Intra-regional credit contagion and global systemic risk in international sovereign debt markets

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This version: 29 August 2013

Abstract

We examine intra-regional credit contagion and aggregate exposures of sovereign credit default swap (CDS) spreads to global risk as measures of aggregate sovereign credit risk in the international financial system. Based on a relatively large global sample of 67 countries with daily sovereign CDS data from 2002-2013 this study documents the dynamic changes in the degree of systemic sovereign credit risk exposure pre- and post the Global Financial Crisis and the European Sovereign Debt Crisis. We find very significant episodes of intra-regional credit contagion concentrating around the 2008-2012 period. Furthermore, we find that systemic risk levels heightened in sovereign credit markets from 2010-2011. Systemic sovereign credit risk levels have increased largely due to deteriorations in macroeconomic fundamentals, rising government debt levels and the global sensitivity to China's sovereign risk premia. Sovereign credit events emanating within regions increase global sovereign risk levels but not the systematic risk exposure to global sovereign risks.

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1. Introduction

The recent sovereign debt crisis that emanated from Europe has exerted its adverse impacts globally highlighting the speed and force with which financial contagion can occur across national borders in the international financial system. Motivated by these recent developments this study seeks to examine the heightened sensitivities to global risk factors as a channel through which the European debt crisis has spread throughout the world and the potential influence of credit rating agencies (CRAs') re-rating activities during these times. The rapid widening of sovereign credit spreads not only within Europe but in other parts of the world raises the importance of better understanding systemic sovereign credit risk. According to the ISDA (2012), the top 9 gross positions held in the credit default swap (CDS) markets are currently referenced on sovereign debt securities – a new phenomenon in recent history.

We focus on assessing systemic sovereign credit risks and regional credit contagion as the recent European debt crisis has highlighted that governments can be the main source of systemic risks and the fact that economies are intricately linked in an era of increasing globalization means that this risk poses a serious threat to the international financial system and the global economy. Our main contribution is in providing a better understanding on the mechanics underlying the development of the recent global sovereign debt crisis that emanated from deteriorating fundamental performance within the European region.

We first focus on sovereign credit contagion within regions as intra-regional contagion may be a prelude to heightened systemic risk levels and ultimately sovereign debt crises. Second, this paper provides a new measure of systemic sovereign credit risk based on a cross-sectional average of national exposures to aggregate world sovereign credit risk. This is in a

similar spirit to the recent work of Berger and Pukthuanthong (2013) in measuring systemic risk on international equity markets. We contribute to the literature on systemic risk by improving the understanding of how systemic risk exposures in the global financial system can change over time. This extends earlier work by Remolona, Scatigna and Wu (2008) on the pricing of fundamentals and risk aversion in sovereign CDS markets.

Consistent with the extant literature, we base our empirical analysis on sovereign CDS spreads as it provides a more direct measure of sovereign credit risk than actual sovereign debt yield spreads as the latter are influenced by interest rate movements, supply changes in sovereign bonds, illiquidity and other factors (Ang and Longstaff, 2013; Pan and Singleton, 2008, Remolona, Scatigna and Wu, 2008). A sovereign CDS contract provides insurance protection against the event of a sovereign debt default. The buyer in exchange for the payment of an annual spread (market risk premia) is permitted to sell defaulted sovereign debt to the CDS seller to redeem the par value of the underlying bond in the event of a sovereign default. The buyer of a CDS is not necessarily required to have an underlying exposure to the sovereign bonds – a situation called naked CDS trading which has allowed speculation on sovereign defaults to enter into sovereign credit markets. As the 5 year maturity segment of the sovereign CDS market is established to be the most liquid, we also restrict our analyses to this tenor to mitigate problems with illiquidity in sovereign debt prices.

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.

Hence, our measures of systemic sovereign credit risks based on the common pricing of global risks in national sovereign CDS spreads is well supported by existing studies on measuring systemic risks.

As the concepts of financial contagion and systemic risk are closely related, we formulate our study around these two issues. Prior research by Ang and Longstaff (2013) on systemic sovereign credit risk has incorporated these developments within a single framework whereas we attempt to look at these separately. Financial contagion is usually marked by the realization of a shock to one country triggering a cascade of falls in other countries where systemic risk arises from shared and simultaneous effects across countries to major shocks. Hence, first we investigate credit contagion within regions and we capture the effects of credit events on the credit spreads of other sovereigns within a geographical region. Second, we study global systemic risk by estimating upper thresholds in the average cross-sectional exposures of national sovereign obligors to a common global risk factor in a multifactor international asset pricing model.

We formulate and test three related hypotheses. First, we hypothesise that there have been significantly more major episodes of credit contagion within geographic regions since the Global Financial Crisis and their effects have become stronger over time. Second, these region-specific episodes of sovereign credit contagion work to reduce the systematic exposures of regions to global risk factors thereby lowering systemic sovereign credit risk levels for geographical regions within the global financial system. Third, systemic sovereign credit risk has been driven by common deteriorations in economic fundamentals and changes in global risk aversion since the onset of the Global Financial Crises and subsequently the European sovereign debt crisis.

We find evidence of intra-regional credit contagion stemming from large jumps in sovereign CDS spreads that cause unanticipated changes in the CDS spreads of other sovereigns within the region. The effects become more pronounced from 2007 onwards. The regional credit events are found to be significantly and positively related to global sovereign credit risk levels. Our separate regression analyses of global sovereign credit risk levels and the systemic risk exposure to those global risks suggests that common movements in sovereign credit spreads are related to financial market variables and market risk appetite, consistent with earlier studies (Baek et al. 2009, Remolona, Scatigna and Wu, 2008, Longstaff et al., 2010 and Ang and Longstaff, 2013), but we also find a major role for China's sovereign risk premia in driving both aggregate global sovereign credit risks and the exposure to that over time. The common deteriorations in country economic fundamentals captured by debt to GDP levels and sovereign credit ratings increase the sensitivity to global sovereign credit risks.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the sovereign CDS data used in this study. Section 4 introduces our empirical methodologies whilst Section 5 studies the nature of sovereign credit contagion and systemic risk. Finally, Section 6 provides concluding remarks and some policy implications.

