CVI WHITE PAPER

CONSTRUCTION AND APPLICATIONS OF THE CORPORATE VULNERABILITY INDEX
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SUMMARY

In July 2012, the Risk Management Institute (RMI) at the National University of Singapore launched the Corporate Vulnerability Index (CVI)[1] . This is a new suite of indices produced by RMI's Credit Research Initiative. RMI Probabilities of Default (RMI PDs)[2] of individual firms are used in the CVI to produce bottom-up measures of credit risk in economies, regions and portfolios of special interest.

The suite of CVIs is available in three distinctive types:

1. **Value-weighted CVI (CVI_{vw})**
   RMI PDs 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_{ew})**
   RMI PDs 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_{tail})**
   In taking the 5th percentile of the highest RMI PD, the most vulnerable firms in a group are measured.

A group of companies can consist of economies, regions or portfolios. For example, the CVIs for Singapore are denoted by CVI_{vw} (SGP), CVI_{ew} (SGP) and CVI_{tail} (SGP). At the launch in July 2012, the CVIs for nine economies and one special portfolio were produced. In August 2013, an additional 5 economies were added. Currently, CVIs are available for the groups of companies listed in Table 1. CVIs for other economies, regions and portfolios of special interest are in the pipeline.

The CVIs are a set of indicators that gauge economic and financial 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 that the CVI are stress indicators, a possibility is the development of derivative instruments (futures, swaps, options) based on CVIs that can be used for crisis hedging.

In line with the Credit Research Initiative's philosophy as a "public good", putting the CVI into the public domain brings an unprecedented level of information availability and transparency to the field of corporate credit risk.

Table 1: Currently available CVI groups (economies with * were added in August 2013)

Category	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)*
Asia	China (CHN), Japan (JPN), Singapore (SGP) Australia (AUS)*, Taiwan (TWN)*
Special Portfolios	S&P500 Index (SPP)

[1] To our knowledge, the term 'Corporate Vulnerability Index (CVI)' was first coined by Ivashenko in a 2003 IMF working paper (Ivashenko, I., 2003, How Much Leverage is Too Much, or Does Corporate Risk Determine the Severity of a Recession, IMF Working Paper WP/03/03). It is clear from this white paper that the construction of the RMI CVI using RMI PDs involves a completely different concept and approach from that in the IMF working paper.

[2] RMI PDs are the product of RMI's "public good" Credit Research Initiative conceptualized in March 2009 by the NUS RMI director, Professor Jin-Chuan Duan. Details on the RMI Credit Research Initiative are available at http://rmicri.org/.

INDEX CONSTRUCTION

The primary inputs to the CVI are RMI PDs for individual exchange listed firms. The current default prediction system used by RMI is based on the forward-intensity model of Duan, Sun and Wang (2012)[3] that effectively links the default/survival of a firm over various periods to several common macro risk factors and firm-specific attributes. The methodology for the parameter estimation is described in Duan and Fulop (2013)[4]. This system is expected to organically evolve to reflect the contributions by the research community in a "selective Wikipedia" fashion. The details on the model calibration and the PD computation are explained in the CRI Technical Report available at http://rmicri.org. The specific PDs used for the CVIs are the one-year ahead default prediction. The official start date for the CVIs is the first trading day of July 2012. At the launch of the CVI in July 2012, back-calculated historical series using end of month data were provided for comparison purposes, except for the S&P 500 which was constructed using daily values. From January 2013, we have updated all back-calculated historical series with daily values. More details are discussed in Appendix B.

In the following, the details for the construction of the three types of CVI: CVI_{vw}, CVI_{ew} and CVI_{tail} are given. The remaining sections of this part 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 PDs 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.

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 is described in greater detail in Appendix A.

[3] Duan, J.-C., J. Sun, and T. Wang (2012), Multiperiod Corporate Default Prediction — A Forward Intensity Approach. *Journal of Econometrics*, 170, 191-209).

