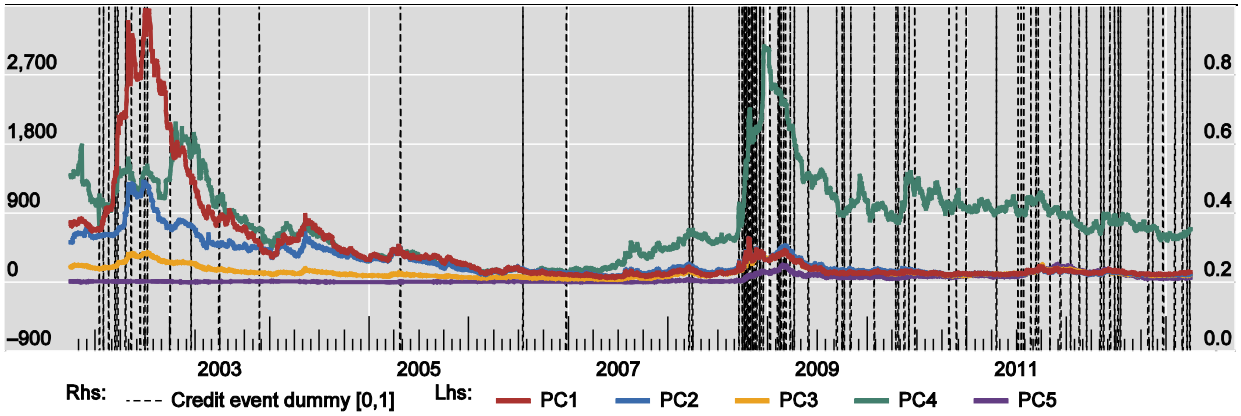


Source: Authors' calculations.

Figure 2. Rising global sovereign credit risks and credit events over time 2002-2013

This figure depicts the build-up of sovereign credit risk in the global financial system as represented by the first five principal components over time (*PC1*,…,*PC5*) alongside the credit event indicator (vertical bars) which takes a value of 1 on days when there were large jumps detected in sovereign credit spreads and zero otherwise.

Principal components and the credit events over time — Graph 2



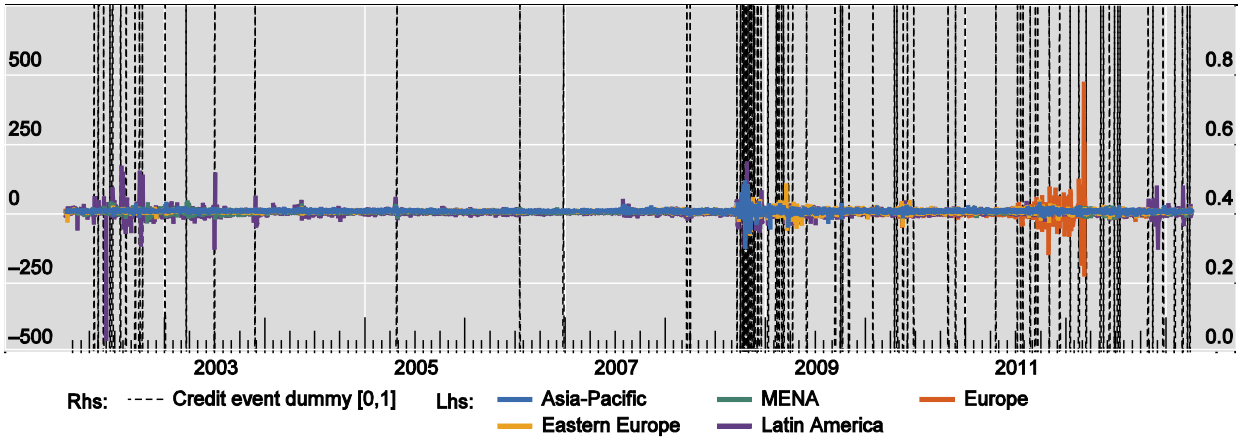
Source: Authors' calculations.

Figure 3. Time varying regional systematic risks and credit events over time 2002-2013

This figure shows the residual sovereign credit risks for each region over the period from 2002-2013 together with the credit event indicator which takes a value of 1 on days when extreme jumps in sovereign CDS spreads are detected and zero otherwise.

Regional average residuals and the credit events over time

Graph 3



Source: Authors' calculations.

