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Netspar DISCUSSION PAPERS

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Systemic Sovereign Credit Risk

Lessons from the U.S. and Europe

DP 04/2011-067

SYSTEMIC SOVEREIGN CREDIT RISK:

LESSONS FROM THE U.S. AND EUROPE

Andrew Ang
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Abstract. We study the nature of systemic sovereign credit risk using CDS spreads for the U.S. Treasury, individual U.S. states, and major European countries. Using a multifactor affine framework that allows for both systemic and sovereign-specific credit shocks, we find that there is considerable heterogeneity across U.S. and European issuers in their sensitivity to systemic risk. U.S. and Euro systemic shocks are highly correlated, but there is much less systemic risk among U.S. sovereigns than among European sovereigns. We also find that U.S. and European systemic sovereign risk is strongly related to financial market variables. These results provide strong support for the view that systemic sovereign risk has its roots in financial markets rather than in macroeconomic fundamentals.

Current draft: April 2011.

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Electronic copy available at: http://ssrn.com/abstract=1815502

1. INTRODUCTION

Recent shocks in the European debt markets have given financial market participants deep concerns about the rapidly-growing amount of sovereign credit risk in the global financial system. These concerns have increased with the rapid widening of all credit spreads throughout Europe in the wake of the Greek and Irish debt crises. This widening has also raised fears that sovereign credit risk may be far more systemic in nature than previously anticipated. Given the massive size of the sovereign debt markets, it is clear that understanding the systemic nature of sovereign credit risk is of fundamental importance.[1]

Furthermore, studying systemic sovereign credit risk may also help resolve the longstanding debate about the source of systemic risk in financial crises. In particular, one strand of the literature views systemic risk as arising from the effects of common macroeconomic shocks on economic fundamentals. Key examples include Gorton (1988), Calomiris and Gorton (1991), Allen and Gale (2000a), Calomiris and Mason (2003), Reinhart and Rogoff (2008, 2009), and others. In contrast, the other strand focuses primarily on the role that financial markets play in creating systemic risk through channels such as capital flows, funding availability, risk premia, and liquidity shocks. Important examples include Diamond and Dybvig (1983), Kaminski, Reinhart, and Vegh (2003), Allen and Gale (2000b), Kodres and Pritsker (2002), Brunnermeier and Pedersen (2009), Allen, Babus, and Carletti (2009), and others.

This paper provides an entirely new perspective on systemic sovereign credit risk by contrasting the systemic credit risk of states within the U.S. with that of sovereign issuers within Europe. For the U.S., we examine the systemic credit risk of the U.S. itself and ten of the largest states by GDP such as California, Texas, and New York. In Europe, our dataset consists of countries within the European Monetary Union (EMU). We examine the credit risk of both core countries, such as France and the Netherlands, and periphery countries, such as Greece and Ireland.

In many ways, the relation between U.S. states closely parallels that of the sovereigns in the EMU. First, under the U.S. Constitution, states are sovereign entities and can repudiate their debts without bondholders being able to claim assets in a bankruptcy process. In fact, several states have defaulted on and repudiated debt in the past. Thus, states within the U.S. have sovereign immunity just as

[1] As evidence of the growing seriousness of the problem, Standard and Poors cut its outlook on the AAA rating of the U.S. from stable to negative on April 18, 2011. Furthermore, discussions of the possibility of a default by the U.S. or by a U.S. state are becoming much more frequent in the financial press. For example, see Samuelson (2009), Wessel (2010), Buttonwood (2010), and Rampell (2011).

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countries within the EMU. Second, each set of sovereigns is in a currency union; U.S states share the dollar as a common currency, while EMU members have the Euro as their common currency. In addition, there are many economic, legal, and political linkages between states, just as there are similar linkages among European countries. On the other hand, sovereign debtors in the U.S. have much closer fiscal linkages than is the case in the EMU. Thus, if systemic risk is driven by common shocks to macroeconomic fundamentals, one would expect a higher level of systemic risk among U.S. states than would be the case among European sovereigns.

In this study, we make use of a novel dataset of state and sovereign credit default swap (CDS) spreads. An key advantage of using CDS data is that it provides a much more direct measure of the credit risk of a sovereign than do sovereign debt spreads. This is because sovereign debt spreads are driven not only by sovereign credit risk, but also by interest rate movements, changes in the supply of the underlying bond, illiquidity effects in sovereign debt prices, and other factors.

In studying sovereign credit risk, our approach will be to first develop an affine credit framework that allows for both systemic risk and sovereign-specific risk. In particular, we extend an affine sovereign credit model similar to that of Pan and Singleton (2008) and Longstaff, Pan, Pedersen, and Singleton (2011) to a multivariate setting. In this framework, nonsystemic shocks lead to individual sovereign defaults while the realization of a systemic shock may trigger a cascade of defaults. We estimate the multivariate model using the full cross section of CDS term structure data for U.S. sovereigns, and similarly for the European sovereigns. A key advantage of this approach is that it provides us with a direct measure of the sensitivity of sovereign debtors to systemic shocks.

A number of important empirical results emerge from this analysis. First, we find that there is dramatic variation across sovereigns in terms of their exposure to systemic shocks. For example, California has more than five times as much systemic risk as the average for the other states in the sample, and nearly three times as much as the U.S. Treasury. In stark contrast, New York has virtually no systemic risk; New York's credit risk appears to be almost entirely idiosyncratic in nature. In Europe, Greece has about three times the systemic risk of other vulnerable sovereigns such as Portugal, Ireland, Italy, Spain, and Belgium, which, in turn, have roughly twice as much systemic risk as the remaining sovereigns in the EMU.

Second, we show that there is much less systemic sovereign risk in the U.S. than in Europe. In particular, systemic credit risk represents only about 12 percent of the total credit risk of U.S. states. In contrast, systemic credit risk constitutes about 31 percent of the total credit risk of the European sovereigns. These results provide direct evidence against the hypothesis that the tighter macroeconomic linkages should lead to higher levels of systemic risk in the U.S. than in Europe.

Third, we find that systemic sovereign credit risk in both the U.S. and Europe is strongly related to financial market variables. Specifically, systemic sovereign credit risk in the U.S. declines significantly when the S&P 500 increases, and similarly for Europe when the DAX increases. Systemic sovereign risk in the U.S. is also significantly related to changes in interest rates and and corporate credit. Curiously, U.S. systemic risk is strongly negatively related to changes in the VIX volatility index. This is consistent with the view that when global financial markets experience turbulence, the U.S. may benefit from flight-to-quality-related capital flows. These results provide new evidence that systemic risk has deep roots in the flows and liquidity of financial markets.

There is an extensive literature on sovereign credit risk. Previous theoretical work focuses on the incentives faced by sovereign debtors to repay their debt. Examples include Eaton and Gersovitz (1981), Grossman and Van Huyck (1988), Bulow and Rogoff (1989a, b), Atkeson (1991), Dooley and Svenson (1994), Cole and Kehoe (1996, 2000), Dooley (2000), and many others. A number of empirical studies focus on the factors that determine individual sovereign credit spreads. These include Edwards (1984, 1986, 2002), Berg and Sachs (1988), Boehmer and Megginson (1990), Duffie, Pedersen, and Singleton (2003), and Zhang (2003). Some recent research provides evidence that sovereign credit spreads are related to common global and financial market factors. For example, see Kamin and von Kleist (1999), Eichengreen and Mody (2000), Mauro, Sussman, and Yafeh (2002), Geyer, Kossmeier, and Pichler (2004), Rozada and Yeyati (2005), Remolona, Scatigna, and Wu (2008), Pan and Singleton (2008), and Longstaff, Pan, Pedersen, and Singleton (2011). This paper contributes to the literature by being the first to focus on U.S. sovereign credit risk and to contrast it with U.S. state credit risk and sovereign credit risk within the EMU. The paper also is the first to estimate the systemic component of sovereign credit spreads from the cross section of CDS term structures.

The remainder of the paper is organized as follows. Section 2 discusses federal and state credit risk within the U.S. and compares it with European sovereigns. Section 3 describes the sovereign CDS data used in the study. Section 4 presents the multivariate affine credit model. Section 5 discusses the estimation of the model. Section 6 studies systemic credit risk of sovereigns in the U.S. and Europe. Section 7 explores the properties of the sovereign-specific portion of sovereign credit risk. Section 8 provides concluding remarks.

2. U.S. FEDERAL, STATE, AND EUROPEAN SOVEREIGNS

U.S. states are comparable to EMU member countries in many ways. First, the GDP of states is roughly similar to the GDP of European countries. Second, and probably less familiar, is that U.S. states have the same sovereign immunity as

countries in that states can repudiate debt, creditors have few, if any, rights to claim assets, and there is no bankruptcy mechanism. Third, both U.S. states and European nations have long histories of default.

2.1 Economic Size of U.S. States and European Sovereigns

The GDP of U.S. states is roughly comparable to the GDP of EMU countries both in terms of levels and dispersion. Table 1 reports the 2009 nominal GDP of the U.S. states and EMU countries used in our study. California's economy is larger than Spain and approximately 90 percent the size of Italy and 70 percent the size of France. The dispersion of GDP across the largest states is also roughly similar to the dispersion of GDP across EMU countries. Florida is roughly equivalent to the Netherlands and Ohio has approximately the same GDP as Belgium. Michigan, despite its recent industrial decline, still has an economy greater than Greece, Portugal, or Ireland taken separately. Thus, U.S. states are roughly comparable economically to their EMU country counterparts.

2.2 Sovereign vs. Corporate Default

Sovereign default is different from corporate default in three important ways. First, if a corporation decides not to repay its debts, bondholders would sue and the courts would hand over assets held in collateral to the bond holders. The U.S. bankruptcy code (Chapters 7 and 11) has both liquidation and restructuring mechanisms to enforce creditor rights. In contrast, if a sovereign repudiates, most of the assets are located domestically within a country and a sovereign cannot credibly commit to handing these assets over in the event of default.

Second, the concept of sovereign immunity protects sovereign assets, even when they are held outside the country. Sovereign immunity prevents individuals from suing countries. Several court cases, international treaties, and legislative changes have weakened the protection of sovereign immunity, but it remains the case that in the U.S., the federal government cannot be sued by an individual unless it has waived immunity or consented to a suit.[2] The grounds for a suit, as specified for example in the 1946 Federal Tort Claims Act, are very narrow and apply only when a federal employee has committed a tort (and excludes breaches of contract).