2. Literature Review

There is a growing empirical literature on the determinants of sovereign credit spreads and the more recent studies in this strand document that sovereign credit spreads are related to common global and financial market factors (for example, Geyer, Kossmeier and Pichler, 2004, Remolona, Scatigna and Wu, 2008, Longstaff et al., 2011, Ang and Longstaff, 2013).

This paper is the first to estimate the *market-based* systemic risk exposure of national sovereign credit spreads from a cross-section of sovereign CDS spreads.

Hilscher and Nosbusch (2009) show that sovereign default risk is closely related to country fundamentals even after controlling for sovereign credit ratings and global factors. Their default risk implied credit spreads track observed market-based bond spreads fairly accurately in out of sample tests. However, their tests were restricted to emerging market debt where the focus on sovereign credit risks traditionally resided.

However, it has been noted recently by Longstaff et al. (2010) and Dieckmann and Plank (2012) that the cross-section of sovereign CDS spreads across advanced economies exhibits a strong degree of commonality. Dieckman and Planck (2012) also provide empirical evidence on the private-to-public risk transfer phenomena arising from the exposures of the global banking sector and the government bail-outs that followed. Longstaff et al. (2011) revealed that sovereign CDS spreads are explained and predicted by US equity, volatility and bond market risk premia.

There has been much recent attention focused on contagion in sovereign debt markets. Fong and Wong (2012) study sovereign risk contagion in 11 euro area countries and the US, UK and Japan using the concept of CoVar – the value-at-risk of a country conditional upon the same of another country. They find that based on weighted averages of the changes in CoVaR, Greece is the most vulnerable to sovereign distress within Europe followed by Portugal, Ireland, Italy and Spain. The Northern European countries like Finland, Germany and the Netherlands were the least vulnerable. Using a similar framework, Fong and Wong (2011) also assess sovereign systemic risk based on a small regional sample comprising the 11 largest Asia-Pacific economies over the 2004-2009 time period.

There has been a dearth of attention on the pricing of sovereign credit risks at the global level. Much focus 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 paper differentiates itself and contributes to the extant sovereign debt literature in this much needed direction.

3. Data

The sovereign CDS data we use for this study is sourced from Markit and Bloomberg databases.[1] Specifically, they are daily closing CDS spreads (ask prices) on five-year CDS contracts for 67 individual countries from 5 geographical regions. The sample countries are shown in Appendix Table A. All spreads are denominated in basis points and are notionally denominated in US dollars. The sample studied covers the time period from January 2002 to March 2013 providing a maximum of 2,934 daily sovereign CDS observations. This is the longest time period for which we have liquid CDS data for a large cross-section of countries.

Table 1 provides summary statistics for the set of five-year sovereign CDS spreads examined. Panel A reports the summary statistics for the levels in sovereign CDS spreads whilst Panel B reports the same for daily changes in sovereign CDS spreads. In Panel A, the average values of all national sovereign CDS spreads vary widely across sovereign obligors in the full sample period. The average CDS spreads range from 395 basis points for Latin America, 198 bps for Middle East and North Africa, 172 bps for Eastern Europe, 153 bps for Asia-Pacific and 110 basis points for the rest of Europe. Latin America has the highest mean and standard

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[1] Another data source for sovereign CDS spreads is Thomson Reuters but these are available for a much shorter time period. For instance, Fong and Wong (2012) were only able to get data for all their sample of eurozone countries and the US, UK and Japan starting from 14 December 2007. We find that there is a large correspondence in the brief time period over which the various data sources overlap.

deviation of spreads (735 basis points) consistent with the chequered debt history of this entire region and especially the painful Argentinean debt crises. On the other hand, Western and Southern Europe has experienced the lowest levels of sovereign risk premia on average but with considerable volatility with a standard deviation of 471 basis points mainly due to the turmoil in the last two years of the sample. The volatility in sovereign CDS spreads is similar in Eastern Europe and the Asia-Pacific region with standard of around 260 basis points, while MENA exhibits the least volatile spreads. Interestingly, daily spread changes in Panel B have been largest on average in Europe with a mean at 0.5570 bps and by far the most volatile with a standard deviation at 61.03 bps. The Asia-Pacific and Eastern Europe have also experienced small daily changes in sovereign CDS spreads on average across the full sample period – 0.0026 and 0.0046 basis points respectively and relatively low volatility. The CDS spread changes at the lower tail of the distribution bear out that Latin America experienced the most adverse 99.9% spread change quantile at 271.88 bps , which represents the effects of the 2002 crisis, while on the other hand European CDS spreads exhibit the lowest 99.9% quantile at 44.65 bps.

[Insert Table 1 here]

4. Empirical Methodology

4.1 Intra-regional and global sovereign credit contagion

The first part of our analysis focuses on measuring the degree of sovereign credit contagion within each of the five geographic regions and across the globe via an event study on sovereign credit events. Hence, we first define the sovereign credit events that may have

triggered credit contagion within respective regions. We essentially follow the empirical framework of Jorion and Zhang (2009) in measuring credit contagion within the US and rely on abnormal jumps in sovereign CDS spreads to identify credit events in the sovereign CDS market.

We define a regional sovereign credit event when

$$\Delta S_{i,t} \geq k \qquad (1)$$

where ΔS is the daily change in sovereign CDS spreads for sovereign i on day t and threshold k is the 99.9% region-specific quantile of the historical sovereign CDS spread change distribution reported in Table 1.

In order to pinpoint the exact onset of the credit event, all consecutive events within each region were identified but only the first observation within a 5-trading-day window was kept. Our approach identifies 89 credit events, arising from 20 individual countries over 2002-2013.

