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# CORPORATE VULNERABILITY INDEX White Paper

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## ABSTRACT

In July 2012, the Credit Research Initiative (CRI) at the National University of Singapore launched the Corporate Vulnerability Index (CVI). The CRI Probabilities of Default (CRI PD) of individual firms are used in the CVI to produce bottom-up measures of credit risk for economies, regions and portfolios of special interest.

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## OVERVIEW

In July 2012, the CRI launched the Corporate Vulnerability Index (CVI), which is a new suite of indices to produce bottom-up measures of credit risk, available in 3 distinctive types:

### 1. Value-weighted CVI (CVI<sub>vw</sub>)

CRI PD are aggregated with each firm weighted by its market-capitalization so that the size of each firm is taken into account.

### 2. Equally-weighted CVI (CVI<sub>ew</sub>)

CRI PD are aggregated with each firm equally weighted. This captures the prevalence of credit risk by focusing on the number of firms at risk.

### 3. Tail CVI (CVI<sub>tail</sub>)

In taking the 5<sup>th</sup> percentile of the highest CRI PD, the most vulnerable firms in a group are measured.

CVI can be aggregated at various macro levels: economy, region, or portfolio. For example, the CVI for Singapore are denoted by CVI<sub>vw</sub> (SGP), CVI<sub>ew</sub> (SGP) and CVI<sub>tail</sub> (SGP). At its launch in July 2012, CVI were available for 9 economies and 1 special portfolio. This coverage has been extended to 16 additional economies over the past few years. Table 1 below details the evolution of the CRI coverage.

Table 1. Currently available CVI groups

Region	Group
North America	Canada (CAN), United States of America (USA)
Europe	Eurozone (EMU), France (FRA), Germany (DEU), United Kingdom (GBR), Denmark (DNK), Norway (NOR), Sweden (SWE), Finland (FIN), Greece (GRC), Switzerland (CHE), Turkey (TUR)
Asia	China (CHN), Japan (JPN), Singapore (SGP), Australia (AUS), Taiwan (TWN), Malaysia (MYS), Philippines (PHL), Thailand (THA), Vietnam (VNM), Indonesia (IDN), Israel (ISR)
Special portfolios	S&P500 Index (SPP)

The CVI are a set of indicators that gauge economic and credit environments in a new dimension. They are best viewed as stress indicators that reflect heightened credit risks

in the corporate sector from three different angles. Given this feature, a possibility is to develop CVI-based derivative instruments (futures, swaps, options) which can be used for hedging in time of crisis.

## METHODOLOGY

The primary inputs to the CVI are the CRI PD for individual exchange listed firms. The current default prediction system used by the CRI is based on the forward-intensity model of Duan *et al.* (2012)<sup>1</sup> that relates a firm's likelihood of default, over various periods, to several common macrofinancial risk factors and firm-specific attributes. For more information about the methodology, please refer to the CRI PD white paper<sup>2</sup>.

The CVI are constructed using 12-month CRI PD of each firm within a specified economy, region, or portfolio. Back-calculated historical series of daily values were provided for comparison purposes. Historical CVI are refreshed on a yearly basis as a part of the CRI yearly system refresh.

In this section, the details for the construction of the three types of CVI:  $CVI_{vw}$ ,  $CVI_{ew}$  and  $CVI_{tail}$  are given. The remaining sections describe criteria for the inclusion of firms and specify how the CVI values will be reported.

### Value-Weighted CVI ( $CVI_{vw}$ )

$CVI_{vw}$  is an aggregation of individual PD weighted by each firm's market-capitalization. In other words, a firm's weight in the aggregation is computed as the fraction of the firm's market-capitalization relative to the total market-capitalization of all constituents of the target group that have a PD on a given day. The market-capitalization for each firm at the end of each trading day is taken from Bloomberg. If a firm does not trade on a particular day, the market-capitalization from the previous valid day (within 20 trading days) is used. If necessary, market-capitalizations are converted into a common currency for the group.

