

Smart Ways to Sell Credit Volatility

Techniques to enhance returns from systematic volatility selling

- **Systematic credit volatility selling is profitable** — We have previously shown (see [Profiting from the Credit Volatility Premium: Selling credit volatility can be consistently profitable even after paying bid-ask](#)) how systematic volatility selling using short dated straddles can be profitable because of the consistently positive credit volatility risk premium.
- **A multi-index strategy can enhance profitability** — Dynamically selecting the “best” index (from a basket of indices) significantly improves the performance of the basic “single index” volatility selling strategy. We use an algorithm based on the implied to realized volatility ratio to do the selection.
- **Dynamically adjusting the trade size helps** — The implied to realized volatility ratio can also be used to systematically size the trade for better profitability. We reduce the trade size when it is less likely to make money and increase it when it is more likely.
- **Hybrid algorithm does the best** — Using a combination of the multi-index and sizing strategies provides the best results. We benefit both from choosing the best index for selling volatility, as well as an optimal trade size.

Anindya Basu
+1-212-723-6453
anindya.basu@citi.com

With thanks to
Ronghao Yu

See Appendix A-1 for Analyst Certification, Important Disclosures and non-US research analyst disclosures.

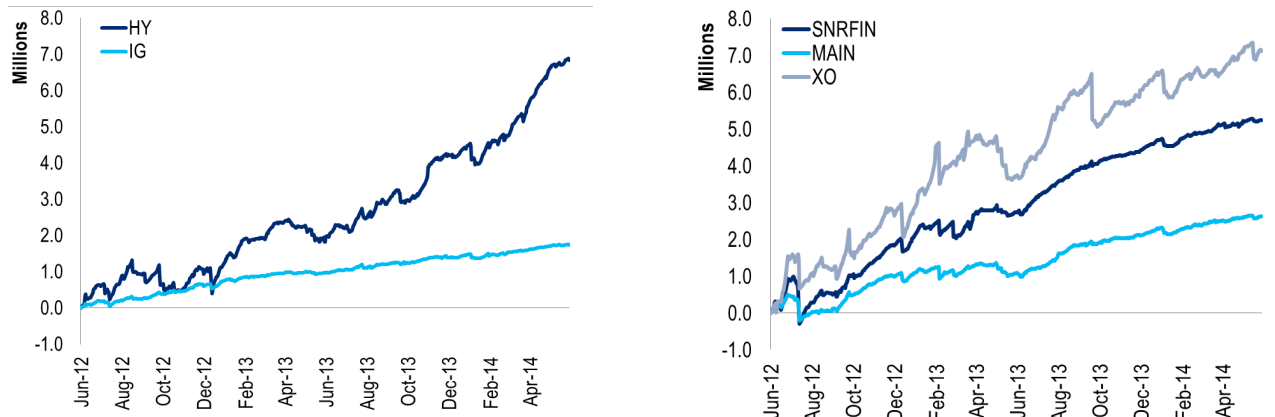
Citi Research is a division of Citigroup Global Markets Inc. (the “Firm”), which does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the Firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision. Certain products (not inconsistent with the author’s published research) are available only on Citi’s portals.

Reviewing the Basic Vol Selling Strategy

The portion of this research report regarding non-OCC issued options is not intended for US clients other than Qualified Institutional Buyers. Investing in options is not suitable for all investors. Please see the disclosures concerning the risks of investing in options below and discuss with your Financial Advisor whether this particular options strategy is suitable for you. Interested investors should contact our trading desk for updated price and liquidity information. Also, complex option strategies may entail higher commissions costs. Our figures do not include fees and other transactions costs.

In a previous publication (see [Profiting from the Credit Volatility Premium: Selling credit volatility can be consistently profitable even after paying bid-ask](#)), we have demonstrated how systematically selling credit volatility can be a very profitable strategy. This is true across all credit indices for which options are traded (see Figure 1) as well as all option expiries.