To assess the contagion effects of sovereign credit events at a regional level for each event we construct an equally weighted portfolio of CDS Spreads (we call this regional CDS spread index *CDX*) that contains all sovereigns in the region apart from the one that triggers the event. At the global level, we measure the effect on a global credit portfolio comprising the US and all the countries in the sample except the event-triggering country.

The reaction of the region surrounding the credit event from day 0 up to 5 post-event days and −5 pre-event days is evaluated by means of the change in the CDS spread of the respective regional portfolio (*CDXC*). First, for each day t in the event window $[t_1, t_2]$ we construct the cross-sectional Average (regional) CDS Spread Change as

$$ACDXC_t = \frac{1}{N}\sum_{i=1}^{N} CDXC_{it} \tag{2}$$

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

$$CACDXC[t_1, t_2] = \sum_{t_1}^{t_2} ACDXC_t \tag{3}$$

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-section 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-section dependence) *t*-statistic is

$$\frac{ACDXC_t}{\sqrt{Var(ACDXC_0)}}, \quad t = -5, \dots, 0, \dots, 5 \tag{4}$$

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

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

4.2 Measuring systemic sovereign credit risk

The second part of our analysis focuses on measuring systemic risk across international debt markets. We first compute an underlying world market factor based on a principal component analysis and then estimate the cross-sectional average loadings on this global risk factor over time to create a measure of time-varying systemic sovereign credit risk.[2] This captures the average exposure to world risk in international debt markets and we consider the exposures above a 99% threshold as being indicative of high systemic risk levels. This works in the same spirit as Berger and Pukthuanthong's (2012) 'fragility index' for equity markets. Their study finds evidence that in periods that countries share a high risk exposure to a common factor, they are more likely to experience simultaneous market crashes. Our measure provides a different perspective to the systemic risk measure based on default intensities implied from a term structure of sovereign CDS spreads recently introduced by Ang and Longstaff (2013).

Rather than focusing on systemic default risk, we are more interested in the systemic aspect of the market pricing of sovereign credit risk as reflected in sovereign CDS spreads.

To compute the world risk factor, we follow a similar principal component analysis (PCA) to Pukthuanthong and Roll (2009). The eigenvalues from our initial PCA is illustrated in Figure 1. It can be seen that the first ten principal components explain 80% of the variations in national sovereign CDS spreads which indicates that we can capture a large proportion of the common risks across our global sample of sovereign CDS with these principal components.

[Insert Figure 1 here]

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[2] These countries are shown in Appendix Table A.

Hence, to estimate the factor loadings on a world risk factor we regress individual sovereign CDS daily spread changes on the first ten[3] principal components as follows:

$$\Delta S_{i,t} = \sum_{j=1}^{10} \beta_{i,j} PC_{j,t} + e_{i,t} \qquad (6)$$

Where $\Delta S_{i,t}$ represent the changes in daily sovereign CDS spreads between day t-1 to day t for country i and $PC_{j,t}$ represents the *jth* principal component estimated from all sovereign CDS spreads during day t.

To estimate equation (5) and to calculate average beta loadings, we follow Berger and Pukthuanthong (2012) in usng a 500 day rolling window for each country and place a decaying weighting scheme on previous daily observations such that the weight placed on daily observation t-x is equal to 0.995^{x-1} thereby allowing the impact of most recent days to be greater and lagged days to decay through time. Countries with less than 100 usable daily observations within the rolling 500 day window are dropped from our analysis.

Anecdotal evidence from the European sovereign debt crisis suggests that international sovereign credit markets have become more closely interconnected on a global level since 2009-2010 with the revelation of budgetary problems in Greece and subsequently other peripheral neighbours in Southern Europe creating fast and furious contagion throughout international debt markets. However, the downside to rising international comovements in sovereign CDS spread changes is that the sensitivities to global risks also heighten across

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[3] Pukthuanthong and Roll (2009) used the first ten principal components as they found these were sufficient to explain approximately 90% of the total variations in all country stock returns. Hence, following their approach we also use the first ten principal components in our analysis on daily log changes in sovereign CDS spreads but these together explain only 80% of the total variations whilst the first principal component is capable of explaining 21%.

countries within the global financial system. Hence, it is important for us to focus on the commonalities in global sovereign credit risk exposures across countries as indicators of global systemic risk in the sovereign debt markets.

Our systemic risk measure is computed by taking the cross-sectional average of the betas associated with the first principal component (primary global risk factor) of the sovereign CDS spread changes as follows

$$SysRisk_t = \frac{\sum_{i=1}^{N} \beta_{i,PC1,t}}{N} \qquad (7)$$

where $SysRisk_t$ is the aggregate systemic risk measure for all countries $i = 1,\ldots, N$ in a given cohort at time t. The beta loadings are estimated over a 500 day rolling window [t-1, t-500].

4.3 Determinants of systemic sovereign credit risk

In the final part of our empirical analyses we explore the determinants of global sovereign credit risks and the systematic risk exposure of national sovereign credits to the predominant global sovereign risk factor in the international financial system. Interdependence between asset price changes may change over time either from changing volatility in the underlying risk factor which is priced or time variations in the beta loading on that risk factor (Bekaert, Hodrick and Zhang, 2009). Hence, it is important to examine the determinants on both to comprehensively understand the systematic pricing of sovereign credit risk. There are many variables that could be potentially related to sovereign credit risk so we are guided by prior work in our selection of determinants. We focus on market-based variables which are also available at daily frequencies.