[4] Duan, J.-C. and A. Fulop (2013), Multiperiod Corporate Default Prediction with the Partially-Conditioned Forward Intensity. National University of Singapore Working Paper.

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 PDs for firms 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^{th} percentile of PDs. 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 FIRMS

The computation used to compute a firm's PD is based on the firm's primary exchange listing, but for construction of the CVI the PD is included in the firm's 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 PDs 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_{vw} (SPP), CVI_{ew} (SPP) and CVI_{tail} (SPP), the constituents coincide with the constituents of the S&P 500 index for each point in time. For the SPP CVI only, missing any 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 9 CVIs that were launched in July 2012, the official start date for the CVIs is the first trading day of July 2012. For the 5 additional CVIs launched in August 2013, the first trading day of August 2013 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 comparison purposes.[5] All CVI series go back to the first trading day of 1996 except for the eurozone which began on the first trading day of 1999.

As of the first trading day of July 2012, the CVIs are daily updated indices and all of them are released at 5pm 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.

[5] The back-calculated historical series are indicated by a gray background color in the CVI graphs.

INDEX APPLICATIONS

As an aggregation of RMI PDs, CVIs can be regarded as bottom-up measure of credit risk in portfolios, economies, and regions. To demonstrate its utility, we provide a number of examples below.

THE CVI IS A NEW KIND OF INDICATOR

The S&P 500 is a commonly traded and quoted price index. In recent years, the VIX has gained in popularity as a volatility index for the S&P 500 index. With CVI_{vw} (SPP), CVI_{ew} (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.

