FIXED INCOME

Fundamental Factor Model for Credit Default Swaps

Author(s): Yingjin Gan

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> INTRODUCTION

The credit default swap market has experienced dramatic changes over the last decade. Credit default swaps have existed since the early 1990s, and experienced an increase in use after 2003. By the end of 2007, the outstanding CDS amount reached a peak of $58.2 trillion. After the financial crisis of 2008, the CDS market has experienced a huge contraction. The amount outstanding fell to $32.7 trillion by the end of 2009 and has remained around $30 trillion over the last few years.[1]

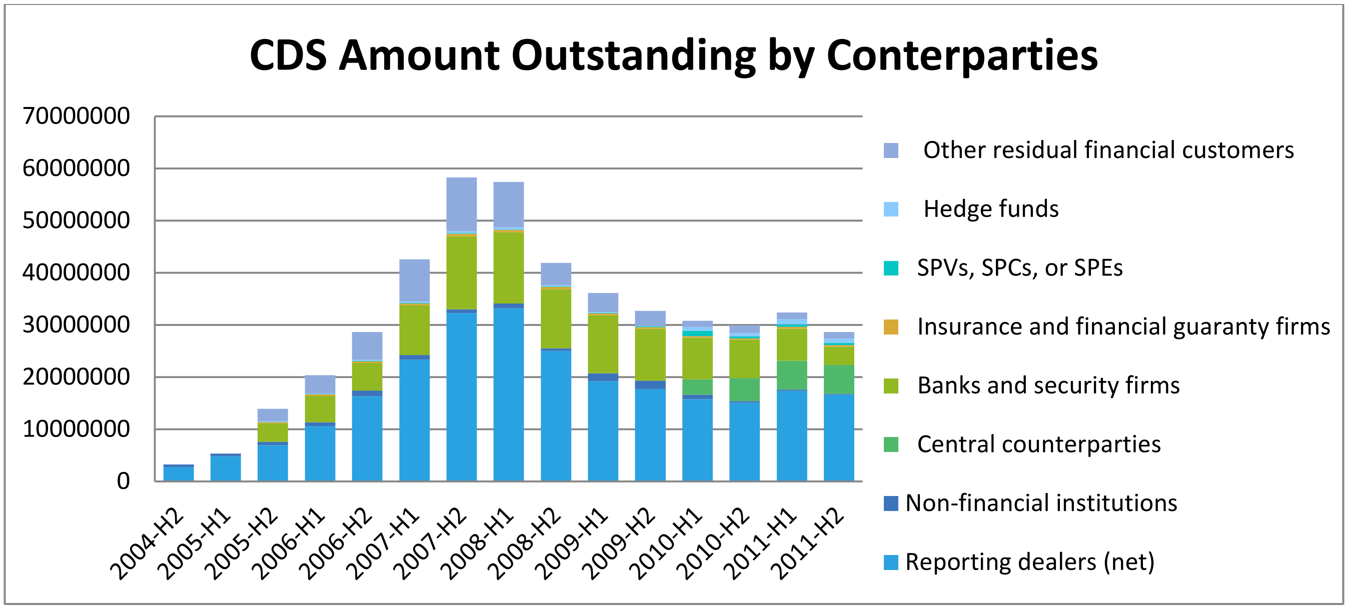

Figure 1: CDS Amount Outstanding by Counterparties

Another noticeable change of the CDS market is the introduction of central counterparties. Prior to 2009, there was no centralized exchange or clearing house for CDS transactions; they all were conducted over-the-counter (OTC). The financial crisis in 2008 led to changes of the CDS market towards increased transparency and regulation. The central clearing houses were introduced both in the US and Europe in 2009.

A credit default swap is an agreement that the buyer of the CDS pays a series of premiums (the CDS spread) to the seller in exchange for protection in the event of a default or other credit event. In the event of default, the buyer of the CDS receives compensation (usually the notional amount of the contract), and the seller of the CDS takes possession of the defaulted loan. The introduction of the CDS market has increased the ability of an investor to "short" a credit, which is often not easy in the cash bond market. CDS are widely used in hedging credit risks and taking active credit bets.

Credit default swaps and bonds of the same issuer typically trade at similar spread levels, as both reflect the market's view of credit risk. The higher the perceived credit risk, the higher the CDS spread, as well as the bond spread, even though the bond spread, such as OAS, and CDS spread are not directly comparable. The market has developed a methodology to compute the par equivalent CDS spread for bonds.[2] Basis refers to the difference between a credit default swap spread and a bond's par equivalent CDS spread with the same maturity date. Investors frequently seek to exploit discrepancies in the bond-CDS basis at a single-name level by trading basis packages. A positive basis package consists of a short position in the bond coupled with short CDS protection position. A negative basis package consists of a long

[1] Source: Bank for International Settlements, Detailed tables on semiannual OTC derivatives statistics at end-December 2011 at http://www.bis.org/statistics/derdetailed.htm.
[2] For details, please refer to "Credit Derivatives Handbook" by Beinstein et. al. JP Morgan 2006.

bond position and a long CDS protection position. In both cases, the idea is that the bond and CDS positions offset each other in the case of default, allowing the investor to take a view on the relative pricing of bonds and CDS without taking on credit risk. To reflect the connection between a bond and a CDS of the same entity, we design our CDS model with a "basis structure": each CDS contract has non-zero exposures to the same set of spread factors as a bond issued by the same entity would have and also additional basis factors, which are defined based on the entity's country of risk. For instance, a CDS on Bank of America in USD will load on the USD bank factor, a long or short slope factor, and a US CDS basis factor. Therefore, the risk of a basis package can be clearly illustrated by the netting of exposures to the cash bond spread factors.

Even though financial market theory suggests that CDS spreads and corporate bond spreads for the same entities should track each other well, the co-movements between the two markets were broken since the financial crisis in 2008. The corporate bond spreads witnessed sharp increases while the widening of CDS spreads was far less pronounced.