We use stock market returns on the S&P 500 index and the German DAX index; the change in the VIX implied volatility index on the S&P 500, the change in the VDAX implied volatility index on the DAX to proxy global risk appetite; the CDX North American Investment Grade index of CDS spreads and the European iTraxx index of CDS spreads to capture corporate credit conditions; and the CDX Emerging Market index of sovereign CDS spread and the 5-year constant maturity swap rate. We also compute a composite of the credit risk assessments provided by the three major credit rating agencies − Standard and Poors, Moodys Investor Services and Fitch to proxy global sovereign re-rating activity and changes in macroeconomic fundamentals. The data for all these variables are obtained from the Bloomberg system and Thomson Reuters Datastream.

5.   Main Findings

5.1 Intra-regional and global sovereign credit contagion 2002-2013

The sovereign credit events in each sample year based on significantly large jumps in sovereign CDS spreads are shown in Table 2. Over the full sample period there were 89 credit events arising from 20 countries. The average size of all the sovereign CDS spread jumps (at the threshold level k = 99.9%) were 228.36 basis points with the maximum spread jump being up to 1215.50 basis points and the smallest credit event was a jump of 43.45 basis points. Sovereign credit events occurred in all regions. Within Europe, the sovereign credit events pertained to Icelandic, Irish, Greek, Portuguese, Italian and Cypriot sovereign credits and within Emerging Europe the credit events were restricted to Russia and Ukraine. For Latin America, the sovereign credit events arose from Argentina, Brazil, Ecuador, Venezuela and Uruguay. For Middle East and North Africa, sovereign credit events were limited to

come from Lebanon, Bahrain and Turkey whilst in the Asia-Pacific region, they emanated from Indonesia and Pakistan. It can be seen that a large proportion of the 89 total credit events (75%) were concentrated around the 2008-2012 period. There were no sovereign credit events during 2004 and 2007 and only one event occurred during 2005. In all other years, there were multiple sovereign credit events. The number of sovereign credit events peaked in 2008 at 23 during the Global Financial Crisis (GFC) when credit events emanated from all regions in that year. The fallout from the sub-prime debt crisis continued into 2009-2010 with major sovereign credit events arising from Iceland and Ireland with their heavy exposures to sub-prime debt. Subsequently, sovereign credit events occurred for Greece, Italy, Portugal and Cyprus over 2010-2012.

[Insert Table 2 here]

The event study results on the impact of all sovereign credit events on regional and global sovereign credit portfolios are presented in Table 3 for the full sample period and two sub-sample periods post-GFC and post-European debt crisis. The event study results clearly indicate that sovereign credit events have immediate and significant effects on neighbouring sovereigns in the same geographical region. The intra-regional impacts are both statistically and economically significant. A sovereign credit event increased daily sovereign CDS spread changes in the region on the same day (t=0) by 13.38 basis points significant at the 1% level. However, there was also a significant cumulative impact of 20.12 bps over the 1 day window [-1, 0]. The cumulative impact was greater over the window [-1,1] at 24.39 bps. These regional credit portfolio reactions are all highly significant at the 1% level. This suggests that sovereign credit events on average increase the borrowing costs of the entire region

surrounding the event country during the two days on either side of the event. There were no significant effects beyond the [-1, 1] event window.

Interestingly, sovereign credit contagion is evident on the event day irrespective of the sub period analysed but it has been the strongest in the sub-sample (2007-2013) with the regional portfolio response being more economically significant than for the full sample. For instance, the portfolio cumulative mean spread change for sovereign credit events in the [-1,1] event window is 24.39 basis points for the full sample period but 28.03 basis points for the 2007-2013 GFC sub-sample and the significance of the reaction is strengthened. Similar evidence is borne out for the day-0 regional credit spread change which increases from 13.38 bps to 16.90. In the 2007-2012 sub-sample period, the impacts of sovereign CDS jumps in individual countries had pervasive and prolonged effects on regional portfolios consistent with heightened levels of risk aversion across all financial markets at the time. The two sub-sample period results also indicate that sovereign credit events have been anticipated and already affected regional sovereign credit portfolios even two days prior to the event day. The day-0 response remains strongly significant after 2009, and the results imply spread changes of 10.82 for the post-European debt crisis period. While the cumulative regional effects during the 2009-2013 post-European debt crisis sub-sample remain present for windows [1, 1] and [-1, 0] and fairly consistent with the full-sample results, the regional response is not as strong as for the 2007-2013 post-GFC sub-sample. The results suggest that the credit events of 2008 triggered by the credit crunch had the most notable impact on the default riskiness of the neighbouring countries. It should also be noted that the number of credit events peaks in 2008.

[Insert Table 3 here]

Panel B of Table 3 presents the reaction of the global credit portfolio to sovereign credit events. The results suggest that credit contagion is also present at the global level but the impact of the events is dampened (roughly half of that in the regional portfolios). The significant effects appear in days 0 and day +1, which implies that there is no anticipation at the global level as opposed to the case of the regional portfolios where the credit events seem to be anticipated a priori and fully reflected in the credit spreads of the region by the end of day 0. Interestingly, the post-European debt crisis sub-sample shows very weak response, for day 0 and cumulatively for [0,1] significance drops to the 10% level and is economically insignificant.

5.2 Time-varying systemic sovereign credit risks

The dynamics of estimated beta loadings (systemic risk exposures) on the primary global risk factor in our multi-factor global asset pricing model is illustrated in Figure 2 and the summary statistics are provided in Table 4.

[Insert Figure 2 & Table 4]

In Table 4, systemic risk levels measured by the cross-sectional average of these beta loadings are highest on average for Eastern Europe and MENA (average betas of 0.87 and 0.83 respectively) and the lowest for North America's sole representative country, the United States (beta of 0.08). Outside of North America, the Asia Pacific displays the lowest levels of systemic risk exposures (average beta of 0.42). However, it is also evident in Figure 2 that systemic risk exposures to global sovereign credit risk varies dramatically over time. Latin American sovereigns have typically been the most variable in their systemic risk exposures

(with a standard deviation of 8.92) followed by the group of Asia Pacific nations (with a standard deviation of 4.91). Whilst Europe and Eastern European sovereigns have traditionally been the least volatile in their systemic risk exposures (standard deviations of 1.07 and 1.69 respectively), since late 2010, the systemic risk levels of sovereigns in Europe have surpassed those of all other regions. Despite having declined rapidly in late 2012 the systemic risk levels have rebounded to remain largely above those of other regions suggesting that the European Debt Crisis continues to make European sovereign debt markets systemically fragile. The periods of highest systemic risk was concentrated from late 2010 to mid-2011 for all regions except Europe which became systemically fragile later on in the escalation of the European Debt Crisis. These highest levels of systemic risk coincided with the sovereign credit jumps from Portugal, Iceland, Italy and Ireland and Greece (PIIIG) over 2009-2011.