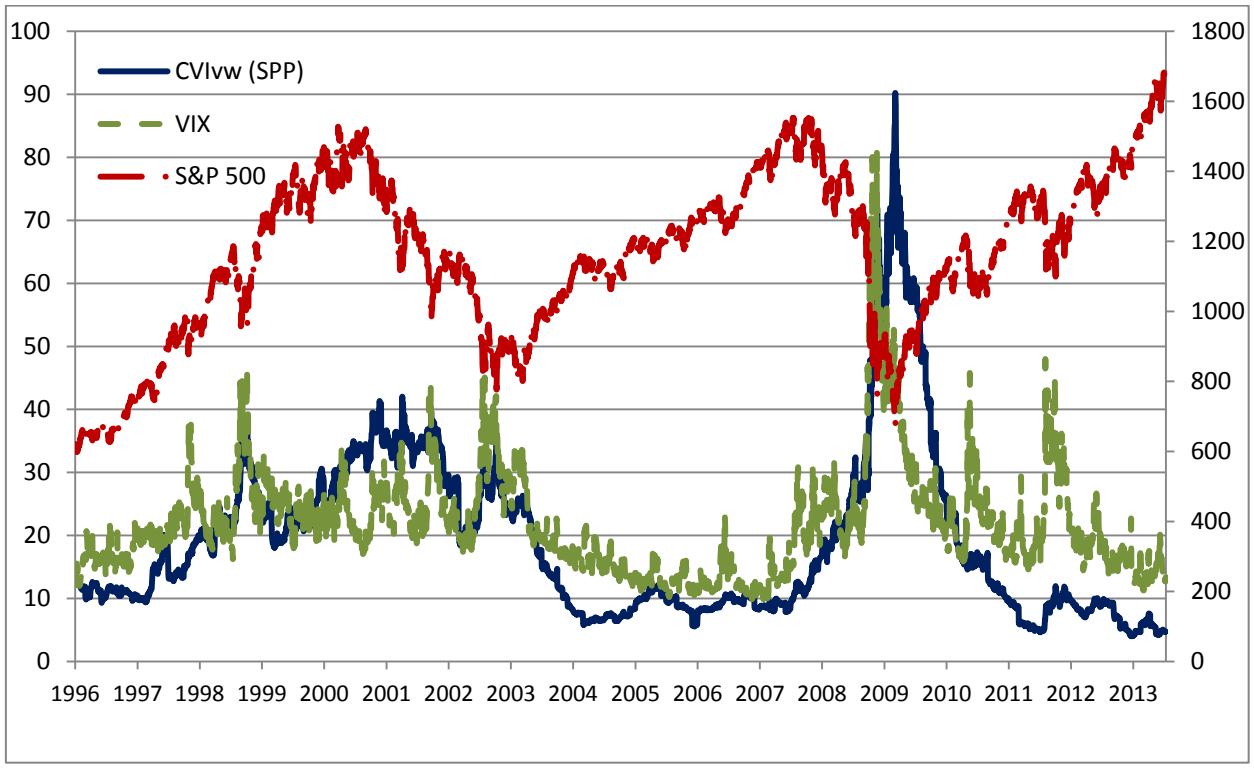

Figure 1: A comparison of the CVI_{vw}(SPP), VIX and S&P 500 index.

THE CVI IS 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 CVI_{tail}(EMU) in basis points, and the right one is for the FTSEurofirst300 index. 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.

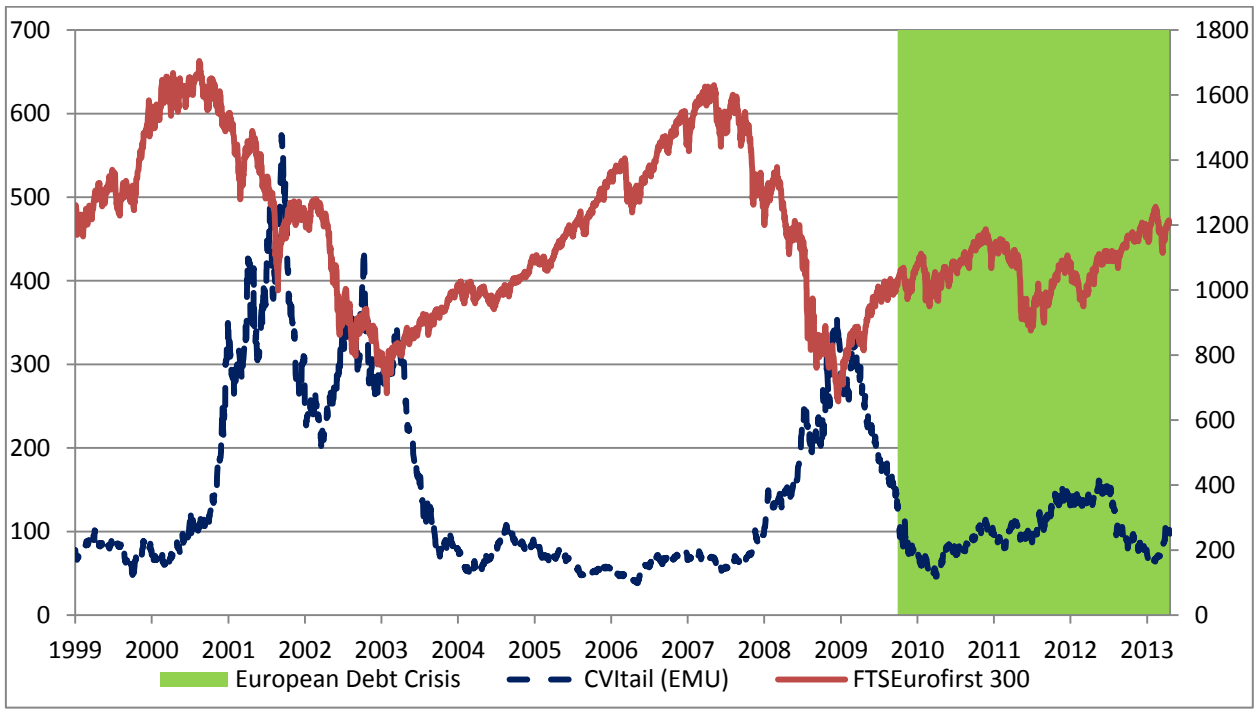

Figure 2: A comparison of the CVI_{tail}(EMU) and the FTSEEurofirst300 during downturns.