Table 1. Distribution of sovereign CDS spreads

Panel A of this table presents the summary statistics on daily sovereign CDS spreads (in basis points) by region over the entire sample period from 2002 to 2013. Panel B presents the summary statistics on daily changes in sovereign CDS spreads (in basis points) by region over the full sample period. N x T represents the total number of country-day observations available across regions. The statistics described below include the mean, median, standard deviation, the minimum and maximum values as well as the 95th, 99th and 99.9th percentile cutoffs.

							Quantiles		
Region	NxT	Mean	Med.	Std.	Max	Min	95%	99%	99.90 %
Panel A: CDS spreads									
Latin America	32894	379	174	728	10350	12	1165	3501	10350
Europe	47424	110	14	471	21681	1	441	1111	8083
Eastern Europe	38410	172	102	260	5479	3	531	986	3364
MENA	23214	197	152	169	1254	8	508	801	1148
Asia-Pacific	31548	152	79	257	3334	1	513	935	3015
All countries	173490	194	96	448	21681	1	637	1557	5508
Panel B: CDS spreads changes									
Latin America	32819	-0.0580	0	37.31	1215.50	-4162.33	17.43	55.74	254.49
Europe	47320	0.5564	0	60.68	8439.10	-3950.46	5.68	23.19	227.68
Eastern Europe	38344	0.0054	0	14.86	1410.07	-707.10	9.37	28.03	106.60
MENA	23106	-0.0285	0	9.31	257.29	-141.66	7.59	23.12	111.30
Asia-Pacific	31452	-0.0009	0	16.64	834.88	-1005.52	6.57	21.44	119.01
All countries	173041	0.1383	0	37.18	8439.10	-4162.33	9.12	31.22	153.93

Table 2. Summary statistics on all sovereign credit events 2002-2013

This table provides a break-down of the total number of sovereign credit events (extreme CDS jumps) detected by year and the number of regions from which these events arose as well as the countries where they emanate over the sample period from 2002-2013. Summary statistics on the average size, standard deviation and the range of the extreme jumps in sovereign CDS spreads defining the sovereign credit events are also shown for each year.

Year	N(events)	N(regions)	Sovereigns	CDS Spread Jump (bps)				
				Mean	Median	StDev	Max	Min
2002	11	3	Brazil, Uruguay, Venezuela, Turkey, Indonesia	416.47	333.33	290.69	968.66	116.34
2003	4	3	Argentina, Uruguay, Turkey,Indonesia	515.12	357.63	507.70	1215.50	129.71
2004	0	0						
2005	1	1	Ecuador	286.45				
2006	2	2	Ecuador, Lebanon	220.13	220.13	192.76	356.44	83.83
2007	0	0						
2008	23	5	Argentina, Ecuador, Uruguay, Iceland, Ireland, Russia, Ukraine, Lebanon, Turkey, Egypt Indonesia, Pakistan	249.04	160.72	205.36	834.88	48.01
2009	14	4	Iceland, Ireland, Ukraine, Bahrain,Pakistan	169.42	170.13	78.80	350.10	49.58
2010	9	1	Ireland, Greece	68.25	65.78	25.94	132.23	47.56
2011	8	1	Greece, Italy, Portugal	93.64	80.93	38.45	159.57	60.19
2012	12	3	Argentina, Cyprus, Malta, Portugal, Pakistan	167.18	103.43	167.19	554.13	49.63
2013	5	2	Argentina, Cyprus	334.33	137.30	443.03	1109.49	51.79
2002-2013	***89***	***5***	***N(Sovereigns suffering credit event) = 20 / 66***	***228.36***	***145.44***	***238.53***	***1215.50***	***43.45***

Table 3. Regional and global "fast and furious" reactions to sovereign credit events

This table presents the average reaction of regional (Panel A), global (Panel B) and regional risk-adjusted (Panel C) portfolio credit spreads to each sovereign credit event in basis points on individual days around the event date and over different event windows around the event. In Panel A for each event, the regional portfolio is an equally weighted portfolio of sovereign CDS spreads of all the non-event countries in the same region as the credit event country. In Panel B for each event, the global portfolio is an equally weighted portfolio of sovereign CDS spreads of all the countries in the four non-event regions in the sample plus the U.S. In Panel C, each sovereign's CDS spread change is adjusted for movements in the global credit risk levels by deducting the global spread index from the sovereign's CDS spread.