In the remainder of the document, we go over the data used to construct the model, the model details and finally present the back testing results. We have recently expanded risk model coverage from corporate CDS only to sovereign and corporate CDS traded in hard currencies.

Estimation and Data Universes

The estimation universe consists of all the sovereign and corporate generic CDS[3] that have a valid CMA NY 4pm close quote at the 3, 5 and 10 year tenors denominated in USD, EUR, JPY and GBP. With the current release, sovereign and corporate CDS contracts denominated in USD, EUR, JPY, GBP, CAD and AUD with valid pricing are covered.

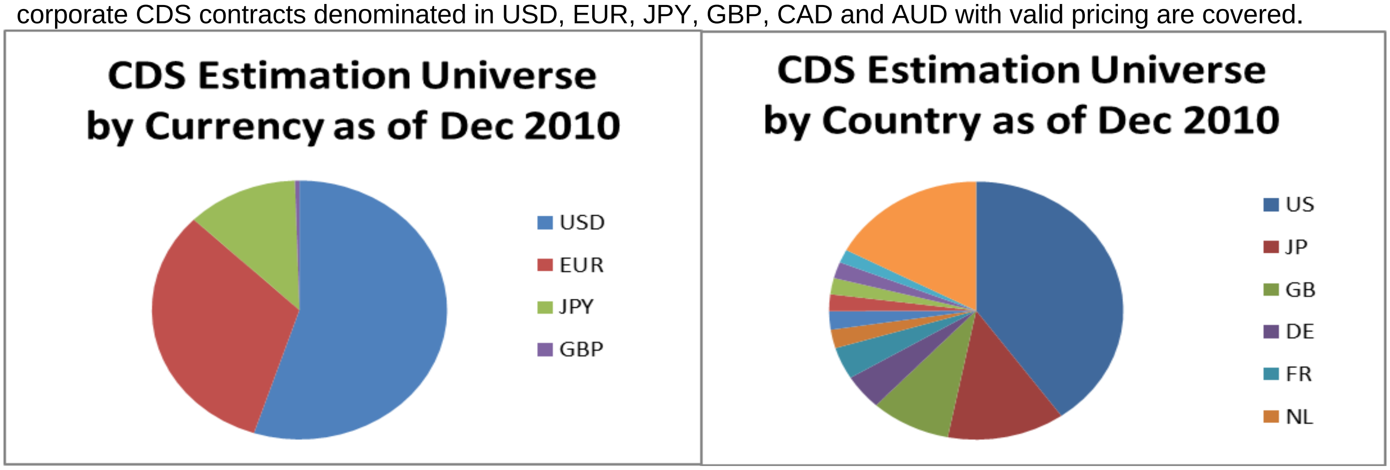

Figure 2: Estimation Universe by Currency and Country

Figure 2 displays the pie charts of the estimation universe by currency and country. The market is dominated by the US and USD in country and currency dimensions. However, contracts written on issuers in Japan and EU countries, especially Germany, France, and Italy are well represented too.

> MODEL STRUCTURE

In general, the total return of a generic security n over time period t can be written as the sum of several return components. Each in turn can be expressed as the product of a factor return and exposure to the factor. The risk (or volatility) of this return comes from the volatility of these factors as well as their correlations. First note that one such

[3] A generic CDS is a constant maturity CDS for a given issuer with a fixed tenor. We distinguish a corporate CDS from a sovereign CDS by BICS sector.

component is of a different nature than all other components: the time component. The time return is the return due to the passage of time with all other factors held constant. In other words, it is the return if the security's maturity (and all its cash flows) were shortened by one period. This component is known with certainty at the beginning of period t conditional on the security surviving till the end of the time period, therefore we subtract it explicitly from the total return. The difference between the total return and the time return, which will be referred to as the stochastic return, is the portion of return that drives risk. It can be written as:

$$R_n^t - R_n^{t,time} = \sum_{k=1}^{K} X_{nk}^t \cdot F_k^t + \varepsilon_n^t \qquad (1)$$

where:
R_n^t is the total return for security *n* during time period *t*,
$R_n^{t,time}$ is the time return for security *n* during time period *t,*
X_{nk}^t is a pre-defined factor exposure of security *n* to a factor *k*, at time *t* with *K* factors in total,
F_k^t is the return to factor *k* at time *t*,
ε_n^t is non-factor return of security *n* at time *t*.

Hereafter, we drop the super-script t for ease of notation. Formula (1) is a generic specification for all asset classes. The factors are of two kinds. Explicit factors are observable in the market and therefore we simply use the observed factor return directly. Currency factors, curve factors and volatility factors are the explicit factors in our model. Implicit factors are obtained via cross-sectional regression. For example, spread factors for different asset classes are implicit. CDS are exposed to the existing cash bond spread factors. In addition, they are exposed to basis factors, which are obtained via cross-sectional regression using the CDS estimation universe.

> SYSTEMATIC FACTORS

Currency Factors

CDS has limited exposure to currency factor when the currency of denomination of a CDS is different than the portfolio currency. The market value, rather than the notional amount represents the exposure to the currency factor.

Curve Factors

In general, CDS has limited exposures to curve factors. For instance, in the figure below, we show the CDSW snapshot for a Bank of America 5Y SR CDS trading at 65.1284 bps with 10 million notional. This contract has a spread DV01 of $5,030.53, and an interest rate DV01 of $45.78 as of April 10 2015. If we use the notional as normalizing basis to convert DV01s to durations, the CDS has spread duration of 5.03 years and interest rate duration of 0.046. For simplicity, we set the exposures of a CDS to all key rate points to zero.

Figure 3: Bloomberg CDSW Snapshot

Volatility Factors

CDS have zero exposure to the volatility factor.