The market-capitalization weighting is applied to all economies and groups of economies, but is not applied to portfolios such as the S&P 500 index. The S&P 500 index is a float-adjusted index where the shares available to investors are used instead of the total shares outstanding. The free-float from Bloomberg for each class of shares is used to calculate the float-adjustment.

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<sup>1</sup> Duan, J. C., Sun, J., and Wang, T. (2012). "Multiperiod Corporate Default Prediction – A Forward Intensity Approach", *Journal of Econometrics*, 179, 191-209.

<sup>2</sup> The CRI at the National University of Singapore (2017), "Probability of Default White Paper"

The weighting scheme of  $CVI_{vw}$  (SPP) is consistent with the S&P 500 index. Before 2005, the S&P 500 index was market-capitalization weighted, and Standard & Poors' transitioned from a market-capitalization weighting to a float-adjusted weighting in two steps. The first step was to switch to a half-float weighting after March 18, 2005. The second step was to switch to a full-float weighting after September 16, 2005. The computation of  $CVI_{vw}$  (SPP) follows this procedure for each period to have the closest counterpart to the S&P 500 price index as possible.

The half- and full-float adjustment are described in greater detail in the Appendix.

## Equally-Weighted CVI ( $CVI_{EW}$ )

The equally-weighted CVI is computed by aggregating each firm's PD with equal weights applied to each firm. In other words, this is just the standard arithmetic average of the firms' PD in a group.

## Tail CVI ( $CVI_{tail}$ )

The Tail CVI provides a measure of the relatively more distressed firms in a group. It is the highest 5<sup>th</sup> percentile of PD. The Tail CVI can also be interpreted as the conditional median of the 10 percent tail, which is a more robust measure of "tail average" than the conditional mean of the 10 percent tail.

## Inclusion of New Firms

The CRI computes the PD of each firm based on their primary exchange. However, in the CVI, the firms are aggregated by country of domicile.

For example, the web services firm Baidu is listed on the NASDAQ exchange in the US, so is computed with the same parameters as any other firm listed in the US. However, Baidu's PD is included in China's CVI. In such a situation, an appropriate exchange rate will be used to convert the firm's market-capitalization.

In regions like the eurozone, some of the public holidays do not coincide. In this case, the aggregation is computed by using PD from the previous trading day for firms that are listed in countries that have a public holiday, and PD from the current trading day for firms that are listed in countries that do not have a public holiday.

Firms are included in the eurozone CVI only if the country the firm is domiciled in is part of the eurozone at that time. For example, Greek firms are only included in the eurozone CVI after January 1, 2001 when Greece joined the eurozone.

For CVI of S&P 500 portfolio, the constituents typically coincide with the constituents of the S&P 500 index for each point in time, and any missing PD value for a company in the S&P 500 is filled in with the most recently available PD.

## Reporting CVI Values

For the first set of nine CVI that were launched in July 2012, the official start date for the CVI is the first trading day of July 2012. For the additional CVI launched in August 2013, in December 2013 and in October 2014, the first trading day of the respective month is set as the official start date. The CVI is reported in basis points up to two decimal places. Back-calculated historical series using daily data are provided for comparative purposes.<sup>3</sup> All CVI series go back to the first trading day of 1996 or when the minimum criterion of 30 companies is met.

As of the first trading day of July 2012, the CVI are daily updated indices and all of them are released at 4.30pm Singapore Standard Time (UTC+8) for the previous trading day. Continuing the example of Baidu in the previous section, Baidu's PD cannot be computed until after US markets close, so China's CVI values cannot be computed until after US PD are computed.

## Back-calculating CVI Values

Since January 2013, all 25 historical CVI series are back calculated using daily values. The parameters used to compute the historical CVI are refreshed on a yearly basis as part of the CRI annual system update to account for new information that have a retroactive impact on the firms' credit risk.

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<sup>3</sup> The back-calculated historical series are indicated by a gray background color in the CVI graphs.