Event	2002-2013		2007-2013		2009-2013	
Window	Mean spread change	t-stat	Mean spread change	t-stat	Mean spread change	t-stat
Panel A: Regional Response						
-2	-0.86	-0.28	0.73	0.25	0.50	0.14
-1	0.53	0.17	-0.37	-0.13	-4.54	-1.23
0	25.84	8.40 ***	16.31	5.66 ***	10.23	2.76 ***
1	-8.20	-2.67 ***	4.22	1.47	1.09	0.30
2	14.04	4.57 ***	0.97	0.34	0.73	0.20
[-2, 0]	25.51	4.79 ***	16.66	3.34 ***	6.19	0.97
[-1, 0]	26.36	6.06 ***	15.93	3.91 ***	5.69	1.09
[0, 1]	17.64	2.87 ***	20.53	3.57 ***	11.32	1.53
[0, 2]	31.68	3.43 ***	21.50	2.49 ***	12.06	1.09
[-2,2]	31.35	4.56 ***	21.85	3.39 ***	8.02	0.97
[-1,1]	18.16	3.41 ***	20.16	4.04 ***	6.78	1.06
Panel B: Global Response						
-2	0.32	0.22	-1.66	-1.20	-1.16	-0.70
-1	0.30	0.21	1.85	1.34	1.15	0.69
0	6.10	4.19 ***	8.52	6.17 ***	3.08	1.85 *
1	2.17	1.49	2.63	1.90 *	0.59	0.35
2	-1.75	-1.20	-1.62	-1.17	-1.98	-1.20
[-2, 0]	6.72	2.67 ***	8.71	3.64 ***	3.06	1.07
[-1, 0]	6.40	3.11 ***	10.37	5.30 ***	4.22	1.80 *
[0, 1]	8.27	2.84 ***	11.15	4.03 ***	3.66	1.10
[0, 2]	6.52	1.49	9.53	2.30 **	1.68	0.34
[-2,2]	7.14	2.20 **	9.72	3.15 ***	1.67	0.45
[-1,1]	8.57	3.40 ***	13.00	5.43 ***	4.81	1.67
Panel C: Regional Adjusted Response						
-2	-1.18	-0.37	2.38	0.87	1.66	0.44
-1	0.23	0.07	-2.22	-0.81	-5.69	-1.49
0	19.74	6.26 ***	7.79	2.83 ***	7.16	1.88 *
1	-10.37	-3.29 ***	1.59	0.58	0.51	0.13
2	15.79	5.01 ***	2.59	0.94	2.72	0.71
[-2, 0]	18.79	3.44 ***	7.95	1.67 *	3.13	0.47
[-1, 0]	19.97	4.48 ***	5.57	1.43	1.47	0.27
[0, 1]	9.37	1.49 ***	9.38	1.71 *	7.66	1.01
[0, 2]	25.16	2.66 ***	11.97	1.45	10.38	0.91
[-2,2]	24.21	3.43 **	12.13	1.97 *	7.14	2.20 **
[-1,1]	9.60	1.76 ***	7.16	1.50	8.57	3.40 ***

Table 4. Summary statistics on global sovereign risk factors

This table reports summary statistics for the multiple global sovereign risk factors extracted as the first ten principal components (PC1, PC2…PC10) from our generalized principal component analysis. The principal components are estimated out-of-sample based on the previous year's covariance matrix of sovereign CDS spreads from 19 core countries representing developed and emerging markets from Latin America, Europe, Eastern Europe, MENA and the Asia-Pacific regions. N represents the number of observations. The statistics described below include the mean, median, standard deviation, the minimum and maximum values as well as the 95th, 99th and 99.9th percentile cutoffs.