Third, unlike corporate default, there is no international recognized process for handling sovereign defaults. Certainly, there are international bodies such as the In-

[2]See Panizza, Sturzengger and Zettelmeyer (2009) for a recent summary of these developments and a summary of the sovereign default literature.

ternational Monetary Fund and consortiums of commercial banks and governments which have helped restructure sovereign debt in the various international debt crises in the 20th Century (see Reinhart and Rogoff (2009) for a detailed timeline), but these have all been ad-hoc responses. Despite some economists showing that an international bankruptcy regime for restructuring defaulted sovereign bonds would be optimal (see, for example, Bolton and Jeanne, (2007)), currently there is no such mechanism for dealing with sovereign default.

State debt is similar to sovereign debt. The 11th Amendment to the U.S. Constitution guarantees that states are treated as sovereigns—no individual, domestic or foreign, can bring suit against a state, with one exception. Suits can be brought against states only with the consent of a state.[3] Thus, just as individual investors cannot claim the assets of the federal government, investors cannot seize state property. Furthermore, in the one case where another sovereign sued a state (*Principality of Monaco v. Mississippi*), the Supreme Court ruled in 1934 that foreign countries cannot sue U.S. states without their consent. Thus, states have sovereign status and there is also no bankruptcy mechanism for handling state default in the U.S., just as there is no international sovereign bankruptcy court.[4] Thus, state and federal debt have economically equivalent status.

In summary, state governments have sovereign protection. This makes U.S. state debt similar to the sovereign debt of sovereign countries—individual investors cannot claim state property or the property of sovereign nations, there is no ability to force a state to pay in the even of repudiation, and there is no legal mechanism to restructure defaulting state debts. The last would not be important if U.S. states would never default – but they have in the past, and may in the future, as we now describe.

2.3 U.S. Federal and State Default

Although the U.S. has legally never defaulted on its debt, it has unilaterally changed the terms of its debt. The 1934 Gold Reserve Act changed the value of a U.S. dollar from $20.67 per troy ounce to $35. Economically this is a default; the U.S. reduced the value of its debt payments relative to an external measure of value and at that time all major currencies were backed by gold. Reinhart and Rogoff (2008) classify

[3]It is notable that despite the many attempts to collect money through the courts from defaulted states, not one defaulting state has ever given consent (see McGrane (1935) for a detailed account).

[4]Local municipalities in certain states can enter Chapter 9 of the Bankruptcy Code similar to Chapter 11 for corporations. However, this does not apply to states.

the U.S. abrogation of the gold clause in 1934 as a default.

In contrast to the implicit default on federal obligations during the Great Depression, the history of state debt in the U.S. is littered with episodes of explicit defaults. Many states have defaulted. In the 1830s and 1840s, several states issued debt to finance canals and railroads. McGrane (1935) discusses these events in detail and lists eight defaulting states and one territory: Arkansas, Florida Territory, Illinois, Indiana, Louisiana, Maryland, Michigan, Mississippi, Pennsylvania. McGrane notes that most states resumed payment, but Florida Territory and Mississippi repudiated their debt completely (also see English (1996)).

These bonds were widely held in Europe, particularly in the United Kingdom. Markham (2002) notes that the drop in value of these bonds and their credit risk was the subject of a nightmare of Ebenezer Scrooge in Charles Dickens' 1843 novel, *A Christmas Carol*, in which Scrooge's investments withered into a "mere United States security."

The partial or complete repudiation of these states' debts was even placed in states' constitutions, or legislation was passed prohibiting payment. McGrane (1935) recounts that when Florida achieved statehood, it wiped out its debt by legislative fiat and its legislature voted that it did not bear liability for debts incurred while Florida was still a territory. Similarly, in 1875, Mississippi's state constitution was amended forbidding any payment on bonds issued on behalf of its two chartered banks, Planters' and the Union. Arkansas defaulted in 1941 and the first amendment to the Arkansas constitution in 1875, which was adopted by an overwhelming popular vote of eight to one, made it illegal to ever pay the interest or principal on the defaulted state railroad and levee bonds (see Bayliss (1964)).

Ten states also defaulted after the Civil War during the 1870s and 1880s: Alabama, Arkansas, Florida, Georgia, Louisiana, Minnesota, North Carolina, South Carolina, Tennessee, and Virginia. All of these states with one exception, Minnesota, took on large debts during the period of Reconstruction and were unable to service them. As McGrane (1935) describes, Minnesota's case is particularly interesting because it was a state untouched by the Civil War. Minnesota defaulted on railroad bonds and although the Governor and other state officials were willing to make investors whole, they were stymied for over 20 years by constitutional amendments passed by Minnesota repudiating the "swindling bonds".

Arkansas has the dubious distinction of the only state to default three times. Its last default, which was also the last default of any state, was in 1933 during the Great Depression. Arkansas defaulted on highway bonds. Reaves (1943) describes that the defaulting bonds were partially refunded in 1934, but it was only in 1943 that the majority of the defaulting issues were refinanced and the state returned to good standing in debt markets.

Clearly, states have defaulted in the past. Investors in defaulted federal or state debt have little redress to settle their claims. Furthermore, in all defaulting state cases so far, the federal government did not step in to make investors whole.

2.4 EMU Country Default

There have also been defaults among countries which are currently members of the EMU.[5] Reinhart and Rogoff (2008) describe several of these episodes. During the Great Depression, Greece went off the gold standard in 1932 and declared a moratorium on all debt payments. Spain suspended interest payments on external debt from 1936–1939 during the Spanish Civil War. Several nations defaulted on debt raised to fight World War II, including Austria, which rendered many previous bond issues worthless in 1945, and Germany, which instituted a brutal currency reform in 1948 by introducing the Deutschmark and rendering most balances in the previous currency, the Reichmark, close to worthless. However, an important difference between these defaults and the situation of EMU member countries today is that these defaults were done when each country had a separate currency. In contrast, the previous defaults of the U.S. states happened under a currency union. Future possible defaults of EMU sovereigns would occur with this feature.

3. THE DATA

As discussed in Duffie (1999), Longstaff, Mithal, and Neis (2005), Pan and Singleton (2008), and many others, a CDS contract functions as an insurance contract against the event that an entity such as a firm or a sovereign defaults on its debt. To illustrate how a CDS contract works, consider the case of California. On January 5, 2011, the market premium or spread for a five-year CDS contract on California was 295 basis points. If there was no default, the buyer would pay the equivalent of an annuity of 295 basis points for the full five-year horizon of the contract. If there was a default, however, the buyer of credit protection could sell the defaulted debt to the protection seller at its par value of 100, after which the contract would terminate. In general, this default-linked cash flow is triggered by the default of a specific reference obligation of the underlying entity.[6]

[5]Other non-EMU countries within the European Union have also defaulted. For example, the United Kingdom last defaulted in 1932 when most of its outstanding debt incurred during World War I was consolidated into a 3.5 percent consol bond.

[6]For a detailed discussion of the characteristics of CDS contracts, see Longstaff, Mithal, and Neis (2005) and Pan and Singleton (2008).

The data for the study include weekly midmarket CDS spreads for the term structure of one-year, two-year, three-year, four-year, and five-year CDS contracts on the U.S. Treasury and ten states. These states are California, Florida, Illinois, Massachusetts, Michigan, Nevada, New Jersey, New York, Ohio, and Texas. The data are obtained from the Bloomberg system which collects CDS market quotation data from industry sources. The notional for the U.S. Treasury CDS contract is specified in Euros. The notional for the state CDS contracts is specified in dollars. The data for the study cover the 139-week period from May 14, 2008 to January 5, 2011. The beginning of this sample period is dictated by the availability of liquid CDS data for all of the states in the study.

In addition to the U.S. data, we also collect the corresponding CDS term structure data for 11 of the largest sovereign borrowers within the EMU: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, and Spain. The data for the European sovereigns also cover the period from May 14, 2008 to January 5, 2011. The notional amounts for the European data are all specified in dollars.[7]

Table 2 provides summary statistics for the federal and state five-year CDS spreads. All spreads are denominated in basis points.[8] The average values of the spreads range widely across the various sovereigns. The average CDS spread for the U.S. Treasury is 38.52 basis points. The average spreads for the ten states are all higher than for the U.S. Treasury, and range from a low of 86.82 basis points for Texas to a high of 243.57 basis points for California.[9]

Both the standard deviations and the minimum/maximum values indicate that there is significant time-series variation in the CDS spreads. For example, the five-year CDS spread for the U.S. Treasury reached a maximum of 99.26 basis points in early 2009. Around the same time period, the CDS spreads for California and Michigan reached maximum values of 402 basis points and 394 basis points,

[7]For several of the European sovereigns, five-year CDS data is missing for a few weeks. For these weeks, we use four-year CDS data to report summary statistics and use the one-year to four-year term structure data to conduct the empirical analysis.

[8]Recently, many CDS contracts are executed on the basis of the protection seller paying points up front rather than a running spread. Despite this, however, the market convention is to quote CDS contracts in terms of their equivalent running spread. We adopt this standard market convention in this paper.

[9]Even though the notional for the CDS contract on the Treasury is denominated in Euros, the CDS spread is expressed as a rate and is, therefore, free of units of account. Thus, no currency translation is required for the U.S. Treasury CDS contract.

respectively. The median values of the CDS spreads are typically fairly close to the average values.

Table 2 also reports summary statistics for the five-year CDS spreads of the European sovereigns in the sample. As shown, many of the average CDS spreads are smaller than those for the states. On the other hand, many of the maximum values for the European sovereigns are comparable to those for the states. The reason for this simply that while both U.S. and European sovereigns had similar CDS spreads at the beginning of the sample periods, CDS spreads in the U.S. widened more rapidly as the subprime/financial crisis unfolded than did European spreads. After the Greek credit crisis of mid-2010, however, European CDS spreads quickly increased to levels comparable to, or even in excess of, those in the U.S.

To provide some additional descriptive statistics, Table 3 reports the correlation matrix of weekly changes in the five-year CDS spreads. The top panel reports the correlations for the U.S. while the bottom panel reports the correlations for Europe.

Focusing first on U.S. sovereigns, the top panel of Table 3 shows that while there is clearly significant cross-sectional correlation in spreads, the correlations are far from perfect. Most of the correlations are less than 70 percent, and many are less than 50 percent. The average correlation across all 11 U.S. sovereigns is only 55.6 percent.

Turning next to the European sovereigns, the bottom panel of Table 3 shows that the cross-sectional correlations tend to be similar in magnitude or slightly higher than those for the U.S. In particular, the average correlation across all 11 European sovereigns is 58.4 percent. This result is somewhat surprising given that we would expect a stronger linkage within the U.S. since U.S. sovereigns would presumably have stronger fiscal, political, and economic connections than would be the case for the countries in the EMU. The stronger correlation among European sovereigns, however, is consistent with the results in Longstaff, Pan, Pedersen, and Singleton (2011) who report that the average correlation of changes in credit spreads across 26 developed and emerging market sovereigns was 73 percent for the 2007–2010 period.