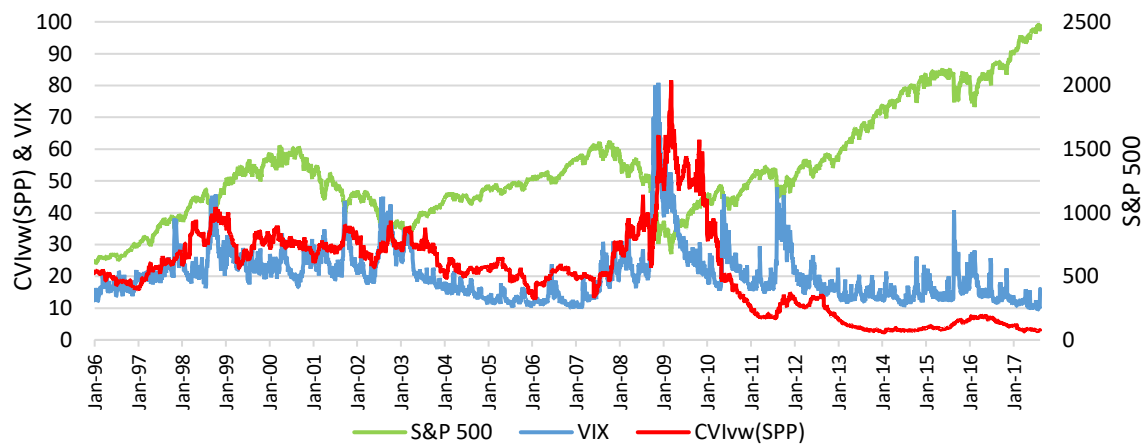
## APPLICATIONS

As an aggregation of CRI PD, CVI can be regarded as bottom-up measure of credit risk for portfolios. This section presents a few examples of how CVI can be used.

### CVI as a New Kind of Indicator for Credit Risk

In recent years, the VIX has gained popularity as a volatility index for the S&P 500 index. With  $CVI_{vw}$  (SPP),  $CVI_{lew}$  (SPP) and  $CVI_{tail}$  (SPP), there are now credit risk counterparts to the standard price and volatility indices.

In Figure 1, the  $CVI_{vw}$ (SPP), the VIX, and the S&P 500 index values are plotted. The left vertical axis gives the scale for the  $CVI_{vw}$ (SPP) as well as the VIX. The right vertical axis is the scale for the S&P 500. It is apparent that the  $CVI_{vw}$ (SPP) conveys additional information as compared to the other two widely used market indicators, especially around the crisis periods. For example, the VIX is less indicative of the crisis during the Internet Bubble period while the  $CVI_{vw}$ (SPP) increases to heightened levels before the bursting of the internet bubble.



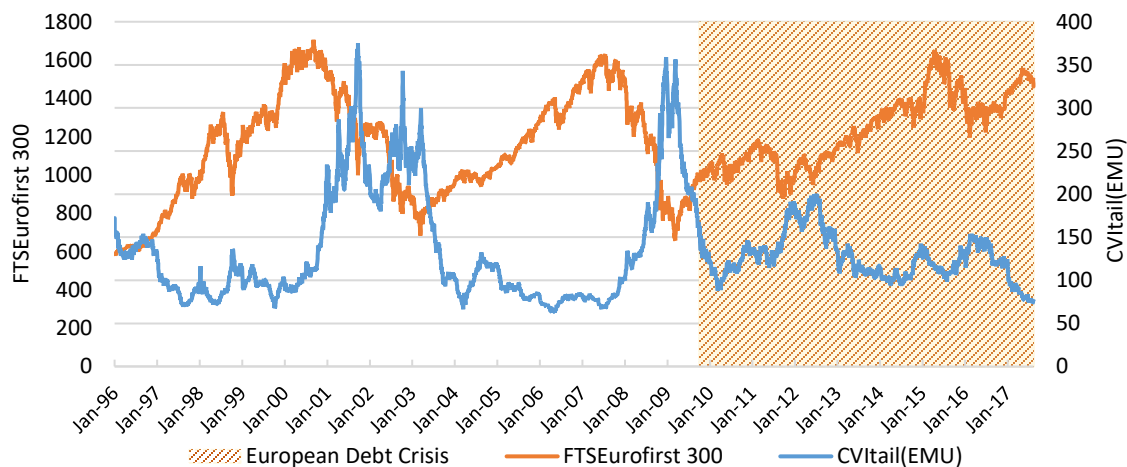
**Fig 1: Comparison of CVIvw(SPP), VIX and S&P 500 index**

Source: CRI 2017, Bloomberg for VIX and S&P 500.