In Figure 2, we illustrate that there are indeed significant variations in systemic sovereign credit risk over time. Systemic risk has built up significantly post-GFC as evidenced by the significant jump in the common sensitivity to global risk (captured by the cross-sectional average of beta loadings) at the end of 2010. Systemic risk levels have reached historical highs and are economically significant with a 1% jump in global sovereign credit risk leading to at least a 3.63% increase in all national sovereign CDS spreads at its fragile height (99th percentile). In fact, there was a major jump in systemic risk levels for all regions in late in 2010 when debt concerns arose for Greece and again in 2011 when the concerns spread to Portugal then Italy. Systemic risk levels for non-European regions appear to have plateaued from the end of 2011. The dynamics of systemic sovereign credit risk have been fairly consistent across all regions.

5.3 Regression results for explaining global sovereign credit risk and systemic sovereign risk exposures across regions

To understand the effects of sovereign credit contagion on the build-up of systemic sovereign credit risks we first examine the determinants of global sovereign credit risk levels (underlying factor volatility) and then the exposures (beta loadings) to that risk over time. Bekaert, Hodrick and Zhang (2009) highlight that both channels can contribute to overall convergence in financial prices. Hence, we compare a common set of market-based and fundamental-based determinants for both the global risk factor and the beta loading on that factor to understand the influences exerted by different geographical regions.

In Table 5, we report the time series regression results for explaining the underlying global sovereign credit risk factor (estimated as the first principal component from the initial principal component analysis). We uncover three main results regarding the global sovereign credit risk factor. First, in model specifications 1 to 5 we establish that sovereign credit risk is indeed significantly related to episodes of sovereign credit contagion. The positive relation indicates that when there is a sovereign credit event, global sovereign credit risk increases by between 6.683 - 7.756 basis points (depending on the mix of control variables) and this is statistically significant at the 5% level. Model 5 indicates that sovereign credit contagion from MENA and Europe is the most significant both statistically and economically with a credit event in these regions increasing daily global sovereign credit risk by 3.254 and 62.65 basis points respectively. In our sample period over 2006-2013, of all regions, Latin America is the only one which has jumps in sovereign CDS spreads that have not led to a heightening in global sovereign risks. This is not surprising given that most of the sovereign troubles have been concentrated in the Middle East and European nations over this recent period. Second,

global sovereign credit risk is predominantly influenced by US market variables as it is completely insensitive to European financial market developments (in model specification 2). There is a significant positive relation between global sovereign credit risk and US stock market returns and the VIX but a negative relation with corporate credit spreads. Third, there is strong evidence to suggest that the global sovereign risk factor is not driven by fundamentals. The average fundamentals in models 1 and 2 across all sample countries as well as the regional components for sovereign credit rating changes and debt to GDP in models 3 and 4 respectively are all insignificant suggesting that global movements in sovereign credit spreads are predominantly driven by market forces and as not country-specific fundamentals corroborating with the findings of Ang and Longstaff (2013). Global sovereign credit risk is positively tied with the perceived default risk of China suggesting that there is a significant influence exerted by the economic performance of China globally.

[Insert Table 5]

In Table 6, we report the time series regression results for explaining the common sensitivity to global sovereign credit risks captured by the estimated beta loadings. We reveal a stark difference in the determinants of the beta loadings versus the underlying global sovereign credit risk factor. Fundamental variables are actually significant in driving the common exposure to global sovereign credit risk across ALL countries whilst they do not affect the underlying risk level. There is a negative relation between sovereign credit rating changes and systemic risk exposure in most cases indicating that sovereign credit rating downgrades tend to heighten the sensitivity to global sovereign credit risks as expected. The positive relation with debt to GDP levels for all countries and specifically the Latin American and European regions suggest that market participants are highly sensitive to fiscal positions in

those regions that are either historically or currently plagued by debt troubles. Market variables are also significant for explaining the systemic exposures to global sovereign credit risk and the signs are largely as expected and consistent with prior studies assessing the explanatory power of market-based variables for sovereign CDS spreads (Ang and Longstaff (2013), Longstaff et al. (2010) and Dieckmann and Plank (2012)). Our results corroborate strongly with those of Berne and Fratscher (2012) as they show that a sharp rise in the sensitivity of financial markets to economic fundamentals has been the main cause of rising sovereign yield spreads and sovereign CDS spreads globally.

Interestingly, we find that episodes of credit contagion are negatively related to the systemic risk exposures to sovereign credit risk indicating that whilst they significantly increase underlying risk levels on average, the risk exposure is actually dampened. This is an important result as it suggests that systemic risk is not increased by sovereign credit contagion in international debt markets. As expected, regional credit events have the most influence on the region's own systematic risk exposure to global sovereign credit risks especially within Europe and MENA.

There is a variation in the risk exposures across regions but the Asia-pacific region is by far the least sensitive to all market and fundamental determinants. Besides being positively affected by the sovereign credit risks of China and revisions in its own sovereign credit ratings, there are not other significant influences on the risk exposure of countries in the Asia-pacific. This indicates that the Asia-pacific's systemic risk is purely based on fundamental sovereign default risks and the economies in these regions are highly dependent on the continuation of China's growth story.