Spread Factors

As mentioned before, change in both CDS spread and bond spread reflect the change in perceived credit quality of the issuing entity. Therefore, in our model CDS contracts load on the same set of factors as bonds issued by the same entity, and some additional basis factors to capture the potential discrepancy in CDS and bond pricing. For simplicity, we refer to the spread factors for cash bonds as "cash bond factors" and the CDS-specific factors as "basis factors".

We first start with the implied change in CDS spread, which is computed as the stochastic return divided by the negative spread duration. We then subtract the "spread change due to exposure to the cash model factors" computed as the product of the exposures and cash model factor returns ($B^{Crd} f^{Crd}$). The residual is the change in basis (ΔS^{Basis}), which is employed as the dependent variable in a regression to derive a set of implicit basis factors.

$$\frac{R - R^{time}}{-SD} = B^{Crd} f^{Crd} + \Delta S^{Basis} \tag{2}$$

Exposures of a CDS to cash bond factors are computed in the same way as for a bond: first based on the country, it gets classified to one of the two model families: the G6 and the Emerging Market models. If the issuer has a country code that belongs to the developed country list, it will have non-zero loading onto one of the G6 models based on the currency. Otherwise, it will load on one of the four EM models based on the country. Developed countries for this purpose include Australia, Canada, US, Japan, UK, the Euro zone, Denmark, New Zealand, Norway, Sweden and Switzerland. Once a contract is classified to the G6 model, the currency of denomination will further classify it into one of the G6 models. On the other hand, once a contract is classified to Emerging Market, the country code will further determine to which regional model it belongs. In the subsequent paragraphs, we review the G6 and Emerging Market models. We provide a briefed summary on the model classification conditions as well as the meanings of the detailed spread factors.

Sovereign Spread Factors

A CDS contract that loads on G6 model factors belongs to sovereign sector if the following conditions are met: BICS sector equals Government and BICS industry group equals Sovereign and the country code is consistent with the currency code. For instance, if the currency is USD, only a contract with country code equal to US will be considered as sovereign, otherwise it will load on Agency spread factors.

$$B^{Sov} f^{Sov} = F^{Sov} + \left(SD_n - medSD_{C(n)}\right) \cdot F^{Sov}_{Slope} + \left(OAS_n - medOAS_{C(n)}\right) \cdot F^{Sov}_{Liq} \tag{3}$$

F^{Sov} is the regression intercept. It represents the average spread movement for the sovereign universe. In the EUR model, this spread factor is replaced by a set of country-specific spread factors. These country factors represent the average spread change for a given country.

F^{Sov}_{Slope} is the slope factor, and $medSD_{C(n)}$ denotes the median spread duration of bonds that belong to the same country C(n) as bond n in the estimation universe.

F^{Sov}_{Liq} is the liquidity factor, and $medOAS_{C(n)}$ denotes the median spread of bonds that belong to the same country C(n) as bond n in the estimation universe.

Agency Spread Factors

A CDS contract that loads on G6 model factors belongs to agency sector if the following conditions are met: BICS sector equals Government and it does not satisfy the condition to be classified as sovereign.

$$B^{Agy} f^{Agy} = F^{Agy}_{G(n)} + \left(SD_n - medSD_{G(n)}\right) \cdot F^{Agy}_{Slope} + \left(OAS_n - medOAS_{G(n)}\right) \cdot F^{Agy}_{Liq} \tag{4}$$

$F^{Agy}_{G(n)}$ are the average spread change for each group in the Agency universe. The groups can be different for each of the G6 models; for instance, the EUR agency model has countries plus supra national, and the USD agency model has the following groups: FNMA, FHLMA, FHLB, FARM and Others.

F^{Agy}_{Slope} is the slope factor, and $medSD_{G(n)}$ denotes the median spread duration of bonds that belong to the same group G(n) as bond n in the estimation universe.

F^{Agy}_{Liq} is the liquidity factor, and $medOAS_{G(n)}$ denotes the median spread of bonds that belong to the same group G(n) as bond n in the estimation universe.

Corporate Spread Factors

A CDS contract that loads on G6 model factors belongs to corporate sector if the BICS sector does not equal Government. We then use BICS industry classification, spread duration, spread, country, rating and seniority to define the exact exposures. As a refresher, corporate spread factors and their definitions for the G6 models are listed in Table 1. The generic structure of the G6 corporate cash model factors can be summarized as follows:

$$B^{Crd} f^{Crd} = F^{Crd}_{Basic} + S^{+}_{n} \cdot \left(F^{Crd}_{I(n)} + 1_{Frgn} \cdot F^{Crd}_{Frgn} + 1_{HY} \cdot F^{Crd}_{HY} + 1_{Sub} \cdot F^{Crd}_{Sub} \right) + \left(SD_n - medSD_{I(n)} \right) \cdot F^{Crd}_{Slope} \quad (5)$$

F^{Crd}_{Basic} is the regression intercept. Most bonds other than those with very low initial spreads will load on an additional industry spread factor. In the EUR model, this basic spread is replaced by a set of country specific factors. Unlike most of the other spread factors, which represent the *proportional* spread change, this factor represents the absolute spread change common for a given market/country.

$F^{Crd}_{I(n)}$ is the industry-specific spread factor, representing the average *proportional* change in spreads of bonds belonging to the same industry, $I(i)$. The exposure to the industry-specific factor is the initial spread level, where S^{+}_{i} denotes max(0, S).