							Quantiles		
	N	Mean	Median	Std.	Max	Min	95%	99%	99.90%
Principal components									
PC1	2934	410.05	147.97	603.37	3541.85	57.64	1809.55	3125.98	3530.21
PC2	2934	275.56	159.04	234.78	1304.52	61.42	740.92	1221.80	1295.34
PC3	2934	132.05	111.39	80.33	543.23	30.96	327.74	384.40	479.32
PC4	2934	806.59	736.52	531.65	3069.14	110.90	1851.11	2545.02	3046.09
PC5	2934	41.02	9.02	52.60	230.90	-4.06	155.79	203.00	219.32
PC6	2934	54.38	13.04	75.38	333.18	-28.57	231.79	285.00	315.00
PC7	2934	98.80	17.17	138.93	580.61	-9.43	405.62	515.82	561.55
PC8	2934	96.74	17.07	131.91	531.85	-21.73	412.75	492.80	527.68
PC9	2934	175.75	178.29	128.46	658.77	14.22	385.36	561.95	648.42
PC10	2934	166.70	126.21	136.10	570.82	14.95	451.39	523.62	553.22

Table 5. Summary statistics on regional risk factors

This table reports summary statistics for the regional risk factors constructed as the cross-sectional averages of country-specific residual risks within different geographical regions from the multi-factor pricing model represented in equation (6). The regional risk factors are shown for Latin America (LA_Risk), Europe (EU_Risk), Eastern Europe (EEU_Risk), MENA (MENA_Risk) and the Asia-Pacific (AP_Risk) regions as well as all regions (All_Risk). N represents the number of observations. The statistics described below include the mean, median, standard deviation, the minimum and maximum values as well as the 95^{th}, 99^{th} and 99.9^{th} percentile cutoffs.

							Quantiles		
Region	N	Mean	Median	Std.	Max	Min	95%	99%	99.90%
Regional average residuals									
LA_Risk	2933	-0.0479	-0.1456	15.64	175.98	-457.88	13.07	39.55	141.16
EU_Risk	2933	-0.0344	-0.1460	13.90	465.74	-222.11	5.11	27.03	106.29
EEU_Risk	2933	-0.0286	-0.0259	7.18	93.62	-78.83	7.66	20.54	72.79
MENA_Risk	2933	-0.0403	-0.0492	4.59	64.24	-50.59	5.54	13.66	36.73
AP_Risk	2933	-0.0929	-0.1882	6.51	105.05	-128.98	5.02	13.74	76.45
All_Risk	2933	-0.0550	-0.1367	6.48	122.03	-111.82	6.35	17.60	66.32

Table 6. Determinants of global sovereign risk factors, 2004-2013

This table reports the estimated coefficients and other summary statistics from the regression of the first five global sovereign risk factors (*PC1, PC2, PC3, PC4, PC5*) on the indicated variables for the period from 29/01/2004 to 29/03/2013. The variable of interest, creditevent is an indicator variable that is equal to one when there is a sovereign credit event occurring within any sample country and zero otherwise. EU_crisis is an indicator variable taking a value of 1 from 2009 until the end of the sample and 0 otherwise. Stock_return denotes the return on the S&P500 stock market index and VIX denotes the daily change in the VIX implied volatility index and Corp_sprds denotes the daily change in the CDX Investment Grade corporate CDS index. Sov_rating_chg are the changes in sovereign credit rating assessments made by Standard and Poors, Moodys and Fitch averaged across all countries. Debt_GDP is the average ratio of all sample countries' general government gross debt to gross domestic product. Adj. R-sq are the adjusted R-squared values for the time series regressions. N denotes the number of days used in the regressions. P-values are reported in parentheses (*, **, *** denote significance at the 10, 5 and 1% levels, respectively).

Dep. Variable	PC1		PC2		PC3		PC4		PC5	
creditevent	-46.278	***	-27.586		-11.632		-80.629		-24.713	***
	[0.0084]		[0.1131]		[0.1529]		[0.2866]		[0.0018]	
creditevent*EU_crisis	58.406	***	41.877	**	18.662		81.075		27.517	***
	[0.0029]		[0.0367]		[0.1122]		[0.3408]		[0.0046]	
EU_crisis	-425.302	***	-280.943	***	-31.141	***	358.294	***	40.291	***
	[0.0000]		[0.0000]		[0.0000]		[0.0000]		[0.0000]	
Stock_return	-0.574	***	-0.466	***	-0.149	***	-0.827	***	-0.022	**
	[0.0000]		[0.0000]		[0.0000]		[0.0000]		[0.0324]	
VIX	1.395	*	0.770		1.604	***	11.259	***	1.834	***
	[0.0550]		[0.2300]		[0.0010]		[0.0000]		[0.0000]	
Corp_sprds	-0.233		0.170		0.792	***	4.379	***	0.246	***
	[0.1448]		[0.2419]		[0.0000]		[0.0000]		[0.001]	
Sov_rating_chg	-1.255		3.863		-9.116	*	-12.518		-6.687	
	[0.8291]		[0.5010]		[0.0803]		[0.1433]		[0.3367]	
Debt_GDP	29.617	***	17.030	***	2.657	***	-4.930		2.873	***
	[0.0000]		[0.0000]		[0.0000]		[0.1495]		[0.0000]	
Constant	-578.356	***	-98.950	*	58.768	*	1229.183	***	-218.261	***
	[0.0000]		[0.0683]		[0.0926]		[0.0000]		[0.0000]	
Adj. R-sq	0.798		0.795		0.892		0.886		0.779	
N	2392		2392		2392		2392		2392	