Although not shown, we note that the correlations between the U.S. and Europe are relatively weak relative to the correlations intra-U.S. and intra-EMU. For example, the average pairwise correlation between the U.S. sovereigns and the European sovereigns is only 25.6 percent. These results, taken in context with those previously documented in the literature for other sovereigns, hint that the nature of U.S. sovereign credit risk may differ fundamentally from that of other sovereigns.

Finally, Table 4 reports the results from a simple principal components analysis for the U.S. sovereigns and for the European sovereigns. The analysis is based on the

correlation matrix of weekly changes in the five-year CDS spreads for the sovereigns in the two regions.

The results indicate that there is greater commonality among the European sovereigns than among the U.S sovereigns. In particular, the first principal component for the U.S. sovereigns explains slightly less than the first principal component for the European sovereigns. The first two principal components for the U.S. sovereigns, however, explain only 70.28 percent of the variation, while the same measure for the European sovereigns is 82.54 percent. The results for the first three principal components are similar. As before, these results are very puzzling given that we would expect credit risk within the U.S. to be more closely linked than would be the case for credit risk within the EMU.

4. MODELING CDS SPREADS WITH SYSTEMIC RISK

There is an extensive literature on modeling sovereign credit spreads. Many recent papers follow the approach of developing a model of the term structure of sovereign spreads and then fitting the model to observed yields or CDS spreads. Important examples of this approach include Duffie, Pedersen, and Singleton (2003), Pan and Singleton (2008), and Longstaff, Pan, Pedersen, and Singleton (2011). Motivated by this literature, we also develop a closed-form model for the term structure of sovereign CDS spreads. A key distinction of our framework, however, is that is introduces the possibility that sovereign defaults may be triggered by the realization of a systemic shock. Thus, in contrast to previous work that models sovereign CDS term structures in a univariate setting, we develop an a multivariate credit model in which joint defaults of sovereigns are explicitly captured in the model. This modeling framework represents a significant extension of the literature on modeling sovereign default risk.

Specifically, we allow for two independent types of credit events to trigger sovereign defaults. The first is an idiosyncratic shock that triggers the default of an individual sovereign. This type of credit event is essentially the same as those underlying standard reduced-form credit models such Duffie and Singleton (1997, 1999), Pan and Singleton (2008), and many others. In particular, we model idiosyncratic default as being triggered by the first jump of a sovereign-specific Poisson process. Let ξ_t denote the intensity of this Poisson process. Following Longstaff, Mithal, and Neis (2005), we assume that this intensity process follows a standard square-root process,

$$d\xi = (a - b\xi)\, dt + c\sqrt{\xi}\, dZ. \tag{1}$$

These dynamics allow for mean reversion and conditional heteroskedasticity in the intensity process and guarantee that the intensity process is nonnegative. The constants a, b, and c and the Brownian motion Z are sovereign specific. We place no restrictions on the correlation structure of the Brownian motions across sovereigns or on the correlation of idiosyncratic defaults across sovereigns.[10]

The second type of credit event is different and can be viewed as a systemic shock. This type of event has potential ramifications for all sovereigns within a common area such as a monetary union. In particular, we assume that when a systemic shock occurs, which is modeled as the arrival of a Poisson jump, each sovereign has some probability of defaulting. The probability of default conditional on the systemic shock, however, is sovereign specific and is denoted γ. Thus, some sovereign borrowers may be more fragile or susceptible to systemic shocks than others. Let λ_t denote the intensity of the Poisson process triggering a systemic shock. This intensity also follows a standard square-root model,

$$d\lambda \;=\; (\alpha \;-\; \beta\;\lambda)\;dt \;+\; \sigma\;\sqrt{\lambda}\;dZ_\lambda, \tag{2}$$

where α, β, and σ are constants, and Z_λ is a Brownian motion that is uncorrelated with the Brownian motions driving the idiosyncratic intensity processes.

Let us now consider the ways in which a sovereign default can occur in this model. First, default occurs the first time that there is an arrival of the sovereign-specific Poisson process. Second, default occurs with probability γ the first time that there is an arrival of the systemic Poisson process (provided, of course, that there has not been a previous idiosyncratic default). Third, default occurs with probability $(1-\gamma)\gamma$ the second time that there is an arrival of the systemic Poisson process. This follows since the sovereign has a $1-\gamma$ probability of surviving the first systemic shock, but then faces a γ probability of succumbing to the second systemic shock. Fourth, default occurs with probability $(1-\gamma)^2\gamma$ the third time that there is an arrival of the systemic Poisson process, and so forth. Thus, there are an infinite number of ways in which a sovereign default can occur in this model. This contrasts sharply with the usual univariate modeling framework in which default occurs the first time there is an arrival of the underlying Poisson process.

Given the properties of Poisson processes, and conditional on the realized paths of the intensity processes ξ_t and λ_t, the probability that no default occurs by time t equals,

[10]Note that since our framework allows idiosyncratic defaults to have some (although not perfect) correlation across sovereigns, we are using the term idiosyncratic in the broader sense of being nonsystemic.

$$= \exp\left(-\int_0^t \xi_s \, ds\right) \left[\sum_{i=0}^{\infty} \frac{1}{i!} \exp\left(-\int_0^t \lambda_s \, ds\right) \left((1-\gamma)\int_0^t \lambda_s \, ds\right)^i\right], \quad (3)$$

$$= \exp\left(-\int_0^t \xi_s \, ds\right) \exp\left(-\int_0^t \lambda_s \, ds\right) \exp\left(\int_0^t (1-\gamma)\lambda_s \, ds\right), \quad (4)$$

$$= \exp\left(-\int_0^t \gamma \, \lambda_s + \xi_s \, ds\right), \quad (5)$$

Thus, we can now proceed to value credit derivatives the standard reduced-form framework of Duffie and Singleton, but with the twist that the instantaneous probability of a default is proportional to $\gamma\lambda + \xi$.

Let r_t denote the riskless rate. Although r_t is stochastic, we assume that it is independent of the intensity processes λ_t and ξ_t, and of the realizations of the underlying Poisson processes. As we show later, this assumption greatly simplifies the model, but has little effect on the empirical results. As in Lando (1998), we make the assumption that a bondholder recovers a fraction $1 - w$ of the par value of the bond in the event of default.

Given the independence assumption, we do not need to specify the risk-neutral dynamics of the riskless rate to solve for CDS spreads. We require only that these dynamics be such that the value of a riskless zero-coupon bond $D(T)$ with maturity T be given by the usual expression,

$$D(T) = E\left[\exp\left(-\int_0^T r_t \, dt\right)\right]. \quad (6)$$

Following Longstaff, Mithal, and Neis (2005), it is now straightforward to represent the values of U.S. Treasury or state CDS spreads in terms of simple expectations under the risk-neutral measure. Let s denote the spread paid by the buyer of default protection. Assuming that the premium is paid continuously, the present value of the spread leg of a sovereign CDS contract can be expressed as

$$E\left[s\int_0^T D(t) \exp\left(-\int_0^t \gamma \, \lambda_s + \xi \, ds\right) dt\right]. \quad (7)$$

Similarly, the value of the protection leg of a CDS contract can be expressed as

$$E\left[w\int_0^T\ D(t)\ (\gamma\ \lambda_t\ +\ \xi_t)\ \exp\left(-\int_0^t\ \gamma\ \lambda_s\ +\ \xi_s\ ds\right)\ dt\right]. \tag{8}$$

Setting the values of the two legs of the CDS contract equal to each other and solving for the spread gives

$$s = \frac{w\ E\left[\int_0^T\ D(t)\ (\gamma\ \lambda_t\ +\ \xi_t)\ \exp\left(-\int_0^t\ \gamma\ \lambda_s\ +\ \xi_s\ ds\right)\ dt\right]}{E\left[\int_0^T\ D(t)\ \exp\left(-\int_0^t\ \gamma\ \lambda_s\ +\ \xi\ ds\right)\ dt\right]}. \tag{9}$$

Given the square-root dynamics for the intensity processes standard results such as those in Duffie, Pan, and Singleton (2000) make it straightforward to derive closed-form solutions for the expectations in Equation (9). The Appendix shows that the sovereign CDS spread can be expressed as

$$s = \frac{w\ \int_0^T\ D(t)\ (A(\lambda,t)\ C(\xi,t)\ +\ \gamma\ B(\xi,t)\ F(\lambda,t)\ dt}{\int_0^T\ D(t)\ A(\lambda,t)\ B(\xi,t)\ dt}, \tag{10}$$

where ξ and λ denote the current (or time-zero) values of the respective intensity processes,

$$A(\lambda,t) = A_1(t)\ \exp(A_2(t)\ \lambda), \tag{11}$$

$$B(\xi,t) = B_1(t)\ \exp(B_2(t)\ \xi), \tag{12}$$

$$C(\xi,t) = (C_1(t)\ +\ C_2(t)\ \xi)\ \exp(B_2(t)\ \xi), \tag{13}$$

$$F(\lambda,t) = (F_1(t)\ +\ F_2(t)\ \lambda)\ \exp(A_2(t)\ \lambda), \tag{14}$$

and where,

$$A_1(t) = \exp\left(\frac{\alpha(\beta+\psi)t}{\sigma^2}\right)\left(\frac{1-\nu}{1-\nu\ e^{\psi t}}\right)^{2\alpha/\sigma^2}, \tag{15}$$

$$A_2(t) = \frac{\beta-\psi}{\sigma^2} + \frac{2\psi}{\sigma^2(1-\nu\ e^{\psi t})}, \tag{16}$$

$$B_1(t) = \exp\left(\frac{a(b+\phi)t}{c^2}\right)\left(\frac{1-\theta}{1-\theta\ e^{\phi t}}\right)^{2a/c^2}, \tag{17}$$

$$B_2(t) = \frac{b-\phi}{c^2} + \frac{2\phi}{c^2(1-\theta\ e^{\phi t})}, \tag{18}$$

$$C_1(t) = \frac{a}{\phi}\left(e^{\phi t}-1\right)\exp\left(\frac{a(b+\phi)t}{c^2}\right)\left(\frac{1-\theta}{1-\theta\ e^{\phi t}}\right)^{2a/c^2+1}, \tag{19}$$

$$C_2(t) = \exp\left(\frac{a(b+\phi)t}{c^2}+\phi t\right)\left(\frac{1-\theta}{1-\theta\ e^{\phi t}}\right)^{2a/c^2+2}, \tag{20}$$

$$F_1(t) = \frac{\alpha}{\psi}\left(e^{\psi t}-1\right)\exp\left(\frac{\alpha(\beta+\psi)t}{\sigma^2}\right)\left(\frac{1-\nu}{1-\nu\ e^{\psi t}}\right)^{2\alpha/\sigma^2+1}, \tag{21}$$

$$F_2(t) = \exp\left(\frac{\alpha(\beta+\psi)t}{\sigma^2}+\psi t\right)\left(\frac{1-\nu}{1-\nu\ e^{\psi t}}\right)^{2\alpha/\sigma^2+2}, \tag{22}$$

and finally,

$$\psi = \sqrt{\beta^2+2\gamma\sigma^2}, \tag{23}$$

$$\nu = (\beta+\psi)/(\beta-\psi), \tag{24}$$

$$\phi = \sqrt{b^2+2c^2}, \tag{25}$$

$$\theta = (b+\phi)/(b-\phi). \tag{26}$$

5. MODEL ESTIMATION

With these closed-form solutions, we can now estimate the model using market CDS spreads. Specifically, we will estimate the model using the term structure of one-, two-, three-, four-, and five-year CDS spreads for each issuer for each date during the sample period. This results in a vector $\bar{\lambda}$ of estimates of the systemic intensity process for each date in the sample period as well as a vector $\bar{\xi}$ of estimates for the sovereign-specific intensity process for each issuer. In addition, this estimation

approach provides estimates of the parameters of the systemic intensity process and the sovereign-specific intensity processes, as well as the sensitivity coefficient for each issuer.