F^{Crd}_{Frgn} is the foreign factor, representing the average incremental proportional changes in spreads for all bonds that are issued by foreign entities.[4]

F^{Crd}_{HY} is the high yield factor, representing the average incremental *proportional* changes in spreads of high yield (HY) bonds.[5]

USD	EUR	JPY	GBP	CAD	AUD
USD Corp: Corp Spread	Country: Austria Country: Belgium Country: France Country: Germany Country: Italy Country: Netherlands Country: Portugal Country: Spain Country: Other Europe Country: Other Non-Europe	JPY Corp: Corp Spread	GBP Corp: Corp Spread	CAD Corp: Corp Spread	AUD Corp: Corp Spread
USD Corp: Aero/Def USD Corp: Air USD Corp: Auto USD Corp: Banks	EUR Corp: Fin EUR Corp: Cons Cyc EUR Corp: non-cyc EUR Corp: Energy	JPY Corp: Fin JPY Corp: Indus JPY Corp: Utility JPY Corp: Corp Other	GBP Corp: Com & Tech GBP Corp: Cons GBP Corp: Energy GBP Corp: Fin	CAD Corp: Fin CAD Corp: Utility CAD Corp: Cons CAD Corp: Corp Other	AUD Corp: Fin AUD Corp: Corp Others

[4] Foreign bonds are identified by Bloomberg fields Country_risk_iso_code (VM101) and Country_of_risk (DX129) when the first field is not available. When both of these fields are not available, we use Country_ISO (DS458).
[5] Bonds rated BB+ and below are considered high yield (HY). Rating assignment is from BB Rating Composite, Moody's, S&P and Fitch, in that order based on availability. If no rating information is available, or rated NR, then we assign a broad rating category (i.e., IG, HY, or Distressed) based on OAS.

USD Corp: Bas Matl USD Corp: Comp USD Corp: Cons Cyc USD Corp: Elec USD Corp: Energy USD Corp: Fin Svcs USD Corp: Gas Util USD Corp: Health USD Corp: Indus USD Corp: Ins USD Corp: Media USD Corp: Non-cyc USD Corp: Oil&Gas USD Corp: Pharma USD Corp: REITS USD Corp: Retail USD Corp: Tech USD Corp: Telecom USD Corp: Trans	EUR Corp: Utility EUR Corp: Com & Tech EUR Corp: Indus EUR Corp: Bas Matl		GBP Corp: Matl & Ind		
USD Corp: Corp Foreign		JPY Corp: Corp Foreign	GBP Corp: Corp Foreign		AUD Corp: Corp Foreign
USD Corp: HY	EUR Corp: HY		GBP Corp: HY	CAD Corp: HY	
USD Corp: Subord	EUR Corp: Subord		GBP Corp: Subord		
USD Corp: Long	EUR Corp: Corp Slope	JPY Corp: Corp Slope	GBP Corp: Corp Slope	CAD Corp: Corp Slope	AUD Corp: Corp Slope
USD Corp: Short					

Table 1: G6 Corporate Spread Factors Comparison

F_{Sub}^{Crd} is the seniority factor, representing the average incremental *proportional* changes in spreads of bonds in the subordinated class[6]. It's positive when spreads of subordinated debt widen on average relative to senior debt, holding everything else the same.

F_{Slope}^{Crd} is the slope factor, and $medSD$ denotes the median spread duration of bonds that belong to the same industry group I(n) as bond n in the estimation universe. The USD corporate spread model uses separate Long and Short slope factors, while other G6 models use just one slope factor.

[6] Subordinated bonds are identified by Bloomberg field IS_SUBORDINATED (DX825).

EM spread factors

If a CDS contract has a country code that is not in the developed market list, it will load on one of the four EM hard currency models: Asia Pacific, Latin America, Eastern Europe and Middle East & Africa. For each of these regional models, the basic spread factor structure is as follows.

$$B^{EM} f^{EM} = S_n^{+}\left(F^{EM} + F_{Industry(n)}^{EM} + F_{Country(n)}^{EM}\right) \tag{6}$$

F^{EM} is the average percentage spread change for a given region.

$F_{Industry(n)}^{EM}$ is the additional average percentage spread change for a given industry group within a given region.

$F_{Country(n)}^{EM}$ is the additional average percentage spread change for a given country within a given region.

CDS basis factors

Unlike the cash model factors, the basis factors are NOT structured separately by currency, but rather we group all the CDS generics in all currencies together and define the implicit basis factors as follows:

$$\Delta S^{Basis} = F_{Basic}^{Basis} + S_n\left(F_{C(n)}^{Basis} + 1_{HY} \cdot F_{HY}^{Basis} + 1_{Sub} \cdot F_{Sub}^{Basis}\right) + \epsilon \tag{7}$$

F_{Basic}^{Basis} is the regression intercept. All CDS contracts have a unit exposure to this factor in the regression. It captures the global market basis between cash bonds and CDS.

$F_{C(n)}^{Basis}$ is the country-specific basis factor, representing the average *proportional* changes in basis belonging to the same country or region[7], $C(n)$. The exposure to the country (region)-specific factor is the initial spread level, S_n. The country-to-factor mapping is provided in Table 2.

F_{HY}^{Basis} is the high yield factor, representing the average incremental *proportional* changes in basis of high yield (HY) entities[8]. It is positive when HY CDS' basis widens on average relative to IG CDS, holding everything else the same.

F_{Sub}^{Basis} represents the average incremental *proportional* changes in basis of CDS in the subordinated class[9].

[7] The country fields used are Bloomberg fields Country_risk_iso_code (VM101) and Country_ISO (DS458) when the first field is not available.
[8] The HY status is defined by Bloomberg field Credit_Rating_Grade (DY896). When this field is not available, we use the condition that the deal spread (SW_SPREAD, SW025) is 400 bps or higher.
[9] Subordinated CDS are identified by Bloomberg field SW_SENIORITY (SW145).