## CVI as a Crisis Barometer

Figure 2 contains plots for the FTSEurofirst300 index and the  $CVI_{tail}(EMU)$ . The left vertical axis is the scale for the FTSEurofirst300 index, and the right one is for the  $CVI_{tail}(EMU)$  in basis points. We can see that both during the 2001 and 2008-2009 crisis period, the  $CVI_{tail}(EMU)$  increased sharply. Also during the European Debt Crisis, the  $CVI_{tail}(EMU)$  has increased but much less than during the other crisis periods. This difference can be explained by the fact that the European Debt Crisis is a crisis of sovereign finance. The corporate sector seems to have been reasonably prepared with stronger balance sheets emerging from the 2008-09 global financial crisis.

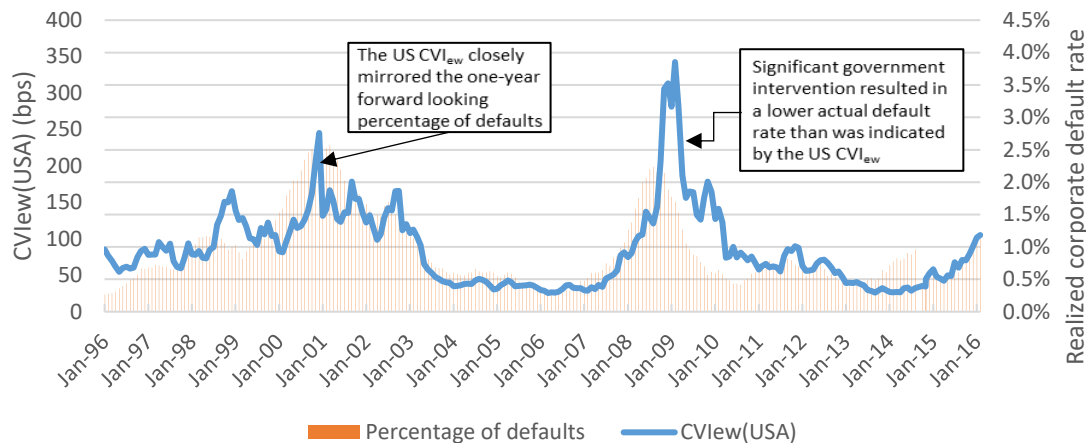


**Fig 2. Comparison of  $CVI_{tail}(EMU)$  and FTSEurofirst 300 during economic downturn**

Source: CRI 2017, Bloomberg for FTSEurofirst 300.

## CVI as an Indicator of Corporate Defaults

Figure 3 shows  $CVI_{ew}(USA)$  and the realized corporate default rate in the next year at every month end. The left vertical axis is the scale for  $CVI_{ew}(USA)$  in basis points and the right vertical axis is for the realized corporate default rate in the next year. As seen, there exists significant co-movement between the two variables. Due to the massive government intervention in 2008, the realized default rate in the subsequent year is much lower than the one predicted by the model based on the data at that time.