In estimating the model for the U.S. issuers, we also impose two minor identifying restrictions. The first is that the sensitivity coefficient γ for the U.S. Treasury is normalized to be one. Thus, the γ coefficients for the states have the interpretation as measuring systemic sensitivity relative to that of the U.S. Treasury. This assumption is simply for convenience in scaling the results. Second, we make the realistic assumption that a Treasury default can only occur in conjunction with a systemic shock. This assumption makes intuitive sense since it is difficult to imagine a scenario in which the U.S. Treasury defaults without sending systemic shock waves throughout the credit markets.

The values for the zero-coupon bonds $D(t)$ that appear in the valuation formula are bootstrapped from one-, three-, six-, and twelve-month LIBOR rates and two-, three-, and five-year swap rates using a standard cubic spline interpolation algorithm. For a description of this algorithm, see Longstaff, Mithal, and Neis (2005).[11] The LIBOR and swap data are obtained from the Bloomberg system. We will also assume that the loss given default is 50 percent, implying $w = 0.50$.[12]

Let s_{ijt} denote the market spread for the i-th issuer for a CDS contract with maturity j years as of date t. Let $\hat{s}_{ijt}$ be the corresponding value implied by substituting in the estimated values of the systemic intensity λ and the sovereign-specific intensity process ξ_i along with the estimated parameter vector θ into the closed-form solution in Equation (10). The parameter vector and the time series of the systemic intensity and sovereign-specific intensity processes are then estimated by minimizing the objective function

$$\min_{\lambda,\xi_1,\xi_2,\ldots,\xi_N,\theta} \sum_i \sum_j \sum_t \left[s_{ijt} - \hat{s}_{ijt} \right]^2 . \tag{27}$$

[11] An alternative approach would be to bootstrap zero-coupon bond prices from the Treasury constant maturity rates reported by the Federal Reserve Board's H.15 release. The results, however, are not sensitive to the choice of the discounting curve. Intuitively, this is because the discounting curve is applied symmetrically to the cash flows from both legs of the CDS contract. Thus, bootstrapping zero-coupon bond prices from the Treasury curve rather than the swap curve has little effect on the fitted value of the CDS spread.

[12] Similarly, this assumption also has little effect on the fitted value of the CDS spread since it is applied symmetrically to both legs of the CDS contract in the estimation process.

We follow the same procedure in estimating the model for the European sovereigns, with the exception that the identification conditions apply to Germany rather than the U.S. Treasury.

The upper part of Table 5 reports the estimated parameters a, b, and c for the sovereign-specific processes for the individual states, and the estimated parameters α, β, and σ for the systemic process. The lower part of the table gives the corresponding results for the European sovereigns. Table 5 also reports the asymptotic standard errors for the parameters and the root mean squared error (RMSE) from fitting the model to the term structure of CDS spreads for each issuer.

Table 5 shows that the speed of mean reversion parameter b or β is negative for many of the U.S. and European sovereigns. This feature is not uncommon in estimating affine models and does not pose a problem since we are estimating the speed of mean reversion under the risk neutral measure rather than the objective measure, and the speed of mean reversion parameter under the objective measure is presumably positive. This argues that there might be a substantial difference between the speed of mean reversion parameters across the two measures. In turn, this implies that there could be a significant risk premium embedded into the pricing of U.S. and European sovereign CDS contracts.

Table 5 also shows that the model fits the term structure of CDS spreads fairly well. The RMSEs from fitting the model to U.S. sovereign issuers range from a low of about one basis point for the term structure of U.S. Treasury CDS contracts, to a high of roughly 16 basis points for Illinois. Six of the states have RMSEs of less than 10 basis points. Comparing these RMSEs to the average five-year CDS values shown in Table 2 indicates that these RMSEs are a relatively small percentage of the absolute level of CDS spreads for these issuers. Similar results hold for the European sovereign issuers.

Finally, note that the systemic intensity process in the U.S. has parameters that are very similar to those for the systemic intensity process in Europe. Similarly, the model fits both the term structure of U.S. Treasury CDS spreads and the term structure of Germany CDS spreads very closely. The RMSEs from fitting the U.S. Treasury and German CDS term structures are 1.179 and 2.528 basis points, respectively.

6. SYSTEMIC SOVEREIGN RISK

In this section, we examine the implications of the results for the systemic component of sovereign default risk. First, we focus on the systemic sensitivity measures estimated from the multivariate credit model. Next, we decompose the default spread for each sovereign into its systemic and sovereign-specific components. We

then contrast the nature of systemic sovereign risk in the U.S. with that in the EMU. Finally, we explore the determinants of systemic sovereign risk using a regression framework.

6.1 Systemic Credit Risk

Figure 1 plots the intensity λ of the systemic risk for the U.S. and the EMU. The U.S. intensity has been, on average, higher than the EMU intensity. Thus, the market perceives that a U.S. default is slightly higher than a German default. The systemic default intensities of the U.S. and Europe are highly correlated at 0.9406. This high degree of commonality in systemic risk across the U.S. and Euro market areas is consistent with Longstaff, Pan, Pedersen, and Singleton (2011), who find that sovereign credit risk is highly correlated across countries. The high correlation between the U.S. and EMU systemic intensities is also partly driven by our sample period which covers the financial crisis. As is well known, correlations tend to increase during market downturns and crisis periods (see, for example, Ang and Bekaert (2002)).

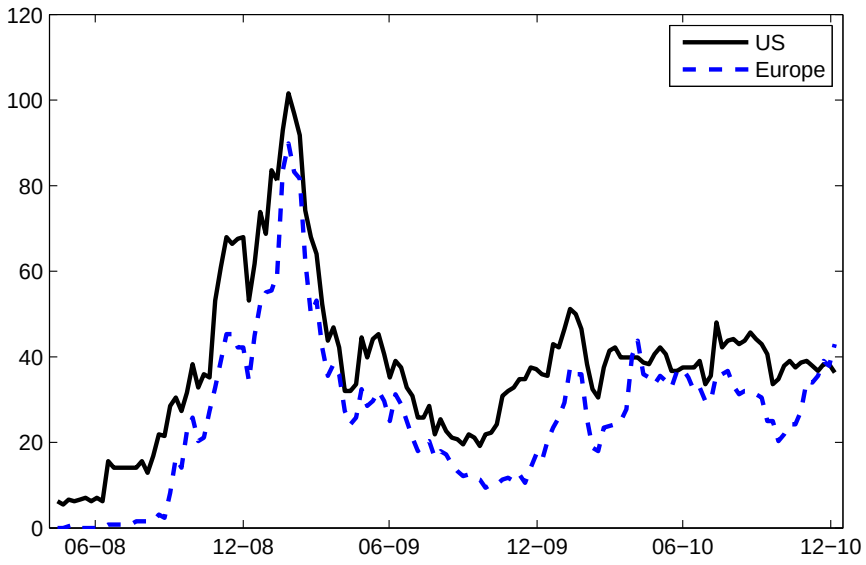

Figure 1. U.S. and European Systemic Sovereign Credit Risk Factors. This figure plots the estimated time series of the intensity process for the two systemic sovereign credit risk factors. The intensity process is measured in basis points.

The U.S. and European systemic intensities increase markedly during the last quarter of 2008 after the default of Lehman Brothers (September 15, 2008). Both systemic intensities reach their peaks of 102 and 90 basis points, respectively, at the end of February 2009. If λ were constant, these intensities represent default probabilities of $1 - \exp(-0.0102) = 0.0101$ and $1 - \exp(-0.0090) = 0.0089$ over the next year. The increases in default intensities during the financial crisis come through two channels. First, there is an explicit increase of sovereign liabilities by bringing onto sovereign balance sheets many of the liabilities of private banks (in the U.S. through the Capital Purchase Program (CPP), the Troubled Asset Relief Program (TARP), and loans and assistance to American International Group (AIG) and auto manufacturers and in Germany the nationalization of Hypo Real Estate and state support of banks through the Financial Market Stabilization Fund). Second, there is an implicit increase in the riskiness of sovereign finances through the deterioration of economic conditions and the fragility of the banking sectors in each country.

Systemic default intensities for both the U.S. and Europe decrease during the first three quarters of 2009. The U.S. intensity starts to increase in November 2009, while the EMU intensity follows later in late December 2009. The U.S. increase may reflect the large losses from Fannie Mae and increasing concerns about large deficits during that quarter. The increase in EMU systemic sovereign risk is likely due to the deteriorating finances of Greece and the downgrading of Greek debt in December 2009. Since March 2010, the U.S. credit intensity has averaged 39 basis points, representing a one-year probability of default of 0.0039 and has been fairly stable. European systemic sovereign risk has been a little more volatile, increasing in April and May 2010 and in December 2010 and January 2011. This volatility reflects the European sovereign debt crisis of Ireland, Spain, Portugal, and other Euro periphery nations. Note that the European systemic default intensity is not elevated through this period indicating that systemic European risk has been relatively subdued even though the yields and default rates of other European nations dramatically increase during this time.