Table 7. Determinants of regional sovereign risk factors, 2004-2013

This table reports the estimated coefficients and other summary statistics from the regression of regional sovereign risk factors for Latin America (LA_Risk), Western Europe (EU_Risk), Eastern Europe (EEU_Risk), Middle-East and North Africa (MENA_Risk), and the Asia-Pacific (AP_Risk) on the indicated variables for the period from 29/01/2004 to 29/03/2013. Reg_creditevent (Other_ creditevent) is an indicator variable that is equal to one when there is a credit event within (outside of) the respective region. EU_crisis is an indicator variable taking a value of 1 from 2009 until the end of the sample and 0 otherwise. Sov_rating_chg are the changes in the regional average sovereign credit rating assessments made by Standard and Poors, Moodys and Fitch. Debt_GDP is the regional average ratio of each country's general government gross debt to Gross Domestic Product. Adj. R-sq are the adjusted R-squared values for the time series regressions. N denotes the number of days used in the regional regressions. P-values are reported in parentheses (*, **, *** denote significance at the 10, 5 and 1% levels, respectively).

Dep. Variable	LA_Risk	EU_Risk	EEU_Risk	MENA_Risk	AP_Risk
Reg_creditevent	44.078 **	5.831 ***	19.257 ***	33.936 ***	50.104 ***
	[0.0400]	[0.0000]	[0.0027]	[0.0015]	[0.0001]
Other_creditevent	17.590	1.330	12.043	1.473	7.455
	[0.1617]	[0.1352]	[0.1551]	[0.5304]	[0.3459]
Reg_creditevent*EU_crisis	6.407	9.874 **	1.774	-8.905	-33.035 ***
	[0.7955]	[0.0178]	[0.8145]	[0.4036]	[0.0096]
Other_creditevent*EU_crisis	-12.669	-0.289	-7.601	-0.732	-5.390
	[0.3151]	[0.8388]	[0.3754]	[0.7681]	[0.4986]
EU_crisis	0.079	1.052	-1.197	0.022	0.189
	[0.9295]	[0.4243]	[0.1860]	[0.9410]	[0.8272]
Sov_rating_chg	-0.175	-0.289	-1.317 **	-1.357 ***	-0.542
	[0.8460]	[0.4959]	[0.0219]	[0.0003]	[0.5496]
Debt_GDP	0.0631	0.0595	0.1297 *	0.0713 ***	0.0525
	[0.4188]	[0.4922]	[0.0889]	[0.0058]	[0.5304]
Constant	-1.258	-9.051	-20.419 **	-19.663 ***	4.051
	[0.905]	[0.3789]	[0.0215]	[0.0001]	[0.7965]
Adj. R-sq	0.107	0.010	0.058	0.123	0.101
N	2392	2392	2392	2392	2392

APPENDIX

Appendix Table A: Constituents of Regional Groups

Latin America	Europe	Eastern Europe	MENA	Asia Pacific	North America	
Argentina	Austria	Bulgaria	Algeria	Australia	United States	
Brazil	Belgium	Croatia	Bahrain	China		
Chile	Cyprus	Czech Republic	Egypt	HongKong		
Colombia	Denmark	Estonia	Israel	Indonesia		
Costa Rica	Finland	Hungary	Lebanon	Japan		
Ecuador	France	Kazakhstan	Morocco	Korea		
El Salvador	Germany	Latvia	Qatar	Malaysia		
Guatemala	Greece	Lithuania	Turkey	Pakistan		
Mexico	Iceland	Poland	Tunisia	Philippines		
Panama	Ireland	Romania		Singapore		
Peru	Italy	Russia		Thailand		
Uruguay	Malta	Slovakia		Vietnam		
Venezuela	Netherlands	Slovenia				
	Norway	Ukraine				
	Portugal					
	Spain					
	Sweden					
	United Kingdom					
13	18	14	9	12	1	67

Appendix Table B, Panel A: Real-life news and detected credit events during the European Debt Crisis

In this Appendix table we provide a chronology of the real-life economic news releases in the US and the European Union (EU) during the height of the recent European Sovereign Debt Crisis (in Panel A) and the correspondence to the dates on which sovereign credit events were detected in our study (days when creditevent=1).