[Insert Table 6]

In sum, we find that sovereign credit risks at the global level are driven by largely international market developements but the systemic risk exposure to global sovereign credit risk is driven by a mix of fundamental and market based variables. We conjecture that the sensitivity to international market conditions in sovereign credit markets is perhaps related to the fact that there is no standard legal process for dealing with the fallout from sovereign defaults unlike for corporate bankruptcy and credit defaults. Whilst international organisations like the IMF have helped countries to work out repudiations and debt restructuring in the past, there exists to date, no international bankruptcy regime for restructuring defaulted sovereign debt. This unique element of sovereign credit may induce market participants to panic more collectively in times of sovereign distress as evidenced by the heightened levels of systemic risk in recent years.

6. Conclusions

In this study, we have examined aggregate sovereign credit risk in the international financial system at both a regional and global level. We first utilise an event study approach to gauge the impact of large jumps in sovereign credit spreads (which we define as sovereign CDS credit events) first on neighbouring countries' sovereign credit risk premia within the same geographical region and second on all other countries in the rest of the world. We subsequently study the time-variations in the degree of systemic sovereign credit risks based on their common sensitivities to a global sovereign credit risk factor generated from principal component analysis. Finally, to understand the flow-on effects of sovereign credit contagion onto global systemic sovereign credit risks, we examine the determinants of both the

underlying global sovereign credit risk factor itself as well as the beta loading on the global risk factor (systemic risk exposure).

We find there are immediate intra-regional impacts from sovereign credit events and most episodes of sovereign credit contagion have concentrated within the period after the Global Financial Crisis (from 2008-2012). We are able to document that this concentration of sovereign credit contagion within regions also had immediate global effects outside of the affected regions and ultimately escalated to heightened global sovereign credit risk levels.

However, in separately analysing the determinants of global sovereign credit risks and the common exposures to that risk we uncover that systemic risk exposures to sovereign credit risk is not increased by episodes of sovereign credit contagion in international debt markets. Whilst sovereign credit contagion increases the levels of sovereign credit risk globally and has adverse spillover effects on other sovereign's credit spreads both intra-regionally and globally, it does not increase the systemic exposure to heightened global risk meaning that market participants view these sovereign credit deteriorations as largely regional problems when pricing sovereign credit risks. There are clear implications of the findings from this research for policymakers in having a better understanding of the nature of systemic sovereign credit risks.

Overall, we extend the literature focusing on the international propagation of sovereign credit shocks and provide new evidence on its transmission mechanism via changes to global sovereign credit risks and the exposure to that global risk factor over time. We contribute an improved understanding of the common pricing mechanism for sovereign credit risk and a new time-varying measure of systemic sovereign credit risk which is a useful metric for

monitoring aggregate risks in sovereign debt markets. Our analysis is able to pinpoint the credit contagion events that led to rising global sovereign credit risks in the international financial system in recent years but at the same time highlight that these did not make international sovereign debt markets more fragile. Moreover, our systemic risk measure can be used in real-time so that policy makers are aware when shocks are likely to have the greatest impact and they can time regulatory reforms and bailout announcements accordingly.

Whilst international banking exposures act as an important channel of contagion, we leave the investigation of the influence of sovereign debt holdings by the financial sector on sovereign credit contagion and systemic risks for future research.

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Figure 1. Eigenvalues for sovereign CDS spreads 2003-2013
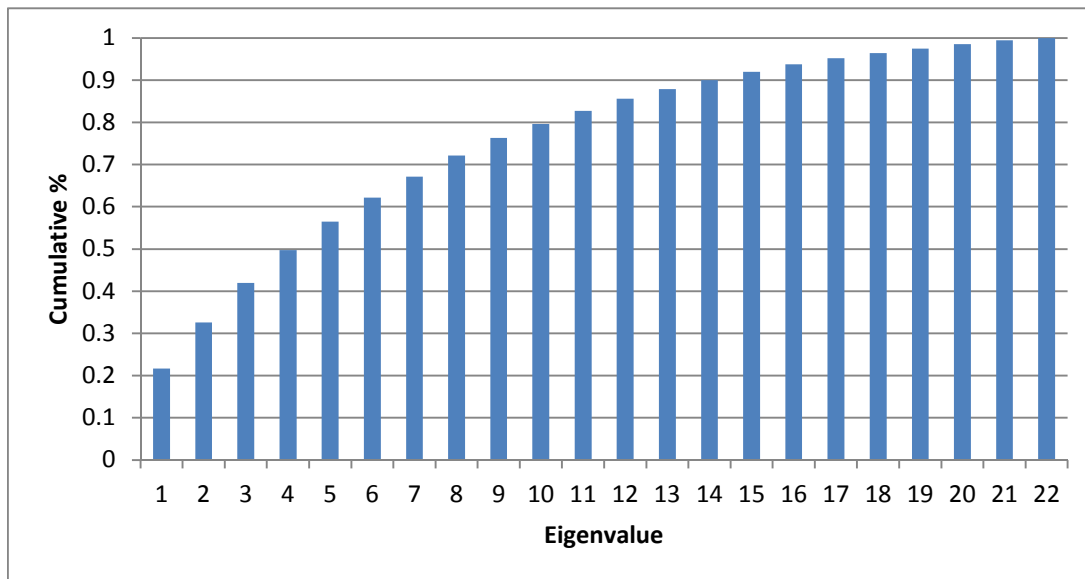
Figure 2. Time-Varying Systemic Sovereign Credit Risk Exposures by Regions from 2006-2013

This figure shows the levels of systemic risk in sovereign credit markets for each region over the period from 2006-2013. Systemic sovereign credit risk exposure is measured as the average of the estimated beta loadings on the global sovereign risk factor which is estimated from the 500 day rolling regression of country credit default swap spread changes on the first principal component from day t-1 to t-500. They are estimated by out-of-sample principal components based on the covariance matrix in the previous calendar year computed with the returns from 17 major countries; that consists of Brazil, Venezuela, Mexico, Turkey, Colombia, Philippines, Malaysia, Russia, Thailand, Korea, China, Panama, Bulgaria, Poland, Qatar, Peru and Croatia. We also place a decaying weighting scheme on previous daily observations such that the weight placed on observation t-x equals 0.995^x-1.