6.2 Systemic Sensitivity

Recall from earlier discussion that the coefficient γ represents the probability that a sovereign defaults conditional on the realization of a systemic credit event. By normalizing the value of γ to one for the U.S. Treasury, the estimated values of γ for the other sovereigns represent the ratio of the conditional probability of default for the sovereign to that of the United States. Similarly, we normalize the EMU sovereigns by the conditional default probability for Germany. Thus, the estimated values of γ can be viewed as an index of relative systemic default risk.

Table 6 shows the estimated systemic default risk indexes. Surprisingly, nine of the ten states studied actually have an systemic index of less than one. The exception is California which has a systemic index of 2.647. The average value of the systemic index taken over all ten states is 0.72; the median value of the systemic index is 0.63. It is also interesting to observe that several of the states appear to have little or no systemic default risk. In particular, Illinois, New York, and Ohio have systemic indexes that are less than 0.10. These results have important implications for the nature of state sovereign default risk in the U.S. since they imply that state default risk is largely sovereign specific rather than systemic.

In stark contrast to the results for the states, Table 6 shows that systemic default risk is far more important for the sovereigns in the European Union. In particular, seven of the European sovereigns have systemic indexes in excess of one, implying that their probability of a default given a systemic shock exceeds that of Germany. The highest value of the systemic index is for Greece which has a value of 4.688. The next highest values are for Italy, Portugal, Belgium, and Ireland with indexes of 1.710, 1.674, 1.662, and 1.604, respectively. The smallest value for the index is for Finland with a value of 0.356. The average value of the systemic index taken over all ten European sovereigns is 1.597; the median value of the systemic index is 1.555.

6.3 How Large is the Systemic Component?

As an alternative way of looking at systemic risk, it is also interesting to decompose the total default risk of each sovereign into its systemic and sovereign-specific components. Since the instantaneous default risk of each sovereign is $\gamma\lambda+\xi$, the systemic component is given simply by $\gamma\lambda$ while the sovereign-specific component is given by ξ. Table 7 reports summary statistics for the systemic component expressed as a percentage of the total default risk for each sovereign.

The results in Table 7 tell a similar story as the results for the systemic index. In particular, the size of the systemic component for the states is typically very small. The average systemic percentage taken over all ten states is only 12.21 percent. Even for California, which has the highest systemic index of $\gamma = 2.647$, the average systemic component is only 36.78 percent of the total credit risk. This reinforces the earlier evidence that state credit risk in the U.S. is largely sovereign-specific in nature rather than systemic.

The results for European are again very different from those for the U.S. The systemic component taken over all European sovereigns is 30.94 percent; the median is 37.03 percent. The smallest average among European sovereigns is 16.77 percent for Ireland. The highest average among European sovereigns is 53.15 for France.

Thus, the results indicate that systemic default risk tends to be two to three times as large a component of default risk in Europe as it is in the U.S.

6.4 What Drives Systemic Sovereign Risk?

We next explore the determinants of systemic sovereign credit risk. Specifically, we study the extent to which a set of domestic and global variables explain changes in the systemic intensity values estimated previously. There are several important reasons for focusing on intensity values rather than on individual CDS spreads. First, the intensities implied from the model are based on the full term structure of CDS spreads. Thus, this approach allows us to use all of the information in the market about systemic credit risk. Second, the intensity reflects the current probability of a systemic event rather than a long-term average. This means that this measure has the potential to be more responsive and, therefore, more informative about the underlying drivers of systemic default risk. Third, our approach parallels that of Duffie and Singleton (1997, 1999), Longstaff, Mithal, and Neis (2005), Pan and Singleton (2008), Longstaff, Pan, Pedersen, and Singleton (2011), and others who study the properties of default intensities estimated from a model of the term structure of credit spreads.

Since there is virtually an unlimited number of variables that could be related to sovereign credit risk, it is important to be selective in the variables considered. In particular, we will focus primarily on market-determined variables since we can observe these at a higher frequency than other variables such as tax receipts or budget deficits (which are generally only available on an annual or semiannual basis).

The first set of four variables are taken from the domestic financial markets. For the U.S., we use the weekly return on the S&P 500 index (excluding dividends), the weekly change in the five-year constant maturity swap rate, the weekly change in the VIX volatility index, and the weekly change in the CDX North American Investment Grade Index of CDS spreads. For Europe, we use the weekly return on the DAX index, the weekly change in the five-year constant maturity Euro swap rate, the weekly change in the VIX volatility index, and the weekly change in the European ITraxx Index of CDS spreads. The data for these variables are all obtained from the Bloomberg system.

The second set of explanatory variables consists of weekly changes in the five-year CDS spreads for three sovereigns or sovereign indexes. In particular, we include the weekly change in the CDS contract for Japan, China, and for the CDX Emerging Market (CDX EM) Index of sovereign CDS spreads. The data for these CDS spreads are also obtained from the Bloomberg system.

Table 8 reports the results from the regressions of weekly changes in the default risk for the issuers on the explanatory variables. Specifically, the table reports the Newey-West t-statistics from the regressions along with the R^2s.

Table 8 shows that U.S. systemic sovereign risk is strongly related to the financial market variables. In particular, the single most significant variable in the regression is the return on the stock market, which has a t-statistic of -4.31. Thus, U.S. systemic credit risk declines significantly as the stock market rallies, and vice versa. This strongly suggests that the fortunes of the U.S. are closely linked to the stock market. U.S. systemic risk is significantly positively related to changes in the swap rate, indicating that the level of interest rates has an important effect on credit risk. Interestingly, changes in the VIX index are significantly negatively related to U.S. systemic credit risk. This is consistent with the view that Treasury bonds may play the role of a "reserve investment" in the financial markets. Specifically, that when uncertainty in the financial markets increases, the resulting global flight to U.S. Treasury bonds makes it easier for the U.S. to finance its operations with nominal debt. Finally, U.S. systemic credit risk is also positively related to changes in investment grade corporate bond spreads (significant at the ten-percent level).

The results also show that U.S. systemic risk is related to the credit spreads of the two largest holders of U.S. Treasury debt. In particular, the $t-$statistic for the CDS spread of Japan is 1.64 (which just misses significance at the ten-percent level), while the t-statistic for China is 1.80 which is significant at the ten-percent level. The R^2 for the regression is 0.352, indicating that a substantial proportion of U.S. systemic credit risk can be explained in terms of the financial market and global credit variables.

Turning now to the results for European systemic sovereign risk, we see a very similar pattern. European systemic risk is again significantly negatively related to stock market returns. As for the U.S., European systemic risk is significantly positively related to changes in corporate credit spreads. Note that the coefficient for changes in the VIX is not significant, consistent with the intuition of the unique role played by U.S. Treasury debt discussed above. Finally, European systemic risk is strongly positively related to the CDS spread of China. As before, the R^2 of 0.431 for this regression indicates that much of the variation in European systemic sovereign risk is captured by these financial market variables.

7. SOVEREIGN-SPECIFIC CREDIT RISK

In this section, we examine the properties of the sovereign-specific or idiosyncratic component of sovereign default risk. We first explore whether there is a geographic structure to sovereign-specific risk using a multivariate cluster analysis. We then

examine whether the extent to which the key financial and global variables are able to explain variation in sovereign-specific credit risk.

7.1 Does Geography Matter?

To provide an alternative perspective on the cross-sectional structure of default risk, we conduct a multivariate cluster analysis of the correlation matrix of weekly changes in the estimated sovereign-specific components. In this cluster analysis, the algorithm attempts to sort the states into groups where the members of each group are as similar as possible. At the same time, the algorithm attempts to form the groups to be as dissimilar from one another as possible. In effect, the algorithm tries to create groupings in a way that maximizes the average correlation between countries in the same group, while minimizing the average correlation between countries in different groups.[13] Since the composition of clusters depends on the choice of the number of clusters to be formed, we use a simple rule of thumb that the number of clusters be roughly $N/3$, where N is the number of individual items to be grouped. For the 10 sovereigns in the U.S. and the ten in Europe, this rule of thumb suggests forming three clusters (we exclude the U.S. Treasury and Germany since, by assumption, their default risk is due entirely to the systemic factor).

Table 9 reports the composition of the clusters. Although we present the clusters in order of the number of issuers each contains, there is no particular significance to this ordering in cluster analysis. Similarly, the cluster analysis algorithm does not place any restrictions on the number of items that can appear in any cluster (other than the obvious requirement that a cluster has to contain at least one element).

The results illustrate that there is a strong regional flavor to state credit risk. In particular, the first cluster contains five states, four of which are located in Midwest/Central part of the U.S: Illinois, Michigan, Ohio, and Texas. The second cluster consists primarily of states on the East and West Coasts such as New York, New Jersey, and California. The third cluster consists only of Florida. This suggests that the credit risk of Florida is sufficiently distinct from that of the other states that the algorithm places it in a separate category altogether.

Turning to the results for Europe, a somewhat different pattern emerges. In particular, the largest cluster consists of the European periphery: Greece, Ireland,

[13]The cluster analysis is done using Ward's method in which clusters are formed so as to minimize the increase in the within-cluster sums of squares. The distance between two clusters is the increase in these sums of squares if the two clusters were merged. A method for computing this distance from a squared Euclidean distance matrix is given by Anderberg (1973, pages 142-145).

Italy, Portugal, and Spain – all countries that have experienced moderate or severe financial distress recently. Thus, there is a clear "misery loves company" structure to the correlation matrix of sovereign-specific spread changes. This pattern is also consistent with the second cluster which consists of Austria, Finland, and the Netherlands, which have all represented strong credits through the global financial crisis. The third cluster shows the most geographical similarity since France and Belgium are neighbors and share many common features such as language. We will next examine in further detail the time series of the state-specific and country-specific intensity processes.

7.2 State-Specific Sovereign Risk

Figure 2 plots the states-specific intensities of the states in the various clusters shown in Table 9. Panel A plots the state-specific ξ intensities of the states in the first cluster: Illinois, Massachusetts, Michigan, Ohio, and Texas. The states in this cluster all exhibit two large increases in credit risk, beginning with the start of the financial crisis in 2008 when U.S. systemic credit risk also increases (see Figure 1) and again in 2010. These state-specific intensities are large; Michigan's intensity reaches a peak of 740 basis points in April 2009 and Illinois' maximum intensity is 680 basis points in June 2010.

The increase in default intensities during 2010 reflects different circumstances for different states. Using data from the Bureau of Economic Analysis, Illinois has the largest debt to GDP ratio, 20.6 percent, in 2009 of all the states considered in the sample and financed the largest projected deficit to GDP ratio in 2011, 2.7 percent, according to the Center on Budget and Policy Priorities. Massachusetts moved from budget surpluses during the late 1990s to budget deficits during our sample period, resulting from a combination of reducing taxes prior to the financial crisis and increased demand for social services during the financial downturn. Similarly, estimates of budget deficits for Texas started increasing dramatically in June 2010 to top $20 billion. In early January 2011, Texas legislators eventually cut spending by more than $30 billion.