Source: Eurostat (http://epp.eurostat.ec.europa.eu/portal/page/portal/publications/collections/news_releases) and Federal Reserve System (http://www.federalreserve.gov/newsevents/press/all/2013all.htm)

Credit event date	US News	EU News
14-Mar-12		
16-Feb-12		**February 6, 2012:** Euro area government debt down to 87.4% of GDP
		January 13, 2012: Euro area external trade surplus 6.9 bn euros;
		January 12, 2012: Industrial production down by 0.1% in both euro area and
16-Jan-12		EU27
08-Dec-11		**December 9, 2011:** EU27 current account deficit 17.2 bn euros
01-Nov-11		
19-Sep-11		**September 16, 2011:** Euro area external trade surplus 4.3 bn euros
09-Sep-11		**September 9, 2011:** EU27 current account deficit 43.2 bn euros
23-Aug-11		
27-Jul-11		**July 22, 2011:** EU27 current account deficit 38.8 bn euros
18-Jul-11		
06-Jul-11		**July 1, 2011:** Recession drove EU27 overall tax revenue down to 38.4% of GDP
29-Dec-10		
23-Nov-10		**November 24, 2010:** Industrial new orders down by 3.8% in euro area
27-Oct-10		
23-Jun-10		**June 28, 2010:** EU27 tax ratio fell to 39.3% of GDP in 2008
01-Jun-10		**May 28, 2010:** EU27 deficit in trade in goods with Russia of 50 bn euros in 2009
14-May-10		**May 12, 2010:** Industrial production up by 1.3% in euro area
		April 22, 2010: Euro area and EU27 government deficit at 6.3% and 6.8% of
22-Apr-10		GDP respectively; EU27 current account deficit 9.2 bn euros
14-Apr-10		**April 14, 2010:** Industrial production up by 0.9% in euro area
27-Jan-10		**January 22, 2010:** EU27 current account deficit 27.7 bn euros
30-Oct-09		
		October 2, 2009: EU27 deficit in trade in goods with Brazil of 9 bn euros in
07-Oct-09		2008, surplus of 3 bn in trade in services
30-Sep-09		
10-Sep-09		**September 11, 2009:** EU27 current account deficit 55.1 bn euros
28-May-09		
07-Apr-09		**April 2, 2009:** EU27 surplus in trade in goods with the USA of 63 bn euros
23-Mar-09		**March 23, 2009:** Euro area external trade deficit 10.5 bn euros
05-Mar-09		**March 5, 2009:** Euro area and EU27 GDP down by 1.5%
26-Feb-09		
17-Feb-09		**February 17, 2009:** Euro area external trade deficit 32.1 bn euros
12-Feb-09		**February 12, 2008:** Industrial production down by 2.6% in euro area
06-Feb-09		
08-Jan-09		**January 8, 2009:** Euro area and EU27 GDP down by 0.2%

Appendix Table B, Panel B: Real-life news and detected credit events during the Global Financial Crisis