Country	Factor	Country	Factor	Country	Factor
HK	ADV	RS	EEU	IL	MEA
KR	ADV	TR	EEU	KW	MEA
SG	ADV	AL	EEU	QA	MEA
TW	ADV	AZ	EEU	SA	MEA
FJ	ADV	BY	EEU	TN	MEA
CN	AEM	GE	EEU	ZA	MEA
IN	AEM	GR	EUHY	EG	MEA
MY	AEM	PT	EUHY	LB	MEA
ID	AEM	IS	EUHY	IQ	MEA
PH	AEM	ES	EUHY	MA	MEA
TH	AEM	IE	EUHY	GA	MEA
PK	AEM	FR	FR	GH	MEA
VN	AEM	GB	GB	JO	MEA
LK	AEM	IT	IT	NA	MEA
MN	AEM	JP	JP	NG	MEA
NZ	AU	BR	LAM	OM	MEA
AU	AU	MX	LAM	SC	MEA
CA	CA	VE	LAM	SN	MEA
CH	CH	CL	LAM	NL	NL
DE	DE	CO	LAM	SE	SE
KZ	EEU	PA	LAM	KY	US
RU	EEU	PE	LAM	BM	US
CY	EEU	AR	LAM	US	US
HU	EEU	EC	LAM	BS	US
PL	EEU	DO	LAM	LU	WEU
UA	EEU	CR	LAM	AT	WEU
BG	EEU	SV	LAM	BE	WEU
HR	EEU	GT	LAM	DK	WEU
RO	EEU	UY	LAM	FI	WEU
SK	EEU	BB	LAM	NO	WEU
CZ	EEU	BZ	LAM	MT	WEU
SI	EEU	JM	LAM	GG	WEU
LV	EEU	TT	LAM	IM	WEU
LT	EEU	AE	MEA	JE	WEU
EE	EEU	BH	MEA		

Table 2: Country to Factor Mapping

Since CDS contracts load on both the cash model factors and the CDS basis factors, it is useful to see how much of the return variation of CDS can be explained by these two groups of factors. To do this, we compute R^2 for cash model factors as follows:

$$1 - \frac{(R_n^{sto} - R_n^{cash})^2}{\sum_n (R_n^{sto})^2} \tag{8}$$

where R_n^{sto} is the stochastic return, which is simply the total local return minus the time return, and R_n^{cash} is the return that can be explained by the cash model factors.

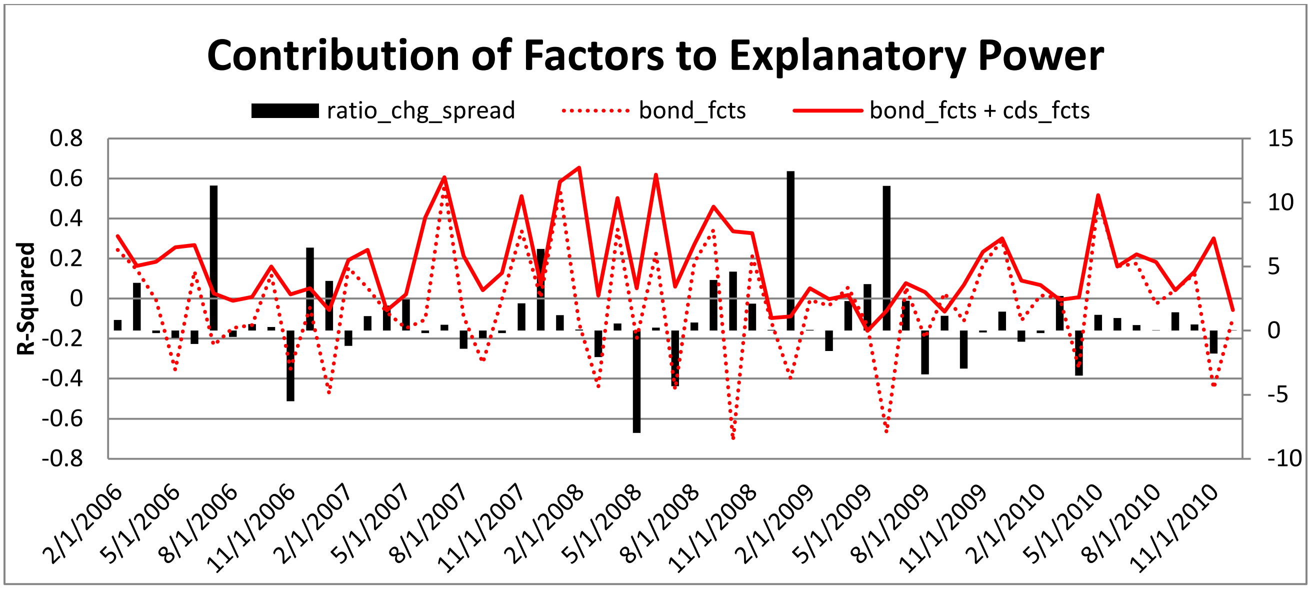

Figure 4: Contribution of Factors to Explanatory Power for USD IG CDS

Figure 4 plots the explanatory power for the cash and basis factors over time for corporate CDS, which account for about 95% of the universe. We observe that the cash model factors don't explain the CDS returns very well. In many periods, the computed cash model factor correlations are negative. This may appear counterintuitive, however, over the last few years, the levels of spread between the cash bond market and CDS market are highly correlated (95%), but the correlation between the changes of spread is actually quite modest at 57%. Therefore, when the ratio of change of cash bond spread to change of CDS spread is high, the cash bond factors can't explain CDS returns well. The black bars in the above figure represent this ratio. In months when this ratio is very high, such as January and June 2009, the change in cash bond market is over 10 times larger than that for CDS. Therefore cash bond factors "over-shoot" a lot in explaining the CDS return variations.

We use the CDX IG to represent the CDS spread, and the cash bond spread is being represented by the asset swap spread of an investment grade corporate index. The levels and changes of these spreads are plotted in Figure 5. The levels of spreads track each other very well, but the changes of spread deviate a lot, particularly around the crisis period in 2008. The widening in spread in cash bond market was much larger than that in the CDX space.