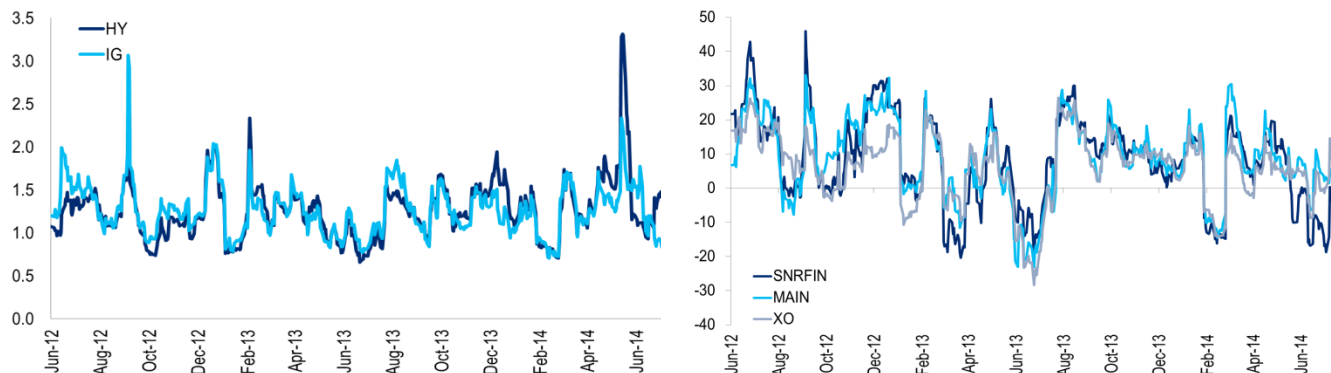
Figure 1. Systematically selling credit volatility using 1 month ATM straddles can be very profitable – this holds for both US (left) and European (right) indices. Cumulative P&L shown using 1M ATM straddles with 100mm notional on each leg, converted to USD using prevalent FX rates.



Source: Bloomberg, Citi Research

These strategies make money because of the mostly positive volatility risk premium in credit markets – this is the spread between implied volatility of credit options and the realized credit spread volatility. It is possible to show that the volatility selling strategy remains profitable as long as implied volatility remains higher than realized volatility, i.e. if the volatility risk premium is positive. This is mostly the case, as we show in Figure 2.

Figure 2. The volatility risk premia for the major credit indices tend to be mostly positive – we show the risk premium using 1 month implied and realized volatilities for both US (left) and European (right) indices.



Source: Markit, Citi Research

We also found that the most profitable volatility selling strategy is to use delta hedged short dated (i.e., 1M) ATM straddles. The P&L for volatility selling strategies is mainly driven by the net gamma of the delta hedged position (see [Profiting from the Credit Volatility Premium: Selling credit volatility can be consistently profitable even after paying bid-ask](#)). Longer maturities and OTM strikes tend to lower the net gamma of a short volatility position – this is why short dated ATM straddles perform the best.

Can we improve on this?

In this report, we outline two methods to improve the performance of the basic volatility selling strategy. The basic strategy works by repeatedly selling delta hedged straddles in fixed size – once the current option position expires, it simply sells a new straddle on the same index.

This strategy is constrained in two ways. First, it sells straddles on the *same* underlying index every time the current straddle expires, i.e. there is no flexibility in the choice of the index. Second, the strategy *always* sells *fixed* size straddles upon option expiry, i.e., there is no flexibility in sizing the trade.

Our enhancements to the basic strategy are based on relaxing these constraints. In the first enhancement, we allow the strategy to choose the “best possible” index from a basket of 5 indices. In the second enhancement, we allow the strategy to adjust the size of the trade based on how likely the trade is to make money. Both these enhancements depend on using the implied to realized volatility ratio as an indicator.

We find that both these methods are effective and improve the profitability of the basic volatility selling strategy. A hybrid of the two methods does the best since it benefits from being opportunistic in the choice of index as well as the trade size.