THE CVI IS 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.

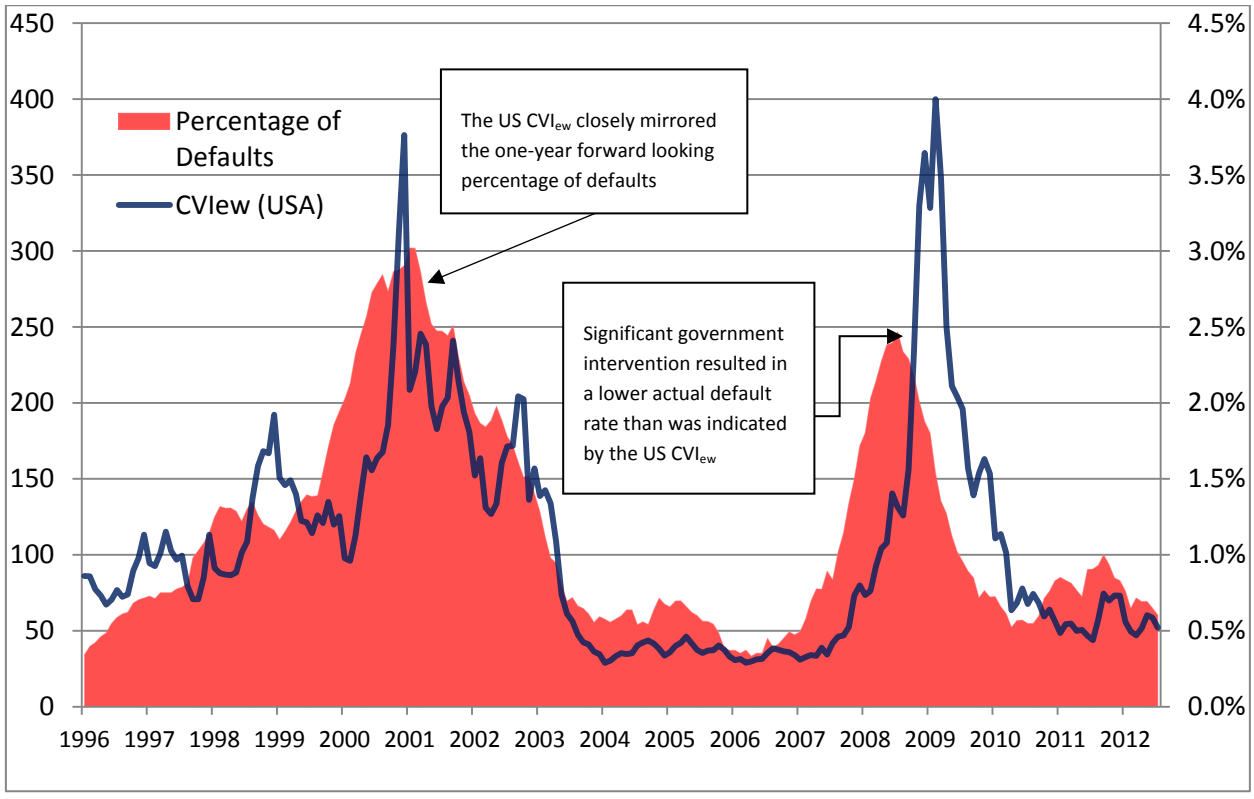

Figure 3: A comparison between CVI_{ew}(USA) and realized defaults in US.