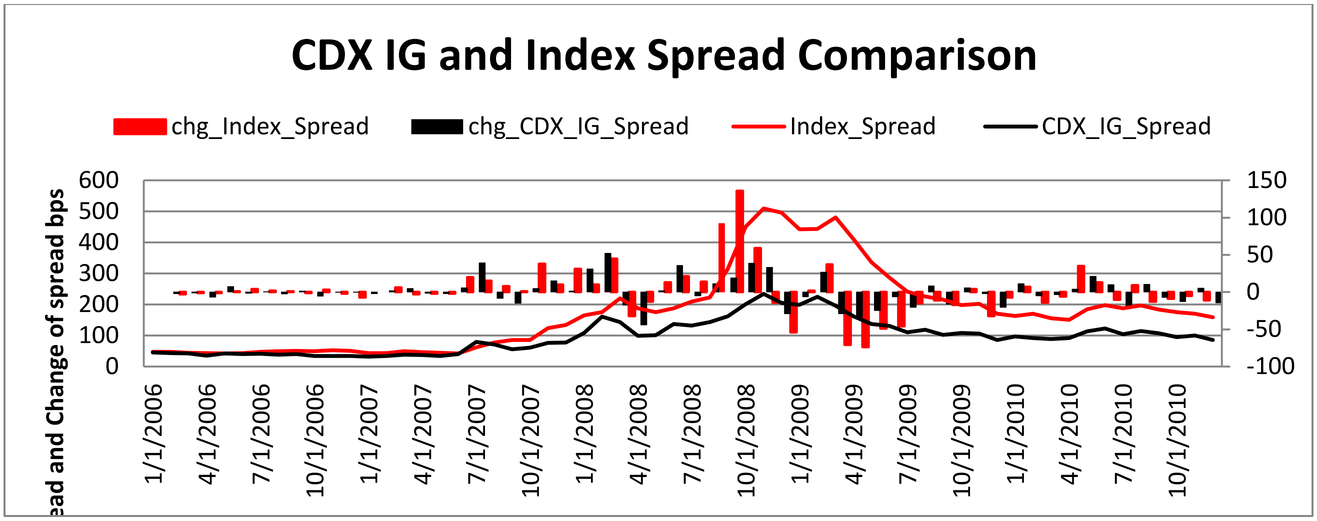

Figure 5: Corporate IG Spread and CDX IG Spread Comparison

> NON-FACTOR RISK AND CORRELATIONS

For CDS contracts, we build a model for the non-factor risk using the panel of residuals ε_n^t from the factor regression (3). To explain a CDS's non-factor variance, we resort to the same peer groups used in the systematic regression. More specifically, after we run the regression to obtain the systematic factors, we subsequently fit a model for its squared residuals $(\varepsilon_n^t)^2$, using the aforementioned groups:

$$|\varepsilon_n^t| = \sum_{C(n)=1}^{C} Y_{C(n)}^t G_{C(n)}^t + \varphi_n^t \tag{9}$$

where

- $Y_{C(n)}^t$ is an indicator function of group $C(n)$ (i.e., 1 if a member of that group, 0 otherwise)
- for non-distressed corporate sector, spread are included in $Y_{C(n)}^t$ to capture the relative spread change effect
- $G_{C(n)}^t$ are coefficients determined by the regression.

The magnitude of the non-factor risk for a corporate CDS is the product of its spread duration, the spread and the the EWMA of the factor $\mathrm{G}_{\mathrm{C(n)}}^{\mathrm{t}}$ with an adjustment $\sqrt{\frac{\pi}{2}}$.

In addition to the magnitude of non-factor risk, we also consider the correlation between CDS contracts and bond of the same issuer. The correlation between two bonds of the same issuer is determined as a function of their duration proximity. We chose to use the same functional form to describe the non-factor correlation between a CDS and a cash bond. For details, please refer to [1].

Construction of factor covariance matrices

The detailed methodology of constructing covariance matrices is described in [1]. Essentially, the covariance matrix is constructed by specifying a few core factors, through which the cross-asset class correlations are computed. The core factors for the CDS basis factors are:

$$\Delta S^{Basis} = F_{core}^{Basis} + S_n\left(F_{core\_DTS}^{Basis} + 1_{HY} \cdot F_{core\_HY}^{Basis}\right) + \epsilon \tag{10}$$

F_{core}^{Basis} is the intercept of the core regression, it captures the overall change in basis across all the CDS market.

$F_{core\_DTS}^{Basis}$ is the incremental proportional change of basis.

$F_{core\_HY}^{Basis}$ is the incremental proportional change of basis for HY CDS.

Model Performance

The Bloomberg CDS model is thoroughly back-tested on numerous portfolios. We tested the market portfolio, country/region portfolios and several long-short portfolios in which we go long one country/region portfolio and short another.

Bias Testing

The bias of a model is measured by the standard deviation of *normalized portfolio returns*,

$$Bias = Std\ Dev\left(\frac{Realized\ Return}{Forecast\ Risk}\right) \tag{11}$$

The figure below gives percentages of time the risk estimate falls within 95 % confidence interval for each portfolio tested. The confidence interval is computed as $\left(1 - \sqrt{\frac{2}{T}}, 1 + \sqrt{\frac{2}{T}}\right)$ under the assumption that *normalized portfolio returns* follow standard normal distribution. T is set to 10. For the market portfolio, about 64% of time the risk forecast is within the interval. However, we do see variations across different portfolios: IT (Italy) is the highest at 88% and the MEA (Middle East and Africa) is the lowest at 12%, which is the result of the small number of observations for the region. Note that all the bias tests are done using local returns, i.e returns without currency tranformation.