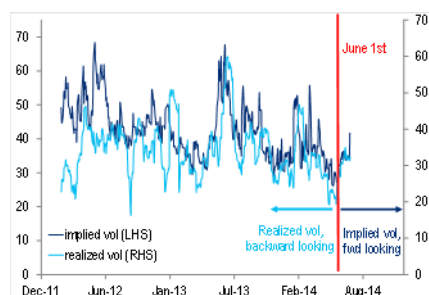
To understand how the strategies work, we first explain the significance of the implied to realized volatility ratio and how we can use it. We then discuss the results from back testing the proposed enhancements.

Using the Implied to Realized Volatility Ratio

The ratio of implied to realized volatility is a metric that is tracked widely in volatility markets. Implied volatility represents the expectation of the volatility level in credit markets going forward. Realized volatility is the actual level of volatility that the credit market experiences over a given time period. In other words, implied is a forward looking measure and realized is a backward looking measure.

Typically, implied volatility tends to be higher than realized volatility in credit (and other) markets because volatility sellers want to be compensated for the uncertainty in how credit spreads will behave going forward. However, during periods of intense market turmoil, realized volatility can spike and volatility selling strategies can backfire – this is when the ratio goes below one. Therefore, if we can figure out a way to predict future behavior of this ratio, we can use that as an indicator of when to sell volatility and when to refrain.

Figure 3. Implied and realized volatility on a given day refers to different time periods.



Source: Citi Research

Now, there is a problem in using the implied to realized volatility ratio computed using the two volatilities on the same day. This is because implied volatility is a forward looking measure, while realized volatility is a backward looking measure. In other words, if we take the ratio of implied to realized volatility as of the same day, we are actually comparing apples to oranges, because the time periods that the two measures refer to are different.

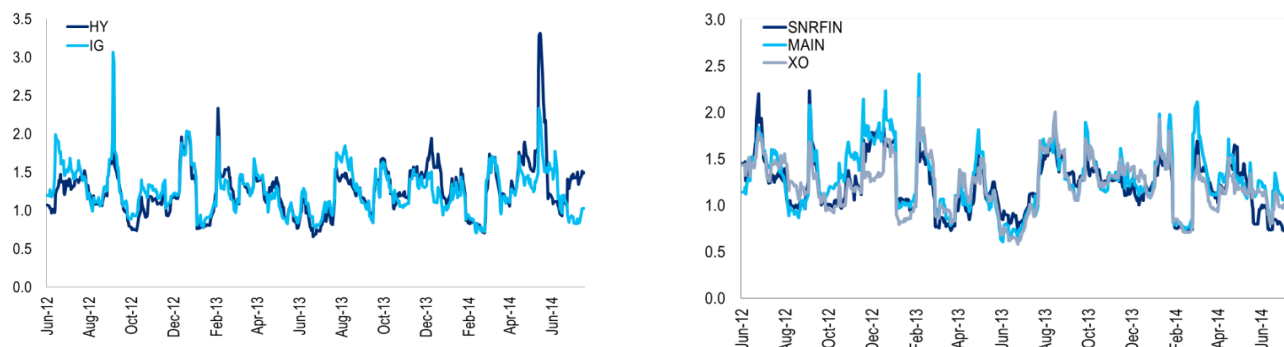
An example will make this clear. Consider the ratio of the 1M implied to realized volatility as of June 1st 2014. The 1M implied volatility refers to the next 1 month period, i.e. from June 1st through July 1st. In contrast, the 1M realized volatility refers to the period from May 1st through June 1st. In other words, the two time periods are different (see Figure 3).

To get around this issue, on any given day, we use the ratio of the backward looking implied volatility to the realized volatility as of that day – this way, the time periods are lined up exactly. So, in our example, we would compute the ratio of the 1M implied volatility as of May 1st to the realized volatility as of June 1st, and construct a time series of volatility ratios computed in this manner.