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 daily observations across regions.

Region	N x T	Mean	Median	StDev	Max	Min	Quantiles		
							95%	99%	99.90%
Panel A: CDS spreads									
Latin America	34600	395	181	735	10350	0	1193	3540	10350
Europe	47697	110	14	471	21681	0	440	1109	8052
Eastern Europe	35478	172	102	260	5479	3	531	983	3361
MENA	22572	198	153	170	1254	8	513	807	1148
Asia-Pacific	31458	153	79	258	3334	1	559	935	3014
Panel B: CDS spread changes									
Latin America	34236	0.0811	0.0000	39.05	1865.21	-4162.33	18.35	62.22	271.88
Europe	47318	0.5570	0.0000	61.03	8439.10	-3950	5.69	23.37	44.65
Eastern Europe	38348	0.0046	0.0000	14.86	1410.07	-707.10	9.37	28.03	106.15
MENA	22494	-0.0307	0.0000	8.57	257.29	-136.59	7.61	22.62	77.09
Asia-Pacific	31643	-0.0026	0.0000	16.60	834.88	-1005.52	6.55	21.31	114.15

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

This table provides a break-down of the number of sovereign credit events in total and the number of regions from which these events arose as well as the countries where they emanate for each year over the sample period from 2002-2013. Summary statistics on the average size, standard deviation and the range of the jumps in sovereign CDS spreads underpinning 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	6	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 reactions to sovereign credit events

This table presents the average reaction of regional (Panel A) and global (Panel B) portfolio credit spreads to each sovereign credit event in basis points on days surrounding the event date and over different events 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 non-event countries in the sample plus the U.S.

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	-6.87	-1.22	-6.79	-2.34 **	-10.59	-2.70 ***
-1	6.74	1.20	7.43	2.56 ***	6.48	1.65
0	13.38	2.37 ***	16.90	5.82 ***	10.82	2.76 ***
1	4.27	0.76	3.70	1.28	1.27	0.32
2	1.17	0.21	0.84	0.29	0.82	0.21
[-2, 0]	13.25	1.36	17.55	3.49 ***	6.71	0.99
[-1, 0]	20.12	2.52 ***	24.33	5.92 ***	17.30	3.12 ***
[0, 1]	17.65	1.57	20.60	3.55 ***	12.08	1.54
[0, 2]	18.82	1.11	21.45	2.46 ***	12.90	1.10
[-2,2]	18.69	1.48	22.09	3.40 ***	8.79	1.00
[-1,1]	24.39	2.50 ***	28.03	5.57 ***	18.56	2.74 ***
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

Table 4. Summary on systemic sovereign credit risk exposures across regions

This table reports summary statistics for the levels of systemic risk in sovereign credit markets within each region and across all countries over the period from 2/12/2004-31/12/2012. Systemic sovereign credit risk is measured as the average of the estimated beta loadings on the global sovereign risk factor which is estimated from the 500 day rolling regression of country credit default swap spread changes on the first principal component from day t-1 to t-500. They are estimated by out-of-sample principal components based on the covariance matrix in the previous calendar year computed with the returns from 17 major countries; that consists of Brazil, Venezuela, Mexico, Turkey, Colombia, Philippines, Malaysia, Russia, Thailand, Korea, China, Panama, Bulgaria, Poland, Qatar, Peru and Croatia. We also place a decaying weighting scheme on previous daily observations such that the weight placed on observation t-x equals 0.995^{x-1}. Nobs represents the number of observations. The statistics described below includes the mean, standard deviations, the minimum and maximum value, median, number of observations, the 95th percentile and 99th percentile.

	Mean	Std. Dev.	Min.	Med.	Max.	N	p 95	p 99
ALL	0.65	3.70	-763.88	0.55	360.67	1803	2.97	8.57
Latin America	0.66	8.92	-763.88	1.28	360.67	1803	4.08	8.90
Europe	0.56	1.07	-32.74	0.06	37.32	1822	2.68	3.63
Eastern Europe	0.87	1.69	-117.95	0.59	62.83	2235	2.49	6.50
MENA	0.83	3.37	-63.28	0.42	82.72	2164	4.32	12.24
Asia Pacific	0.42	4.91	-374.48	0.59	279.49	2148	1.94	15.96
North America	0.08	0.10	-0.07	0.05	0.44	2375	0.31	0.42

Table 5. Determinants of global sovereign credit risk over 2006-2013

This table reports the estimated coefficients and other summary statistics from the regression of the global sovereign credit risk factor (first principal component) on the indicated variables. In Columns 1 and 3-5, Stock market return denotes the return on the S&P500 stock market index and in column 2 it is the DAX stock market index return. In column 1 and 3-5, Implied_Vol denotes the daily change in the VIX volatility index and in column 2 it is the daily change in the VDAX volatility index. In column 1 and 3-5, Itrx_Corporate denotes the daily change in the CDX IG index and in column 2 it is the daily change in the ITraxx index for Europe. China denotes the daily changes in the sovereign CDS spreads for China. Sov_Rating_Chg are the changes in sovereign credit rating assessments made by Standard and Poors, Moodys and Fitch averaged across all countries (and this is also constructed by regions – LA=Latin America, EU=Europe, EEU=Eastern Europe, MENA=Middle East and North Africa, AP=Asia-Pacific). Debt_GDP is the average ratio of each country's general government gross debt to Gross Domestic Product (and this is also constructed by regions). ALL_Creditevent is an indicator variable that is equal to one when there is a credit contagion event within any sample country (and this is also constructed by region). Adj. R-sq are the adjusted R-squared values for the time series regressions. Nobs denotes the number of days used in the regressions. P-values are reported in parentheses (*, **, *** denote significance at the 10, 5 and 1% respectively).