THE CVI AS AN INDICATOR FOR RECESSIONS

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

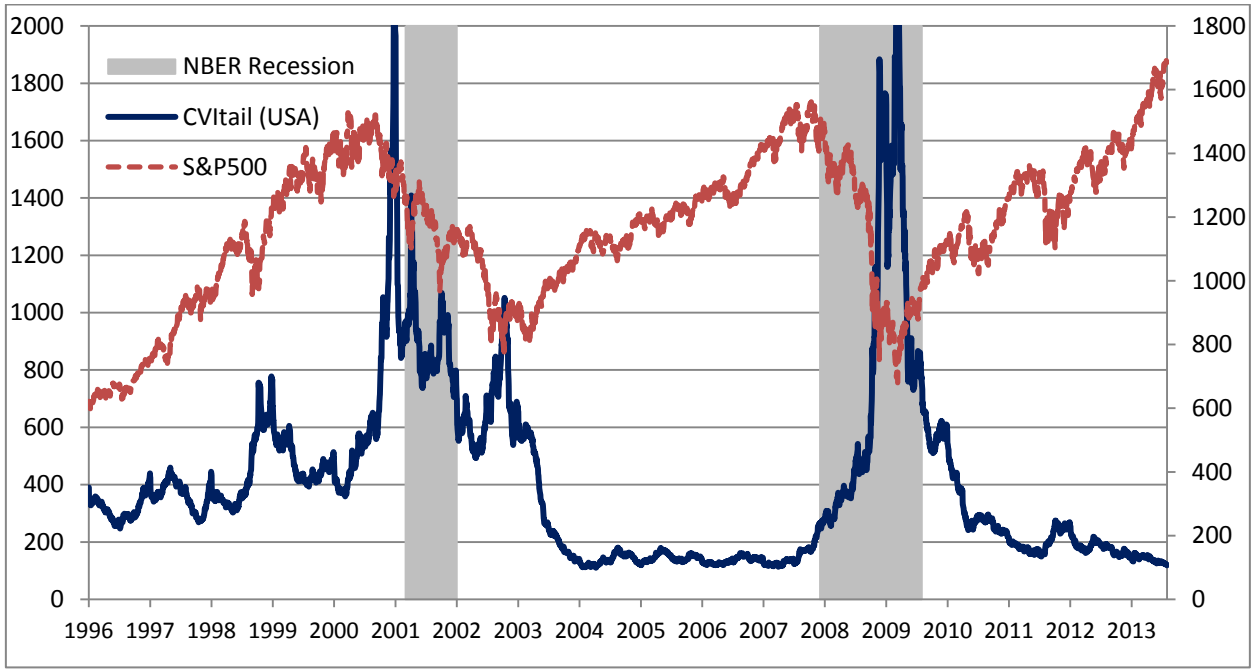

Figure 4: A comparison of CVI_{tail}(USA) and S&P 500 index during NBER recessions.

THE 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.