We now get back to our fundamental question – is there a way to predict this ratio? To answer that, we look at the behavior of this ratio over time for all the major indices (see Figure 4). It is clear that the time series is strongly mean reverting for the 1M period, and we can confirm this using statistical tests¹.

¹ For this purpose, we used the ADF (Augmented Dickey-Fuller) test.

Figure 4. Backward looking implied to realized volatility ratios for 1M ATM volatility is strongly mean reverting across all indices, both US (left) and European (right)².



Source: Citi Research

What does that mean in terms of forecasting? Clearly, if the ratio is too high, we expect it to mean revert lower and vice-versa. In other words, it would make sense to sell volatility during the period when the ratio reaches a trough.

To understand why this makes sense, consider our earlier example. If the ratio is at a trough on June 1st, it means that going forward, our expectations are for it to go up because of mean reversion. Therefore, if we sell volatility on June 1st using a 1M ATM straddle, then we would expect the implied to realized volatility ratio over the next 1 month period to be higher than the current value, i.e., implied is likely to be higher than realized over that time period. Therefore, selling volatility over this period should be profitable.

In the next few sections, we show how we enhance performance by using this dynamic to overlay a layer of intelligence over the basic volatility selling strategy.

² We show the history going back 2 years – a longer history is shown in [Of barbecues and bonfires: A recipe for structured credit?](#) (p 21).

#1: The Rotating Index Strategy

The first overlay that we use relaxes the constraint of using the same underlying index to sell straddles upon option expiry. On each option expiry date, we select a (potentially different) underlying index from the set of 5 major indices³ for which credit options are traded, and sell 1M ATM straddles on that index.

How does the index selection process work? We have designed the algorithm for index selection in such a way that it selects the index for which (we believe) volatility selling is most likely to be profitable over the next month.

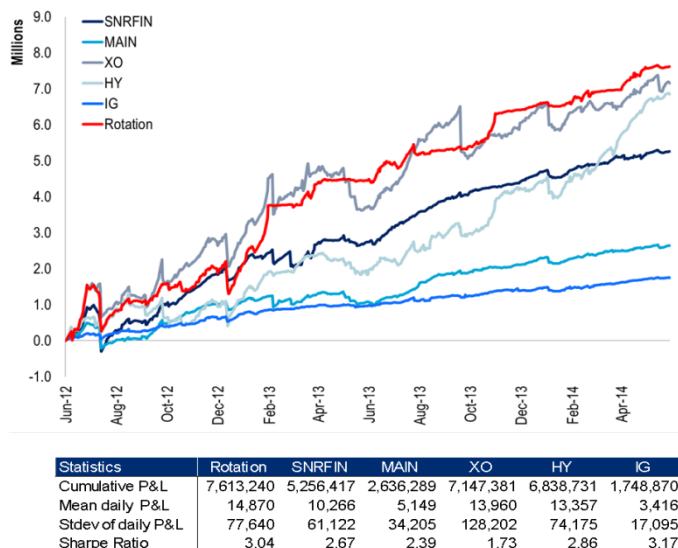
The process has 3 steps. First, we compute the time series of the (backward looking) implied to realized volatility for each index, as described earlier. Next, we compute the z-score for the current ratio of each index, using a look back period of 1 year. Lastly, we rank the indices in the order of their z-scores, and choose the one with the lowest z-score.

Why do we expect this to work? Clearly, the index with the lowest z-score is the one where the implied to realized ratio is closest to its trough, at least based on the look back period we use. This means that over the next one month period, it is most likely that the ratio for the chosen index will rise. In other words, implied volatility is likely to exceed realized volatility over that time period. Therefore, selling delta hedged straddles for the chosen index has the highest likelihood of being profitable.

Performance Analysis

We show the cumulative P&L from the rotating index strategy in Figure 5, along with some statistics. In each case, we have computed the P&L from selling a 1M ATM straddle on the appropriate index with 100 million notional on each leg. For ease of comparison, we have converted the P&L for the European indices into USD using the daily FX conversion rate.