	1	2	3	4	5
Stock market return	0.00302**	-0.0000458	0.00741	-0.000341	0.00243
	(0.042)	(0.883)	(0.311)	(0.956)	(0.666)
Implied_Vol	0.372**	0.132	0.397**	0.380**	0.262
	(0.03)	(0.52)	(0.038)	(0.043)	(0.158)
Itrx_Corporate	-0.0556**	-0.0164	-0.0456**	-0.0605**	-0.0365
	(0.011)	(0.552)	(0.018)	(0.041)	(0.166)
China	2.058	2.851	2.309**	2.856*	2.148
	(0.155)	(0.144)	(0.038)	(0.051)	(0.117)
ALL_Sov_Rating_Chg	0.884	1.662			
	(0.588)	(0.406)			
All_Debt_GDP	-0.0372	-0.0771	0.165		
	(0.73)	(0.418)	(0.331)		
ALL_Creditevent	6.848**	7.756***	6.790**	6.683**	
	(0.01)	(0.005)	(0.011)	(0.012)	
LA_Sov_Rating_Chg			-0.254	-0.0697	-1.461
			(0.950)	(0.985)	(0.701)
EU_Sov_Rating_Chg			0.585	1.545	1.011
			(0.358)	(0.170)	(0.367)
EEU_Sov_Rating_Chg			0.874	0.31	0.0396
			(0.710)	(0.925)	(0.990)
MENA_Sov_Rating_Chg			11.26	13.61	10.91
			(0.301)	(0.234)	(0.301)
AP_Sov_Rating_Chg			-2.987	0.832	4.533
			(0.798)	(0.937)	(0.664)
LA_Debt_GDP				0.378	0.105
				(0.225)	(0.710)
EU_Debt_GDP				0.55	0.22
				(0.136)	(0.536)
EEU_Debt_GDP				0.0359	0.0983
				(0.668)	(0.205)
MENA_Debt_GDP				0.0675	0.141
				(0.75)	(0.487)
AP_Debt_GDP				-1.399	-0.634
				(0.165)	(0.531)
LA_Creditevent					1.183
					(0.851)
EU_Creditevent					3.254***
					(0.005)
EEU_Creditevent					15.46*
					(0.058)
MENA_Creditevent					62.65***
					(0.003)
AP_Creditevent					9.704**
					(0.041)
Adj. R-sq	7%	3.9%	6.8%	7%	17%
Nobs	1483	1509	1482	1482	1482

Table 6. Determinants of systemic sovereign credit risk exposures over 2006-2013

This table reports the estimated coefficients and other summary statistics from the regression of daily systemic risk measures (estimated beta loadings) on the indicated variables. Stock market return denotes the return on the S&P500 stock market index for ALL countries, Latin America, MENA (Middle East and North Africa) and the Asia-Pacific region and the DAX stock market index return for Europe and Eastern Europe. Implied_Vol denotes the daily change in the VIX volatility index for ALL countries, Latin America, MENA and the Asia-Pacific regions and the daily change in the VDAX volatility index for Europe and Eastern Europe. Itrx_Corporate denotes the daily change in the CDX IG index for ALL countries, Latin America, MENA and the Asia-Pacific region, and the daily change in the ITraxx index for Europe and Eastern Europe respectively. China denotes the daily changes in the sovereign CDS spreads for China. 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 average ratio of each country's general government gross debt to Gross Domestic Product. Reg_Creditevent (Other_Reg_Creditevent) is an indicator variable that is equal to one when there is a credit contagion event within (outside of) the respective region. Adj. R-sq are the adjusted R-squared values for the time series regressions. Nobs denotes the number of days used in the regional regressions. P-values are reported in parentheses (*, **, *** denote significance at the 10, 5 and 1% respectively).

	ALL	Latin America	Europe	Eastern Europe	MENA	Asia-Pacific
Stock market return	0.00602**	-0.00289***	-0.000525**	0.000244***	-0.00298***	0.00127
	(0.024)	(0.000)	(0.029)	(0.000)	(0.000)	(0.593)
Implied_Vol	0.0598*	-0.0501***	0.312**	0.0102**	0.0350***	0.0178
	(0.095)	(0.000)	(0.041)	(0.013)	(0.000)	(0.343)
Itrx_Corporate	0.0175**	-0.00125	-0.0669**	0.00604***	-0.0178***	0.00722
	(0.018)	(0.721)	(0.030)	(0.000)	(0.000)	(0.112)
China	-0.649	0.478***	-5.481***	-1.042***	-0.502***	2.710*
	(0.253)	(0.000)	(0.008)	(0.000)	(0.005)	(0.085)
Sov_Rating_Chg	-5.971**	1.114***	-7.428***	-1.961***	24.56	-4.238**
	(0.011)	(0.000)	(0.007)	(0.000)	(0.527)	(0.038)
Debt_GDP	0.138**	0.124***	0.122**	-0.00953	-0.00376	-0.0375
	(0.047)	(0.000)	(0.014)	(0.478)	(0.839)	(0.673)
Reg_Creditevent	-1.465**	0.208	-7.162**	0.0811	-0.807**	0.0241
	(0.016)	(0.754)	(0.028)	(0.807)	(0.016)	(0.969)
Other_Reg_Creditevent		-0.385	-4.664**	-0.0923	-0.216	0.0173
		(0.600)	(0.029)	(0.452)	(0.444)	(0.936)
Adj. R-sq	1.2%	3.2%	1.2%	19.1%	2.9%	0.2%
Nobs	2151	2100	2125	2147	2130	2133

APPENDIX

Appendix Table A Constituents of Regional Cohorts

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		
CostaRica	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