Credit event date	US News	EU News
		December 12, 2008: Industrial production down by 1.2% in both euro area and EU27
15-Dec-08		
04-Dec-08		**December 4, 2008:** Euro area and EU27 GDP down by 0.2%
	December 1, 2008: Federal Reserve will offer $150 billion in 84-day credit	
01-Dec-08	through its Term Auction Facility;	
20-Nov-08		
		November 17, 2008: Euro area external trade deficit 5.6 bn euros; **November**
	November 17, 2008: Federal Reserve will offer $150 billion in 28-day credit	**14, 2008:** Euro area and EU27 GDP down by 0.2%
17-Nov-08	through its Term Auction Facility today	
	November 10, 2008: Federal Reserve will offer $150 billion in 17-day credit through its Term Auction Facility today; **November 10, 2008:** Federal Reserve Board and Treasury Department announce restructuring of financial support to	
11-Nov-08	AIG	
05-Nov-08		
	November 3, 2008: Federal Reserve will offer $150 billion in 84-day credit	
03-Nov-08	through its Term Auction Facility today	
	October 31, 2008: Approval of the discount rate action of the Federal Reserve Bank of Atlanta; **October 30, 2008:** Approval of the discount rate action of the Federal Reserve Banks of Philadelphia, Richmond, Minneapolis, and Dallas; **October 29, 2008:** Approval of the discount rate action of the Federal Reserve Banks of Chicago, Kansas City, and St. Louis; **October 29, 2008:** FOMC statement and approval of discount rate action by Federal Reserve Banks of	
31-Oct-08	Boston, New York, Cleveland, and San Francisco	
27-Oct-08		
	October 21, 2008: Board issues statement concerning its approval of the proposal by Wells Fargo and Company to acquire Wachovia Corporation; **October 21, 2008:** Federal Reserve announces the creation of the Money Market Investor Funding Facility (MMIFF); **October 20, 2008:** Agencies encourage participation in Treasury's Capital Purchase Program, FDIC's Temporary Liquidity Guarantee Program; **October 20, 2008:** Federal Reserve	**October 22, 2008:** EU27 current account deficit 30.9 bn euros
22-Oct-08	will offer $150 billion in 28-day credit through its Term Auction Facility today;	
		October 17, 2008: Euro area external trade deficit 9.3 bn euros
	October 16, 2008: Written agreement with AmericasBank; **October 16, 2008:**	
16-Oct-08	Written agreement with Alliance Bancshares California	
	October 9, 2008: Statement on the efforts of Citigroup and Wells Fargo to reach	
10-Oct-08	an accord regarding the acquisition of Wachovia Corporation	
	October 8, 2008: Approval of the discount rate action of the Federal Reserve Banks of New York, Philadelphia, Cleveland, Richmond, Atlanta, Chicago, Minneapolis, Kansas City, Dallas, San Francisco, and St. Louis; **October 8, 2008:** Board authorizes Federal Reserve Bank of New York to borrow securities from certain regulated U.S. insurance subsidiaries of AIG; **October 7, 2008:** Board announces creation of the Commercial Paper Funding Facility (CPFF) to	**October 8, 2008:** Euro area GDP down by 0.2% and EU27 GDP stable
08-Oct-08	help provide liquidity to term funding markets	
	October 6, 2008: Approval of proposal by Mitsubishi UFJ Financial Group to acquire voting shares of Morgan Stanley; **October 6, 2008:** Federal Reserve will offer $150 billion in 85-day credit through its Term Auction Facility today; **October 6, 2008:** Board announces that it will begin to pay interest on depository	
06-Oct-08	institutions' required and excess reserve balances	
	September 29, 2008: Federal Reserve and other central banks announce further coordinated actions to expand significantly the capacity to provide U.S. dollar liquidity; **September 26, 2008:** Federal Reserve and other central banks	
29-Sep-08	announce operations to address funding pressures	
	September 19, 2008: Federal Reserve Board announces two enhancements to its programs to provide liquidity to markets; **September 18, 2008:** Federal Reserve and other central banks announce further measures to address elevated pressures in funding markets; **September 16, 2008:** Federal Reserve Board, with full support of the Treasury Department, authorizes the Federal Reserve Bank of New York to lend up to $85 billion to the American International Group	**September 17, 2008:** Euro area external trade deficit 2.3 bn euros
17-Sep-08	(AIG)	
	March 28, 2008: Federal Reserve will offer $50 billion in 28-day credit through its Term Auction Facility on April 7 and April 21, 2008 ; **March 27, 2008:** Federal Reserve announces public meetings on the notice by Bank of America to	
28-Mar-08	acquire Countrywide Financial	
	March 17, 2008: Approval of the first discount rate action of the Federal Reserve Banks of Boston, Cleveland, Richmond, Chicago, Minneapolis, Kansas City, and San Francisco; **March 16, 2008:** Federal Reserve announces two initiatives designed to bolster market liquidity and promote orderly market functioning; **March 14, 2008:** The Federal Reserve is monitoring market developments closely and will continue to provide liquidity as necessary to promote the orderly functioning of the financial system; **March 11, 2008:** FOMC statement: Federal Reserve and other central banks announce specific measures	
17-Mar-08	designed to address liquidity pressures in funding markets	