Panel B of Figure 2 graphs the state-specific intensities for the states in the second cluster: California, Nevada, New Jersey, and New York. California's state-specific default risk appears to be similar to these other states, so its overall high default probabilities are due to California's large loading on U.S. systemic risk (see Table 6). The intensities for these four states are highly correlated with an average cross-correlation of 90 percent. These states share a number of similarities: California and Nevada have the highest state unemployment rates among the states considered over the sample and California and Nevada have been very hard hit by declining property prices. Although much smaller than its neighboring state

California, it is not surprising that Nevada is exposed to many of the same economic forces facing California. Similarly, New Jersey and New York are adjoining states and there is a high linkage of these economies. This may explain the increase in the states' intensities in February 2010 and June 2010. California and New York's fiscal years end in March 2010 and the challenges for both states in meeting budget deficits could have spilled over to shared concerns in the neighboring states. Similarly, the increase in intensities in June 2010 may reflect the difficulties in financing deficits for the budget deadline of July 1 for California and the June 28 deadline for approving New York's budget bill, which if not passed would have led to a New York government shut down.

Finally, Panel C of Figure 2 graphs the default intensity of the third cluster, which consists of just Florida. Unlike the first two clusters, Florida saw a very early spike in its state-specific intensity in July 2008. This coincides with the bailouts and credit lines provided to Fannie Mae and Freddie Mac to deal with deteriorating conditions in the mortgage market, to which Florida was highly exposed.

7.3 Euro Country-Specific Sovereign Risk

In Figure 3, we plot country-specific intensities ξ for the Euro members. Panel A graphs the intensities for the countries in the first cluster: Greece, Ireland, Italy, Portugal, and Spain, all of which are Euro periphery countries. Policymakers have been preoccupied in managing financing and avoiding default for these countries since the financial crisis. Interestingly, all these countries, with the exception of Greece, saw large increases in their sovereign-specific default risk from late 2008 through 2009. This mirrors the increase in German systemic risk and corporate default rates over this time. It is only in January 2010 that Greek-specific intensities start to rise, even though knowledge of Greece's growing deficits and financing problems were well known in 2009. The intensity for Greece rises from 187 basis points at the end of December 2009 to close to 10 percent at the beginning of May 2010. This is when Ireland's intensity starts to rapidly increase, also reaching nearly 10 percent at the end of the sample. This is due to market perceptions that Ireland's measures taken in 2008–2009 to fix the problems in its banking sector are insufficient and additional measures, involving co-ordinated Euro action, are necessary.

Panel B of Figure 3 plots the intensities for the countries in the second cluster: Austria, Finland, and the Netherlands. As is the case for the states (see Figure 2) and the countries in the first cluster, default intensities rise during the financial crisis. They remain elevated, and for the Netherlands also increase, after 2009. In contrast, the Belgian and French country-specific default risk shown in Panel C barely changes during the financial crisis. Clearly, most of the variation in the default risk of Belgium and France during the 2008–2009 period was due to

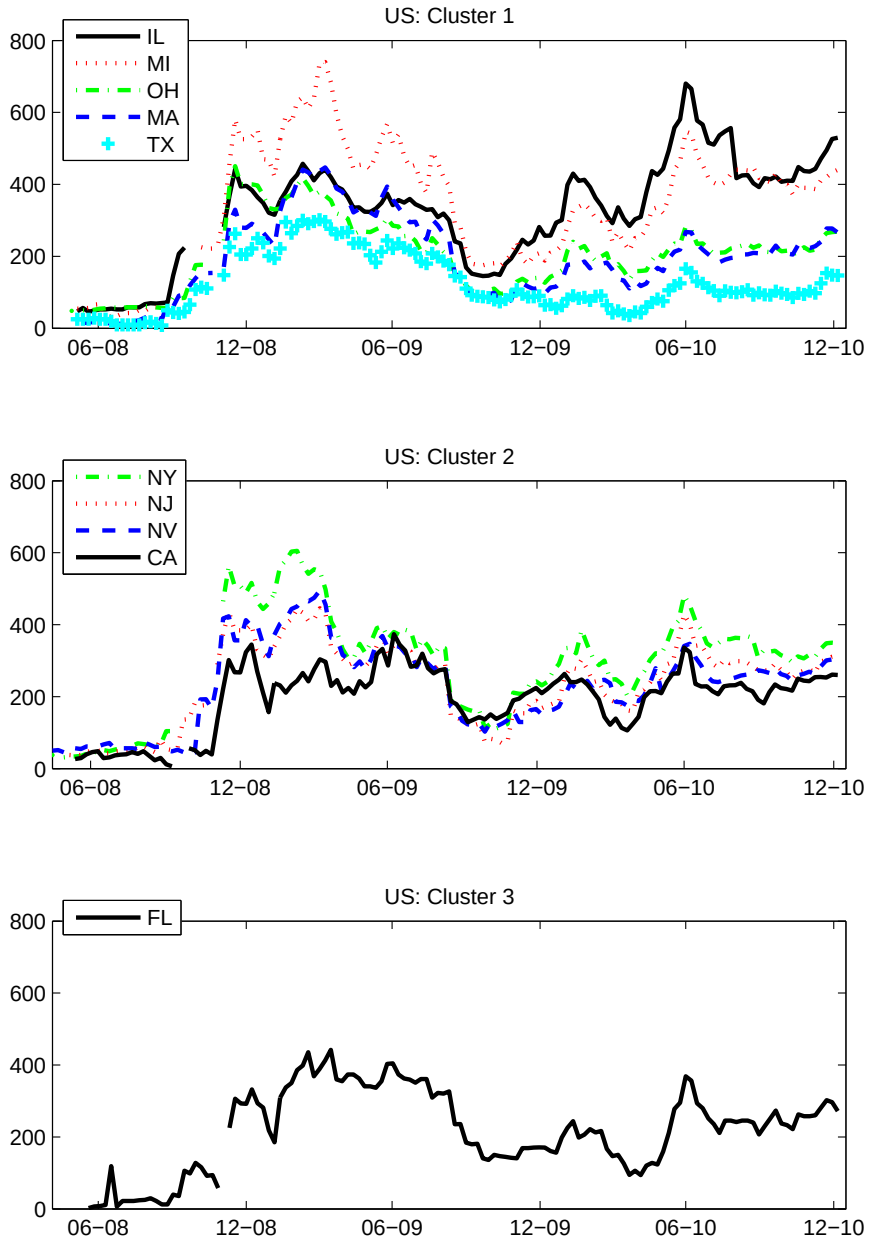

Figure 2. State-Specific Credit Risk for the U.S. Clusters. The upper, middle, and lower panels plot the state-specific intensity process for the states in the first, second, and third clusters, respectively. The intensities are measured in basis points.

changes in systemic risk. Only towards the end of the sample do Belgian and French sovereign-specific intensities start to increase.

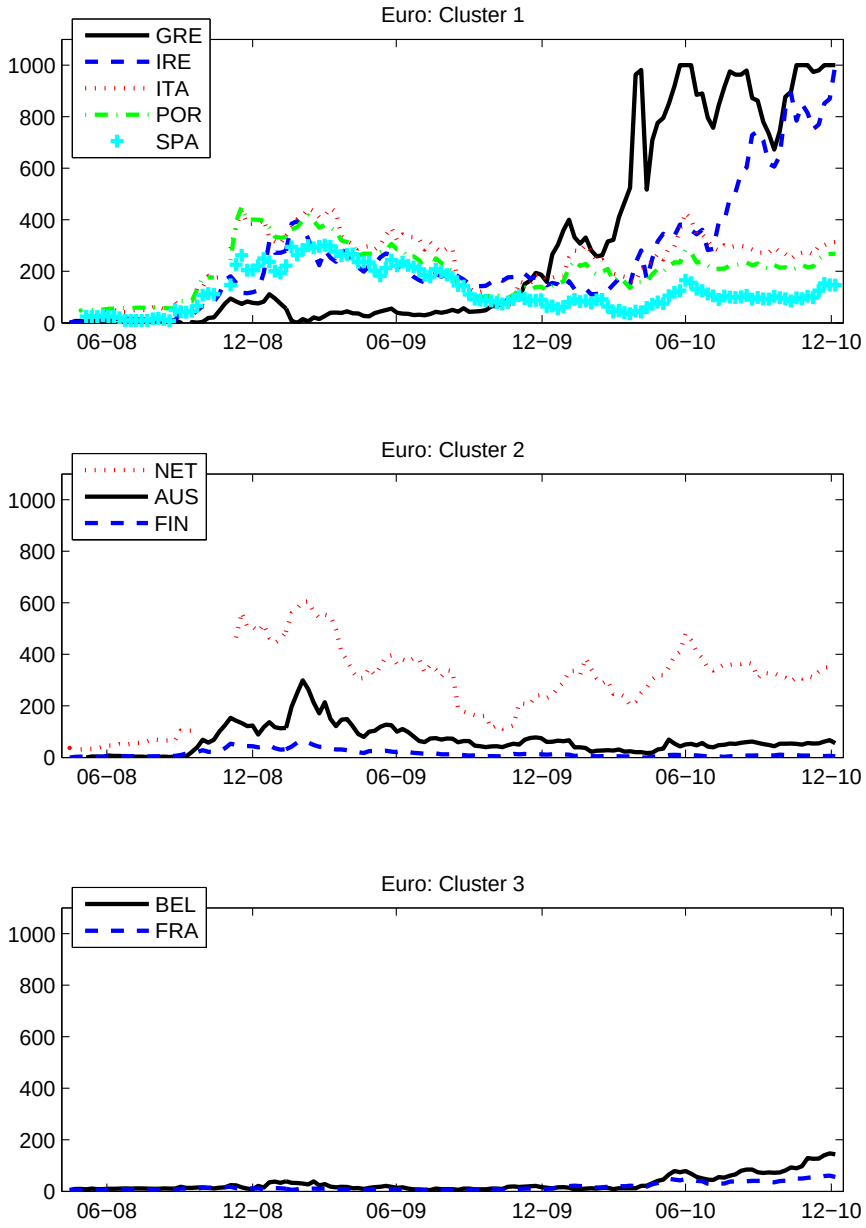

Figure 3. Country-Specific Credit Risk for the European Clusters. The upper, middle, and lower panels plots the country-specific intensity processes for the countries in the first, second, and third European clusters, respectively. The intensities are measured in basis points.