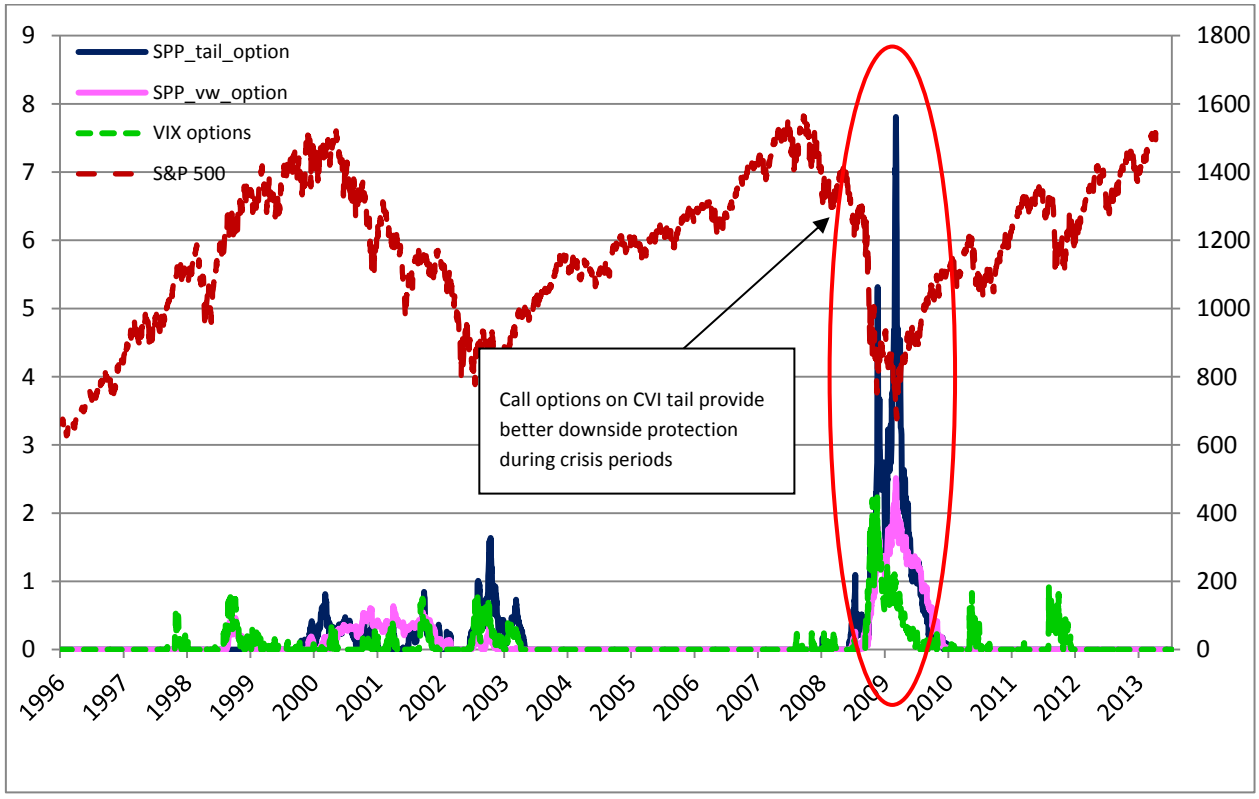

Figure 5: A comparison of the daily scaled payoffs of synthetic one-year CVI_{tail}(SPP) call option, one-year VIX call option and the S&P 500 index.

APPENDIX A- CALCULATION OF 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.

APPENDIX B- BACK CALCULATING HISTORICAL SERIES

At the launch of the CVIs in July 2012, month-end values were used to produce all back-calculated series except for S&P 500 series which used daily data for back-calculated series. From January 2013, all back-calculated series are refreshed with back-calculated daily values. For the economies launched in July 2012, the historical daily PD series are using the calibration parameters of June 2012, for the economies launched in August 2013, the calibration parameters of July 2013 are used. Compared with month-end values that were previously used for the back-calculated series, back-traced daily values are based on a similar logic, however they are not completely identical.

As an illustration of the difference between back-calculated month-end PDs and daily PDs, we discuss one example that is linked to the treatment of missing values. In case a firm has missing inputs necessary to calculate the PD and there are no available data points in the last twelve trailing months, the missing inputs are imputed with sector median values. To check if the sector median substitution is a reasonable treatment, PD changes are compared and points with abnormal changes are deemed to be not suitable for substitution. More specifically, when reporting historical PD, the sector replacement is not done if it results in a relative change in PD of 10% or more where the initial PD was at or above 100bps, or an absolute change in PD of 10bps or more where the initial PD was below 100bps. The difference between month-end and daily calculation resides in the comparison period. For example, assume that company A has a PD of 100 bps at the end of November 2010, and the PD increases to 150 bps on December 30th 2010. The median substitution happens on December 31st 2010, resulting in a PD of 110 bps. When compared with the last data point to detect abnormal changes, a daily change from 150 bps to 110 bps would be flagged out, while the month-end change of 10 bps is below the threshold. As a result, on December 31st 2010, company A has a PD of 110 bps in the monthly calculation whereas it has a PD of 150 bps from the previous date in the daily back-calculation.

The above example illustrates one potential difference between historical month-end and historical daily calculations. An exhaustive list of examples is beyond the scope of this document, but questions can be addressed to rmicri@nus.edu.sg.