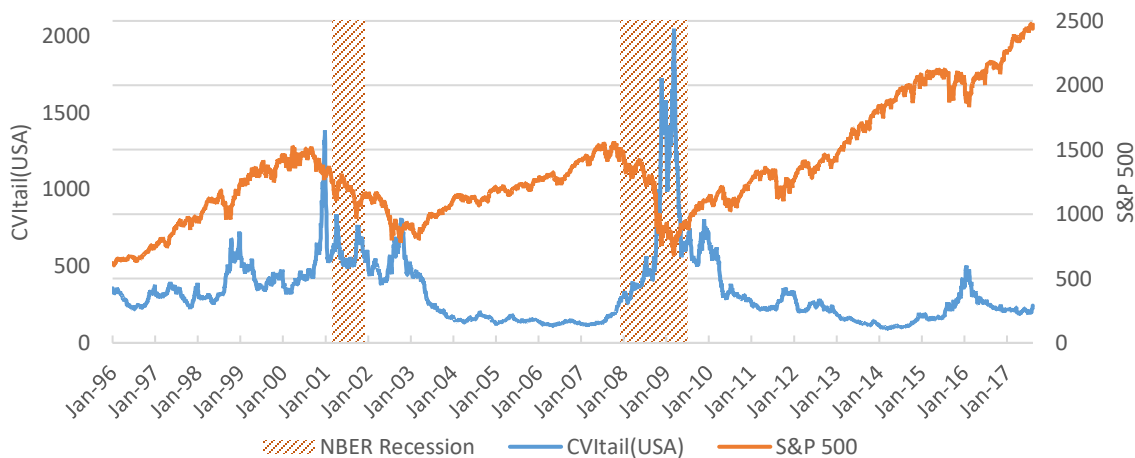


**Fig 3: Comparison of CVIew(USA) and realized corporate default in the US**

Source: CRI 2017.

## CVI as an Indicator of Recession

Figure 4 shows the S&P 500 index and the CVI<sub>tail</sub>(USA), along with NBER recessions indicated in gray. The left vertical axis is the scale for the CVI<sub>tail</sub>(USA) in basis points, and the right one to the S&P 500 index. The CVI<sub>tail</sub>(USA) significantly increases during the crisis periods in 2000 and 2008, but is not as volatile as the S&P 500 in normal periods.



**Fig 4. Comparison of CVI<sub>tail</sub>(USA) and S&P 500 index during NBER recessions**

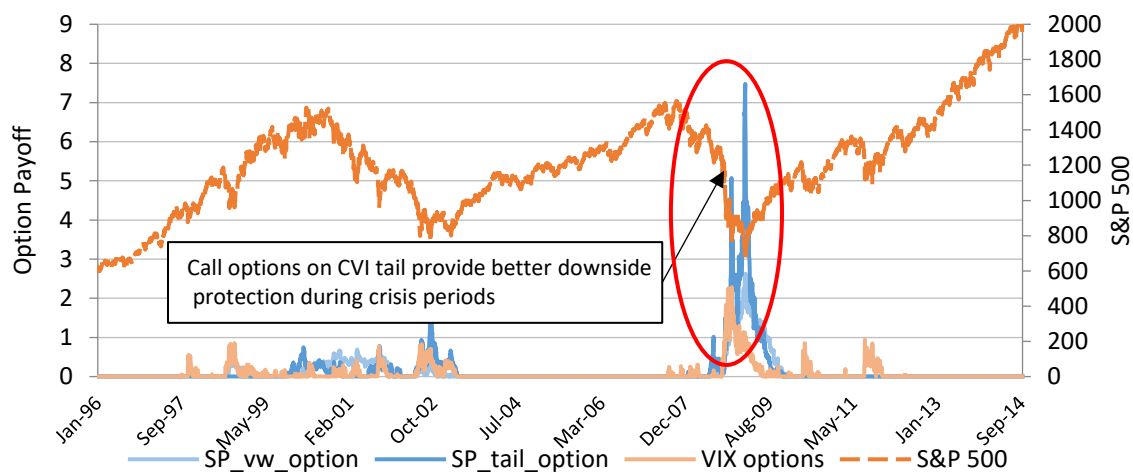
Source: CRI 2017, Bloomberg for S&P 500.

## CVI as a Hedging Tool

Thus far, we have illustrated the CVI's utility in indicating or predicting crises or recessionary periods. During such periods, investors seek to protect their downside risks. We conjecture that if options on the CVI were available, they could be used as a hedging tool for portfolio insurance purposes.

In Figure 5, the daily scaled payoffs of synthetic one-year  $CVI_{tail}(SPP)$  call option, one-year VIX call option are on the left axis and the S&P 500 index is on the right axis.  $CVI_{tail}(SPP)$  and VIX call options are constructed on a monthly basis, using their 75th percentile as their strike price. Maturity is one year. The plotted payoffs are scaled by the respective strike price.