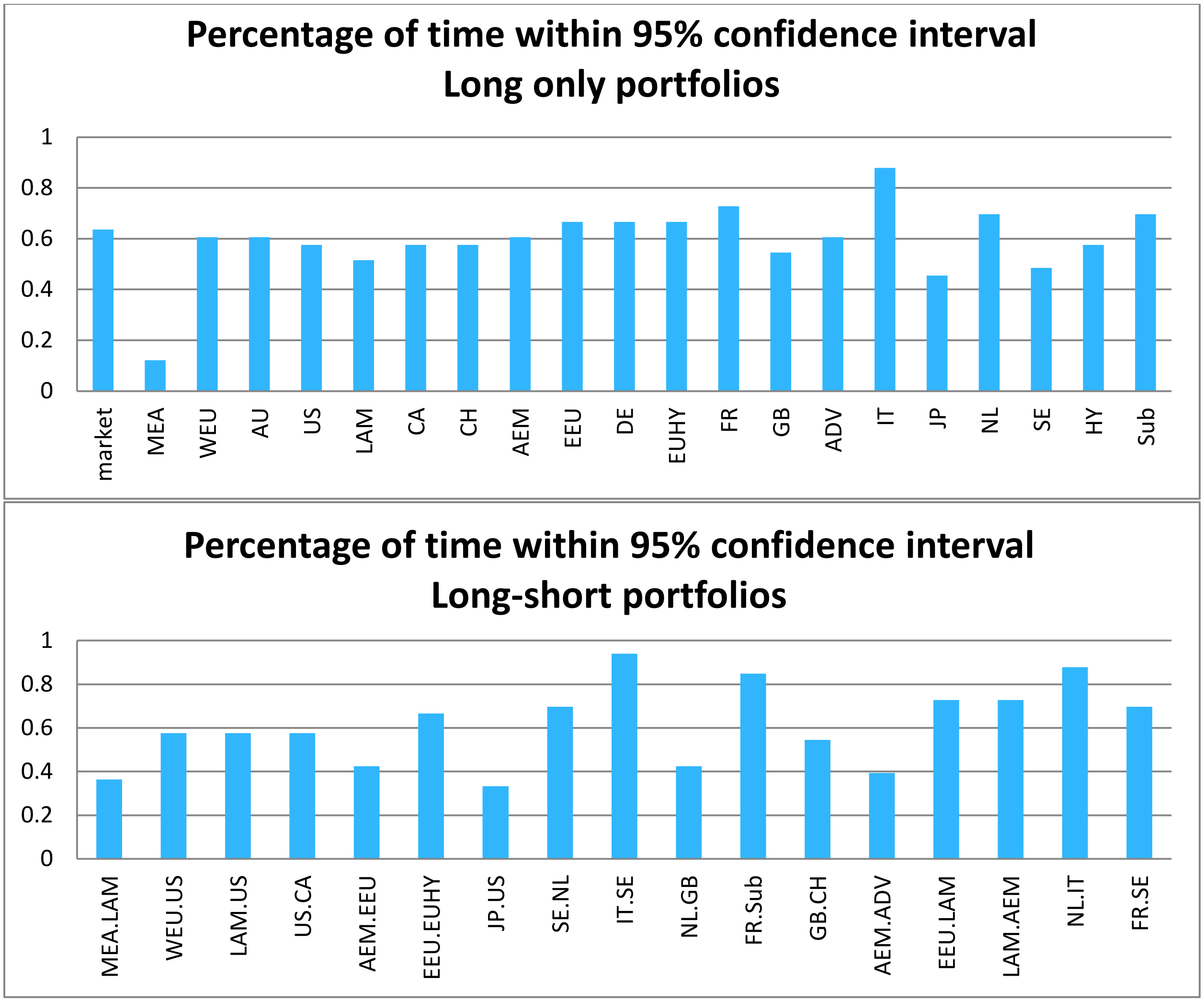

Figure 6: The percentage of time the risk estimate was within confidence interval

The bottom panel shows the percentages of time the risk estimate falls within the confidence intervals for long-short portfolios. On average, the risk model performance for long-short portfolios is not as good as that for long-only portfolios, which we observe in the back test for cash bonds universe as well.

Figure 7 shows evolution of the model bias over time for equally weighted CDS portfolio and USD corporate bond portfolio. The corporate bond portfolio underestimates risk around the 2008 crisis and overestimates risk after the crisis. The CDS portfolio, on the other hand, didn't overestimate risk around the crisis. The green dotted line in the panels indicates the confidence bounds. One can observe that most of the time the model predicted risk is within the 95% confidence interval.