7.4 What Drives Sovereign-Specific Credit Risk?

Given the evidence of common patterns in the country-specific default intensities in Figures 2 and 3, we now investigate the determinants of sovereign-specific credit risk. We regress weekly changes in the sovereign-specific intensity for each issuer on the same set of financial market and global explanatory variables used in the systemic regressions. Table 10 reports the results from these regressions.

A number of interesting patterns can be seen in these results. For example, the explanatory power of these regressions is generally lower for the U.S. sovereigns than for the European sovereigns. In particular, the average R^2 for the U.S. and European sovereigns is 0.122 and 0.181, respectively.

One possible reason for the higher explanatory power in Europe may be that the ITraxx corporate index is significantly positive (at the ten-percent level) for all but one of the European sovereigns. This result parallels the findings in Longstaff, Pan, Pedersen, and Singleton (2011) that global sovereign CDS spreads are strongly related to corporate spreads. In contrast, the corporate index is only significant for several of the U.S. states.

Another intriguing pattern in Table 10 is that stock market returns are significant for a number of states: Florida, New Jersey, New York, and Ohio. In contrast, stock market returns are only significant for Austria. Thus, sovereign-specific risk in the U.S. is more linked to equity markets than is the case in Europe. One reason for this might be that U.S. sovereigns have a greater reliance on capital gains income tax receipts than do European sovereigns.

8. CONCLUSION

This paper studies the nature of systemic sovereign credit risk by examining the pricing of CDS contracts on the U.S. Treasury, a number of key U.S. states, and major EMU countries. An important advantage of comparing the U.S. with Europe is that the analysis can provide new insights into whether systemic sovereign credit risk arises from common macroeconomic fundamentals or from the influence of global financial markets.

Using a multifactor affine credit model, we are able to decompose sovereign credit risk into a systemic component and a sovereign-specific component. We find that systemic risk represents a much smaller fraction of total credit risk for U.S. states than is the case for members of the EMU. This result is surprising since we would expect U.S. states to be more closely linked in terms of their economic fundamentals. This result provides clear evidence against the hypothesis that systemic risk is primarily an artifact of common macroeconomic fundamentals.

We find that U.S. systemic sovereign credit risk is highly correlated with Eu-

ropean systemic credit risk. Furthermore, we show that both are strongly related to financial market variables such as stock returns. This argues that systemic risk may arise largely through the global financial system.

One particularly intriguing result of our analysis is that U.S. systemic credit risk is significantly negatively related to changes in the VIX index. Thus, as markets become more volatile, the credit risk of the U.S. Treasury improves. This result is consistent with the hypothesis that the financial position of the U.S. improves as flights to quality occur in turbulent periods.

The results in this paper have many important implications for sovereign credit risk. Clearly, future work is needed to understand the deep reasons for the strong relation between systemic sovereign risk and financial markets.

APPENDIX

After multiplying terms, taking expectations, and rearranging, the numerator of Equation (9) can be expressed as,

$$w \int_0^T D(t)\ E\left[\exp\left(-\int_0^t \gamma\ \lambda_s\ ds\right)\right] E\left[\xi_t\ \exp\left(-\int_0^t \xi_s\ ds\right)\right] + \gamma\ E\left[\lambda_t\ \exp\left(-\int_0^t \gamma\ \lambda_s\ ds\right)\right]\ E\left[\exp\left(-\int_0^t \xi_s\ ds\right)\right]\ dt. \qquad (A1)$$

Let $A(\lambda, t)$ denote the first expectation in this expression. Standard results such as Duffie, Pan, and Singleton (2000) imply that $A(\lambda, t)$ satisfies the partial differential equation

$$\frac{\sigma^2}{2}\lambda A_{\lambda\lambda} + (\alpha - \beta\lambda)A_\lambda - \gamma\lambda A - A_t = 0, \qquad (A2)$$

subject to the boundary condition $A(\lambda, 0) = 1$. Substituting the expression for $A(\lambda, t)$ given in Equation (11) into Equation (A2) shows that the partial differential equation is satisfied provided that $A_1(t)$ and $A_2(t)$ satisfy the Riccati equations,

$$\frac{\sigma^2}{2}\lambda A_2^2 - \beta A_2 - \gamma - A_2' = 0, \qquad (A3)$$

$$\alpha A_2 - \frac{A_1'}{A_1} = 0. \qquad (A4)$$

Integrating Equation (A3) for $A_2(t)$, and then substituting $A_2(t)$ into Equation (A4) and integrating for $A_1(t)$ gives Equations (15) and (16) after using the initial conditions $A_1(0) = 1$ and $A_2(0) = 0$ to determine the constants. The same procedure can be used to verify that the third expectation in Equation (A1) is given by Equation (12) (where the parameters α, β, and σ are replaced by a, b, and c in the partial differential equation and γ is set equal to one).

Let $F(\lambda, t)$ denote the fourth expectation in Equation (A1). Standard results can again be used to show that $F(\lambda, t)$ satisfies the partial differential equation in Equation (A2) with the boundary condition $F(\lambda, 0) = \lambda$. Substituting the expression for $F(\lambda, t)$ into Equation (A2) shows that the partial differential equation is satisfied provided that $F_1(t)$ and $F_2(t)$ satisfy the Riccati equations,

$$(\alpha + \sigma^2)A_2 - \beta - \frac{F_2'}{F_2} = 0, \tag{A5}$$

$$\alpha F_2 + \alpha F_1 A_2 - F_1' = 0. \tag{A6}$$

Integrating Equation (A5) for $F_2(t)$, and then substituting $F_2(t)$ into Equation (A6) and integrating for $F_1(t)$ gives Equations (21) and (22) after using the initial conditions $F_1(0) = 0$ and $F_2(0) = 1$ to determine the constants. The same procedure can be used to verify that the second expectation in Equation (A1) is given by Equation (13). The solution for the sovereign CDS spread s in Equation (10) is then given by substituting the expressions for the respective expectations given in Equations (11) through (14) into the numerator and denominator of Equation (9).

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Table 1

Nominal 2009 GDP in Millions of U.S. Dollars This table reports the 2009 Nominal GDP for the indicated States and Countries. GDP is measured in millions of U.S. dollars. Data from the Bureau of Economic Analysis and the World Bank.

	GDP
California	1,884,452
Florida	729,485
Illinois	621,101
Massachusetts	362,413
Michigan	361,126
Nevada	125,115
New Jersey	478,391
New York	1,085,131
Ohio	466,021
Texas	1,141,287
USA	14,119,000
Austria	384,908
Belgium	468,522
Finland	237,512
France	2,649,390
Germany	3,330,032
Greece	329,924
Ireland	227,193
Italy	2,112,780
Netherlands	792,128
Portugal	227,676
Spain	1,460,250

Table 2

Summary Statistics for U.S. and European Sovereign CDS Spreads. This table reports summary statistics for the five-year CDS spreads for the indicated sovereigns. The sample consists of weekly observations for the May 14, 2008 to January 5, 2011 period.

	Mean	Std. Dev.	Min.	Med.	Max.	Serial Corr.	N
California	243.57	81.98	63.00	268.00	402.00	0.962	133
Florida	137.10	50.47	39.00	135.00	240.00	0.960	133
Illinois	187.61	87.32	25.00	191.00	369.00	0.982	130
Massachusetts	120.93	54.67	21.00	124.00	243.00	0.978	134
Michigan	207.45	87.76	45.00	218.00	394.00	0.976	131
Nevada	171.76	73.03	42.00	183.00	329.00	0.967	138
New Jersey	179.06	76.31	33.00	196.00	337.00	0.973	135
New York	176.95	77.19	32.00	196.00	318.00	0.976	131
Ohio	122.04	52.04	35.00	125.00	251.00	0.972	134
Texas	86.82	42.01	20.00	79.00	180.00	0.976	134
USA	38.52	18.06	7.10	37.98	99.26	0.964	139
Austria	82.78	47.29	6.80	77.82	260.90	0.952	136
Belgium	75.63	48.76	10.00	62.01	227.68	0.977	139
Finland	31.04	16.59	5.30	28.98	88.33	0.970	139
France	47.49	26.95	6.75	43.78	108.84	0.975	139
Germany	33.56	17.16	4.40	33.75	90.61	0.959	139
Greece	353.34	316.99	32.19	230.25	1055.41	0.986	139
Ireland	205.94	143.40	17.30	162.48	613.43	0.982	139
Italy	121.86	58.34	24.75	113.68	241.03	0.963	139
Netherlands	44.58	26.38	6.30	41.27	123.33	0.970	139
Portugal	155.43	133.54	21.33	93.84	500.02	0.978	139
Spain	126.61	80.54	24.25	98.83	349.90	0.977	139

Table 3

Correlation Matrix of Weekly Changes in CDS Spreads. The top panel of this table reports the correlation matrix of weekly five-year CDS spread changes for the U.S. sovereigns. The bottom panel reports the correlation matrix of weekly five-year CDS spread changes for the European sovereigns. The sample consists of weekly observations for the May 14, 2008 to January 5, 2011 period.

U.S.	CA	FL	IL	MA	MI	NV	NJ	NY	OH	TX	USA
CA	1.000										
FL	0.425	1.000									
IL	0.657	0.529	1.000								
MA	0.595	0.410	0.653	1.000							
MI	0.678	0.323	0.691	0.773	1.000						
NV	0.610	0.305	0.514	0.647	0.617	1.000					
NJ	0.726	0.352	0.615	0.665	0.683	0.630	1.000				
NY	0.721	0.428	0.648	0.664	0.716	0.668	0.842	1.000			
OH	0.633	0.432	0.722	0.827	0.844	0.637	0.696	0.700	1.000		
TX	0.614	0.351	0.590	0.771	0.748	0.577	0.647	0.572	0.777	1.000	
USA	0.320	0.158	0.197	0.259	0.278	0.283	0.280	0.262	0.270	0.364	1.000

EUROPE	AUS	BEL	FIN	FRA	GER	GRE	IRE	ITA	NET	POR	SPA
AUS	1.000										
BEL	0.589	1.000									
FIN	0.816	0.649	1.000								
FRA	0.691	0.727	0.664	1.000							
GER	0.745	0.713	0.720	0.820	1.000						
GRE	0.319	0.330	0.327	0.411	0.392	1.000					
IRE	0.650	0.529	0.542	0.544	0.533	0.559	1.000				
ITA	0.573	0.580	0.584	0.597	0.536	0.553	0.675	1.000			
NET	0.716	0.668	0.785	0.587	0.665	0.325	0.548	0.554	1.000		
POR	0.343	0.420	0.358	0.469	0.395	0.771	0.755	0.691	0.398	1.000	
SPA	0.503	0.567	0.493	0.563	0.485	0.727	0.738	0.808	0.560	0.845	1.000

Table 4

Principal Components Analysis Results. This table reports summary statistics for the principal components analysis of the correlation matrix of weekly changes in five-year CDS spreads for the U.S. and European sovereigns. The correlation matrix is computed using all available overlapping observations for each pairwise correlation.