We note a few key observations from these charts: (i) call options on  $CVI_{tail}(SPP)$  generate a higher payoff than the one for  $CVI_{vw}(SPP)$ ; (ii) when compared to the call option on VIX, the payoffs on both of  $CVI_{vw}(SPP)$  and  $CVI_{tail}(SPP)$ , were generated when it was needed most – during crisis periods (ie. internet bubble, and sub-prime crisis), when the S&P 500 declined drastically, (iii) as both of  $CVI_{vw}(SPP)$  and  $CVI_{tail}(SPP)$  options yield lower payoffs than those on the VIX during the non-crisis periods, options on the CVI would be relatively less expensive.



**Fig 5. Comparison of daily-scaled payoffs of synthetic 1-year  $CVI_{tail}(SPP)$**

With a call option, 1-year VIX call option, and S&P 500 index

Source: CRI 2014, Bloomberg for S&P 500.

## CONCLUSION

The CVI, constructed using the CRI PD of individual firms, is a new measurement to gauge economic and credit environment. The 3 distinctive types of CVI are  $CVI_{vw}$ ,  $CVI_{ew}$  and  $CVI_{tail}$ .

They are best viewed as stress indicators that reflect credit risks of a specific economy or portfolio from three different angles.

CRI currently provides daily updated CVI for 24 economies and 1 special portfolio.

## APPENDIX: CALCULATING FLOAT ADJUSTMENT

To clarify the calculation of the float adjustment, consider the specific case where a firm has two classes of shares, A and B. This can easily be generalized to a different number of classes. The *investable weight factor* is the fraction of shares in a class that are freely floating. The investable weight factors for class A and B are  $IWF_A$  and  $IWF_B$ , the total shares outstanding for each class are  $Q_A$  and  $Q_B$ , and the prices for each class are  $P_A$  and  $P_B$ . For the trading day  $t$ , if the full-float adjustment is used, then instead of using the market-capitalization of the firm, the quantity:

$$IWF_A(t)Q_A(t)P_A(t) + IWF_B(t)Q_B(t)P_B(t)$$

is used in the weighting. Suppose that the class B shares does not trade on day  $t$ , then the previous valid value for  $P_B$  is used.

During the period between March 18 and September 16, 2005, a half-float adjustment was used. In that case, instead of using the market-capitalization of the firm, the quantity:

$$\frac{1}{2}(IWF_A(t) + 1)Q_A(t)P_A(t) + \frac{1}{2}(IWF_B(t) + 1)Q_B(t)P_B(t)$$

is used in the weighting.

## ABOUT THE CREDIT RESEARCH INITIATIVE

The Credit Research Initiative (CRI) was launched by Professor Jin-Chuan Duan in July 2009 at the Risk Management Institute of the National University of Singapore. Aiming at “Transforming Big Data into Smart Data”, CRI covers over 80,000 public firms and produces daily updated Probabilities of Default (1-month to 5-year horizon), Actuarial Spreads (1-year to 5-year contract) and Probability of Default implied Ratings on over 40,000 currently active, exchange-listed firms in 133 economies. CRI also distributes historical time series of over 40,000 inactive firms due to bankruptcy, corporate consolidation or delisting for other reasons. In addition, CRI produces and maintains Corporate Vulnerability Indices (CVI), which can be viewed as stress indicators, measuring credit risk in economies, regions, and special portfolios.

As a further step, CRI converts smart data to actionable data to offer bespoke solutions to meet demands of its users. A concrete example is our development of the BuDA (Bottom-up Default Analysis) toolkit in collaboration with the International Monetary Fund (IMF). BuDA is an automated analytic tool based on the CRI-PD system, enabling IMF economists to conduct scenario analyses on the macroeconomic and financial linkage.

CRI publishes Weekly Credit Brief and Semi-Annual Credit Summary, highlighting key credit-related events, offering insights based on the CRI-PDs of the entities involved, and providing useful statistics on credit risk of economies and/or sectors

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