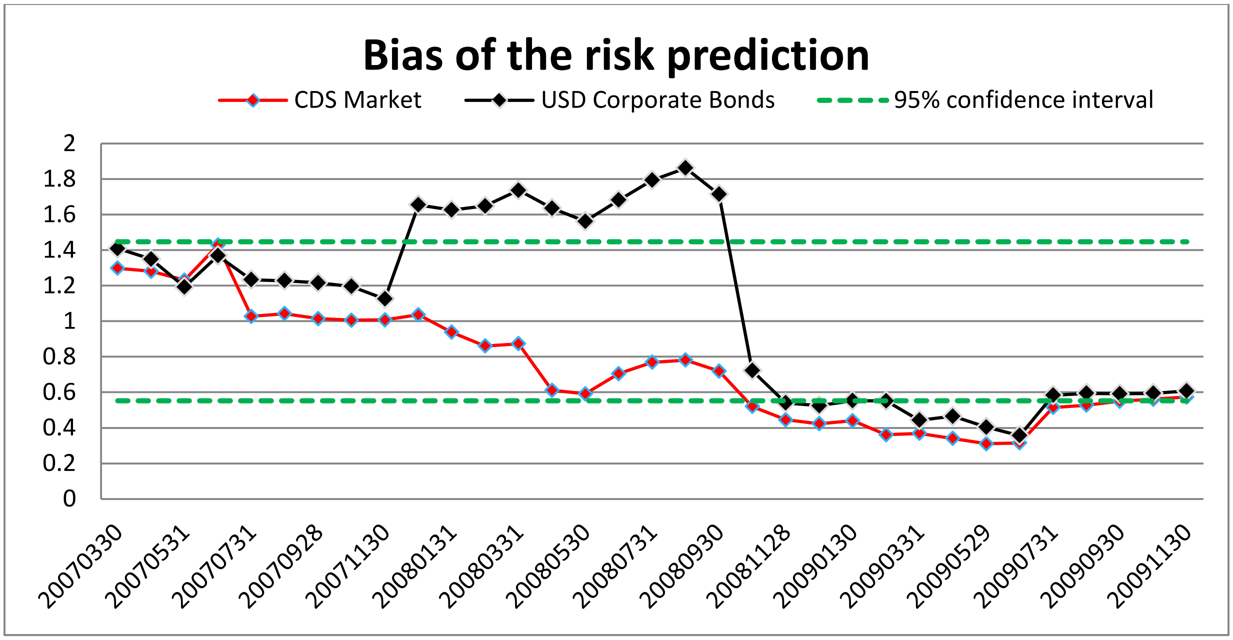

Figure 7: Evolution of bias over time

Portfolio Returns vs. Predicted Risk

Figure 8 shows the realized returns of equally weighted CDS portfolios against risk forecasts of our model. The top panel is the result from an equally weighted CDS portfolio and the bottom panels is the result from a long-short portfolio (long Latin America and short Emerging Asia). The results indicate the following: the risk prediction responds promptly to the volatility in the realized portfolio returns, which is a highly desirable feature of the risk model. Similar to the corporate cash bond models, the responsiveness in the CDS model is due to the "duration times spread" DTS technique. Our methodology models the percentage change in spread rather than the absolute spread level, hence yielding a model with improved and timely risk prediction.

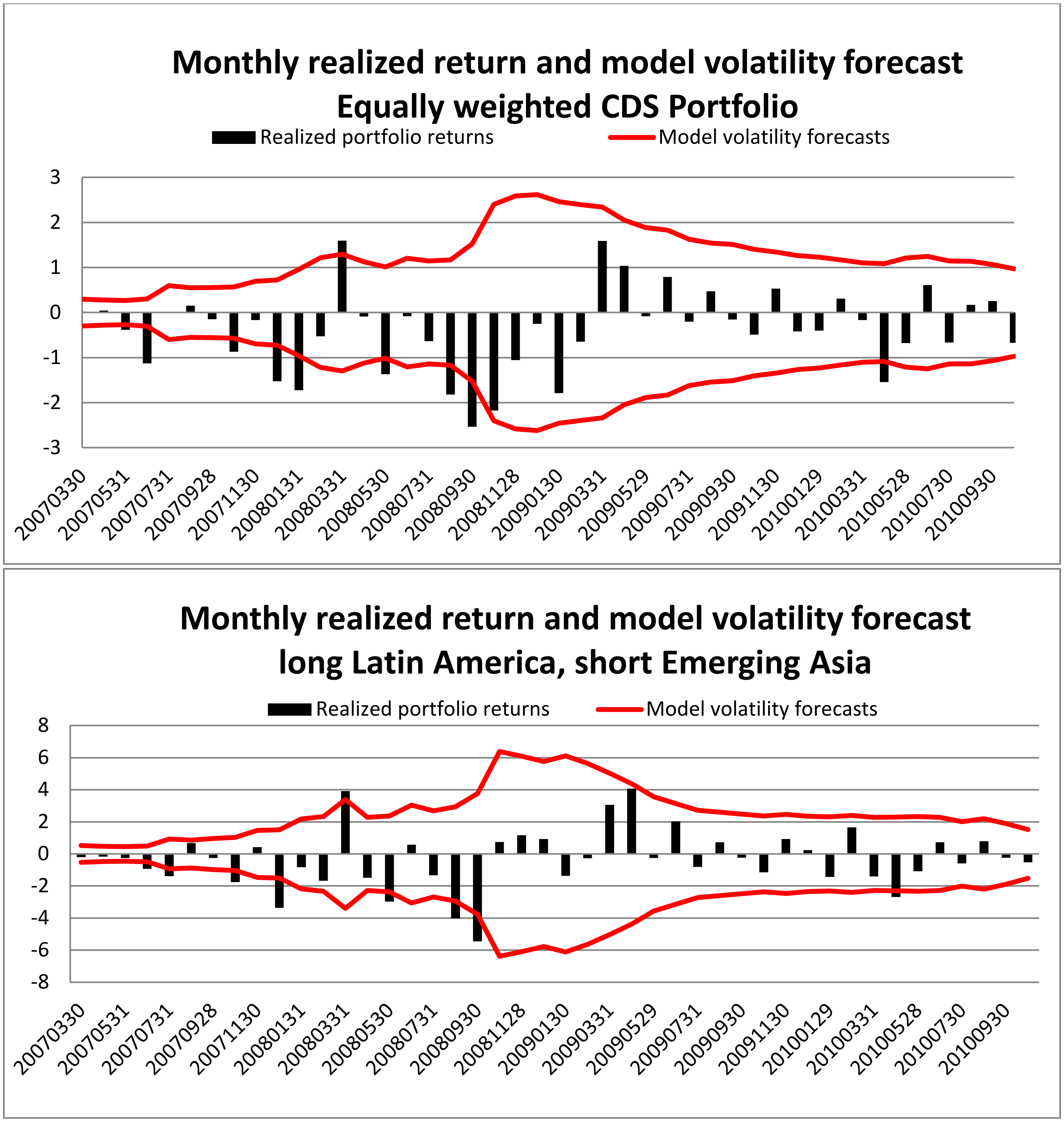

Figure 8: Realized Return vs. Predicted Risk

> SUMMARY AND CONCLUSIONS

- We have presented a CDS factor model based on fundamental factors.
- The CDS model is constructed with the connection between the cash bond market and the CDS market in mind, where each CDS contract loads on both the cash model factors and the CDS basis factors
- The structure of the model is chosen to be intuitive and with fully transparent methodology.
- The model stays unbiased with no significant under- or over-forecasting of risk for a broad variety of portfolios.

> REFERENCES

[1] Yingjin Gan and Luiza Miranyan, “Fixed Income Fundamental Factor Model”, February, 2012.

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