Region	Principal Component	Percentage Explained	Cumulative Percentage Explained
USA	First	61.83	61.83
	Second	8.45	70.28
	Third	7.48	77.76
Europe	First	62.40	62.40
	Second	14.95	77.35
	Third	5.19	82.54

Table 5

Estimation Results for the CDS Valuation Model Using Federal and State CDS Spreads. This table reports the parameter estimates and their standard errors obtained by fitting the CDS valuation model to the term structure of CDS spreads for the indicated Federal and State CDS contracts. For the systemic processes, the parameters reported are α, β, and σ. The RMSEs are measured in basis points. The sample consists of weekly observations for the May 14, 2008 to July 16, 2010 period.

	Parameter			Standard Error			
	a	b	c	a	b	c	RMSE
California	0.00250	−0.1768	0.1064	0.00013	0.0114	0.0254	11.790
Florida	0.00306	0.1912	0.0268	0.00015	0.0187	0.2914	9.384
Illinois	−0.00010	−0.0566	0.0096	0.00019	0.0094	0.2592	15.758
Massachusetts	0.00140	0.0813	0.0174	0.00005	0.0068	0.1290	4.115
Michigan	0.00214	0.0549	0.0440	0.00018	0.0151	0.1074	13.448
Nevada	0.00171	−0.0508	0.1724	0.00012	0.0153	0.0246	10.218
New Jersey	0.00092	−0.0332	0.0253	0.00011	0.0135	0.1466	9.505
New York	0.00206	−0.1980	0.0607	0.00009	0.0064	0.0252	7.549
Ohio	0.00108	−0.0796	0.2172	0.00004	0.0043	0.0049	3.595
Texas	0.00091	0.0914	0.0389	0.00007	0.0135	0.1213	5.419
US Systemic	0.00009	−0.4720	0.2868	0.00001	0.0041	0.0020	1.179
Austria	0.00006	−0.0976	0.0506	0.00005	0.0176	0.0901	5.592
Belgium	−0.00019	−0.4646	0.2319	0.00002	0.0091	0.0070	4.181
Finland	0.00033	−0.1356	0.0228	0.00002	0.0188	0.1950	2.253
France	−0.00026	−0.4346	0.2013	0.00001	0.0065	0.0056	1.632
Greece	0.00081	−0.9786	0.5692	0.00022	0.0194	0.0083	51.694
Ireland	0.00115	−0.2562	0.3291	0.00010	0.0083	0.0076	12.742
Italy	0.00136	−0.1176	0.1623	0.00008	0.0166	0.0288	8.904
Netherlands	0.00041	0.0136	0.0954	0.00002	0.0175	0.0571	2.548
Portugal	0.00063	−0.1926	0.2969	0.00012	0.0115	0.0126	16.556
Spain	0.00129	−0.0792	0.2232	0.00009	0.0118	0.0182	10.153
Euro Systemic	0.00042	−0.4332	0.2672	0.00002	0.0161	0.0056	2.528

Table 6

Systemic Default Indexes This table reports the estimated value of the systemic default index parameter γ and its standard error for the indicated sovereigns. The value of γ is constrained to be 1.000 for the USA and Germany. The sample consists of weekly observations for the May 14, 2008 to January 5, 2011 period.

	Systemic Index	Standard Error
California	2.647	0.045
Florida	0.909	0.035
Illinois	0.000	0.031
Massachusetts	0.468	0.014
Michigan	0.731	0.054
Nevada	0.854	0.043
New Jersey	0.982	0.041
New York	0.000	0.022
Ohio	0.066	0.011
Texas	0.536	0.018
USA	1.000	–
Austria	1.173	0.028
Belgium	1.662	0.014
Finland	0.356	0.007
France	0.933	0.005
Germany	1.000	–
Greece	4.688	0.238
Ireland	1.604	0.049
Italy	1.710	0.037
Netherlands	0.668	0.011
Portugal	1.674	0.057
Spain	1.506	0.036

Table 7

Summary Statistics for the Percentage Systemic Component of U.S. and European Sovereign Default Risk. This table reports summary statistics for the percentage that the systemic component represents of the total credit risk of the indicated sovereigns. The sample consists of weekly observations for the May 14, 2008 to January 5, 2011 period.

	Mean	Std. Dev.	Min.	Med.	Max.	N
California	36.78	13.62	17.60	32.16	92.81	133
Florida	18.18	12.32	5.80	14.53	73.17	133
Illinois	0.00	0.00	0.00	0.00	0.00	130
Massachusetts	10.59	6.02	3.46	9.49	40.07	134
Michigan	8.83	4.33	3.35	7.71	26.76	131
Nevada	13.63	6.24	6.27	12.11	47.64	138
New Jersey	15.05	5.55	7.15	13.59	36.72	135
New York	0.00	0.00	0.00	0.00	0.00	131
Ohio	1.28	0.38	0.62	1.22	2.50	134
Texas	17.73	9.73	5.58	15.42	60.01	134
USA	100.00	0.00	100.00	100.00	100.00	139
Austria	34.31	16.16	0.00	30.76	100.00	136
Belgium	56.87	25.23	0.00	67.67	89.97	139
Finland	39.75	22.20	0.00	33.49	100.00	138
France	53.15	23.70	0.00	55.99	92.58	139
Germany	100.00	0.00	100.00	100.00	100.00	139
Greece	44.48	30.24	0.00	35.00	100.00	138
Ireland	16.77	9.82	0.00	15.30	45.71	139
Italy	31.84	15.36	0.00	31.32	71.60	139
Netherlands	39.79	21.10	0.00	34.27	100.00	138
Portugal	32.84	26.78	0.00	22.24	96.01	139
Spain	28.24	19.53	0.00	22.32	79.74	139

Table 8

Regression Results for Systemic Risk. This table reports the t-statistics and other summary statistics from the regression of weekly changes in the systemic credit process on the indicated variables. Mkt denotes the return on the S&P500 for the US, and the return on the DAX for Europe. VIX denotes the weekly change in the VIX volatility index. Corp denotes the weekly change in the CDX IG index for the US, and the weekly change in the ITraxx index for Europe. Japan, China, and EM denote the weekly changes in the CDS spreads for the respective sovereigns or sovereign indexes. The sample consists of weekly observations for the May 14, 2008 to January 5, 2011 period.

Region	Intercept	Mkt	Swap	VIX	Corp	Japan	China	EM	R^2	N
US Systemic	0.55	-4.31^{**}	2.60^{**}	-2.83^{**}	1.80^{*}	1.64	1.80^{*}	-0.50	0.352	138
Euro Systemic	0.56	-1.97^{**}	-0.61	-1.60	1.86^{*}	1.44	2.67^{**}	1.02	0.431	138

Table 9

Credit Clusters. This table reports the clusters formed on the basis of the correlation matrix of the weekly changes in the nonsystemic sovereign credit processes. The pairwise correlations in the correlation matrix are computed using all available overlapping observations for each pair.

Region	Cluster 1	Cluster 2	Cluster 3
USA	Illinois Massachusetts Michigan Ohio Texas	California Nevada New Jersey New York	Florida
Europe	Greece Ireland Italy Portugal Spain	Austria Finland Netherlands	Belgium France

Table 10

Regression Results for the Sovereign-Specific Credit Processes. This table reports the t-statistics and other summary statistics from the regression of weekly changes in the sovereign-specific credit processes on the indicated variables. Mkt denotes the return on the S&P500 for the US, and the return on the DAX for Europe. VIX denotes the weekly change in the VIX volatility index. Corp denotes the weekly change in the CDX IG index for the US, and the weekly change in the ITraxx index for Europe. Japan, China, and EM denote the weekly changes in the CDS spreads for the respective sovereigns or sovereign indexes. The sample consists of weekly observations for the May 14, 2008 to January 5, 2011 period.

Region	Intercept	Mkt	Swap	VIX	Corp	Japan	China	EM	R^2	N
California	0.48	−0.31	−2.51**	−0.31	0.13	−0.50	−0.08	−1.11	0.094	132
Florida	0.14	−1.77*	−2.11**	−0.82	−2.07**	0.55	−3.52**	−3.17**	0.136	132
Illinois	1.45	−1.64	−1.39	−0.07	−1.66*	−0.84	0.81	−1.54	0.135	129
Massachusetts	0.73	−1.50	−0.89	−1.50	−0.13	1.19	−0.40	−1.24	0.074	133
Michigan	0.51	−0.63	−1.84*	−1.44	0.08	0.66	−0.03	−1.57	0.113	130
Nevada	0.70	−0.93	−0.19	−0.56	0.68	−0.47	−0.33	−1.41	0.089	137
New Jersey	0.44	−2.56**	−1.62	−2.41**	−0.99	0.05	0.19	−1.58	0.132	134
New York	0.33	−1.95*	−1.13	−1.66*	−1.75*	0.36	0.71	−3.19**	0.217	130
Ohio	0.94	2.35**	−0.80	1.83*	2.63**	−0.58	2.81**	2.69**	0.144	133
Texas	0.31	−0.18	−1.10	−0.31	0.02	1.96**	−0.11	−0.89	0.082	133
Austria	0.04	−2.21**	−0.62	−2.49**	1.98**	1.36	0.76	0.12	0.336	135
Belgium	1.52	0.85	−0.97	−0.86	1.78*	−0.51	−0.91	−0.97	0.061	138
Finland	−0.21	−0.83	−0.58	−0.85	1.99**	0.37	0.96	0.67	0.281	137
France	1.37	0.47	−1.52	0.74	2.01**	−0.07	−2.83**	−1.41	0.147	138
Greece	1.42	1.34	−1.01	−1.69*	1.42	−0.72	−2.05**	−1.73*	0.086	137
Ireland	1.70*	−1.32	−2.20**	−2.13**	2.24**	0.06	0.41	0.71	0.184	138
Italy	0.78	−0.63	−2.34**	−0.74	2.71**	−0.82	−1.17	−0.13	0.232	138
Netherlands	0.15	−0.52	0.05	−1.32	1.85*	1.03	1.22	0.53	0.177	137
Portugal	0.94	0.96	−2.56**	−0.55	1.87*	−1.27	−1.03	0.65	0.161	138
Spain	1.33	−0.02	−1.84*	−1.36	2.26**	−0.98	−1.06	−0.59	0.146	138