Figure 5. Performance statistics for the various volatility selling strategies using 1M ATM straddles with 100mm notional on each leg. Cumulative P&L converted to USD for all strategies.



Source: Citi Research

³ The set of indices consists of CDX IG, CDX HY, iTraxx Main, iTraxx Xover and iTraxx Senior Financials.

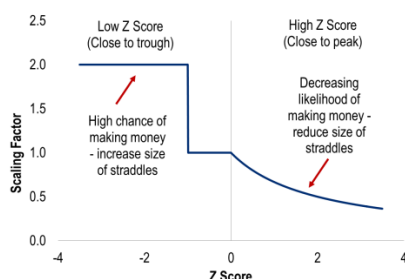
We find that the rotation strategy outperforms all the single index strategies in terms of cumulative P&L. The closest single index strategy is the XO strategy, but the daily volatility for that strategy is about 65% higher. On a volatility adjusted basis, the rotation strategy outperforms all except the IG volatility selling strategy, as we see from the Sharpe ratios.

#2: Optimally Sizing Straddles for Vol Selling

The second overlay that we use relaxes the other constraint on the basic strategy – instead of selling volatility using a fixed size straddle every time an option position expires, we attempt to dynamically size the trade based on our belief about how likely it is to make money. However, the underlying index remains the same throughout.

Once again, we use the 1M backward looking implied to realized volatility ratio as an indicator. Given the strong mean reversion shown by the 1M ratio, we can conclude that it makes sense to increase the size of the straddles when this ratio is close to a minimum (trough) and reduce the size when the same ratio is close to a maximum (peak).

Figure 6. How we compute the factor for scaling straddle size.



Source: Citi Research

For our decision process, we use the z-score for the implied to realized volatility ratio based on a 1 year look back. We size the trade by scaling it using a factor that depends on the z-score. We illustrate how the scaling factor behaves in Figure 6. To summarize:

- If the z-score highly negative (i.e. trade highly likely to make money based on mean reversion), then the scaling factor is 2.0, i.e., we double the size of the trade from 100 million notional to 200 million.
- If the z-score is somewhat negative (i.e. trade reasonably likely to make money), then the scaling factor is 1.0, i.e., we use the normal trade size of 100 million.
- If the z-score is positive (i.e. trade is less likely to make money), then the scaling factor goes down in inverse proportion to the z-score. As the z-score becomes highly positive (negligible chance of making money), the notional goes to zero.

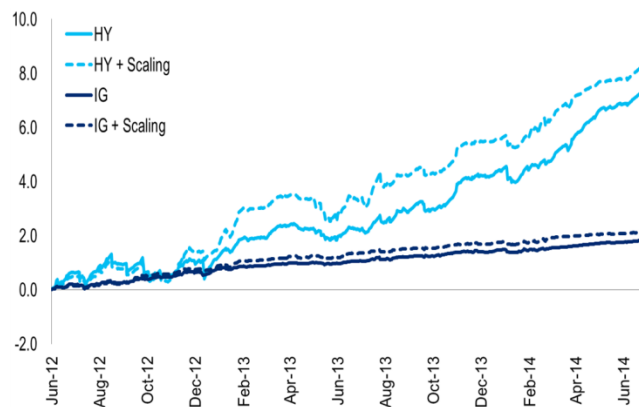
The basic idea here is to size the trade depending on how likely the trade is to make money, based on our estimate of the z-score. The higher the likelihood, the larger the size of the straddle that we sell.

Performance Analysis

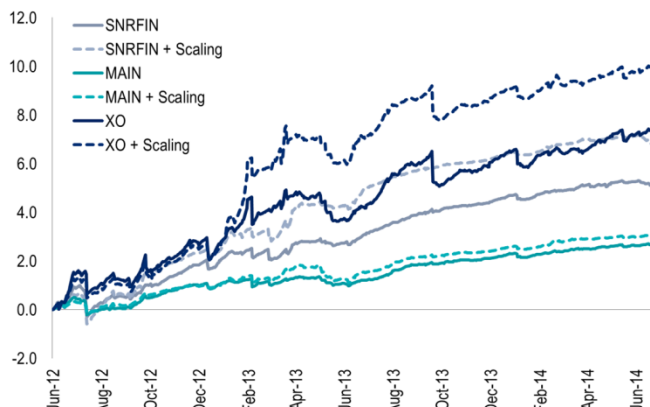
The results from this strategy is shown for each of the 5 major indices in Figure 7. We show the cumulative P&L from selling 1M ATM straddles with variable notional on each leg (as described in the algorithm), all converted to USD at prevailing exchange rates.

We find that opportunistically sizing the straddle does make a significant difference in profitability. On a volatility adjusted basis, the Sharpe ratio shows an improvement in the range of 4% (HY) to 25% (XO) across the 5 different indices.

Figure 7. Performance statistics for the scaling algorithm – in each case the dotted line shows the cumulative P&L(in USD) for the basic strategy overlaid with scaling. The performance improves for both US (left) and European (right) indices, both in terms of total P&L and Sharpe ratios.



Statistics	IG	IG + Scaling	HY	HY + Scaling
Cumulative P&L	1,748,870	2,067,418	6,838,731	7,773,583
Mean daily P&L	3,416	4,177	13,357	15,673
Stdev of daily P&L	17,095	19,411	74,175	83,584
Sharpe Ratio	3.17	3.42	2.86	2.98



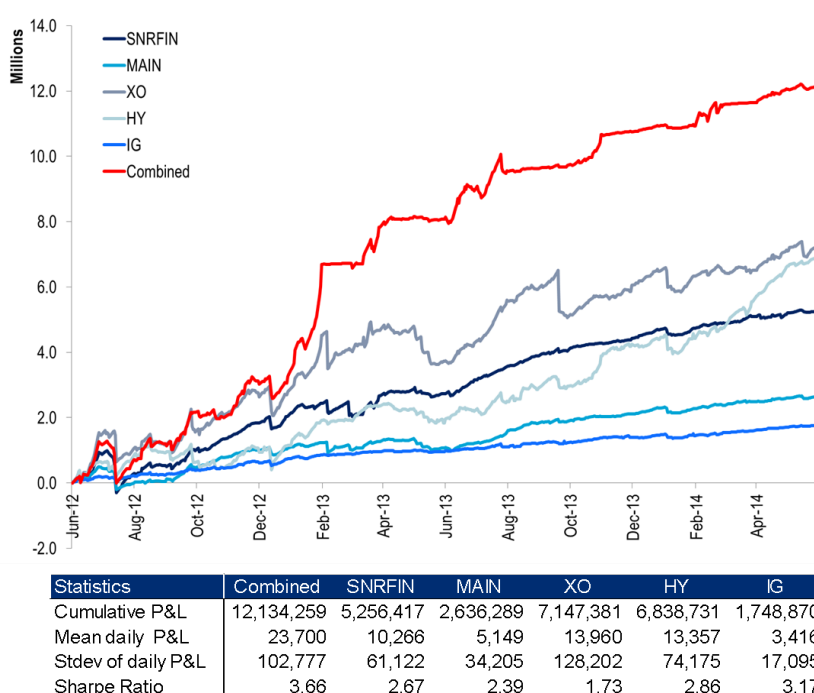
Statistics	SNRFIN	SNRFIN + Scaling	MAIN	MAIN + Scaling	XO	XO + Scaling
Cumulative P&L	5,256,417	7,129,124	2,636,289	2,999,425	7,147,381	9,743,442
Mean daily P&L	10,266	14,173	5,149	5,963	13,960	19,371
Stdev of daily P&L	61,122	72,902	34,205	37,031	128,202	142,092
Sharpe Ratio	2.67	3.09	2.39	2.56	1.73	2.16

Source: Citi Research

Bringing it All Together

The third overlay combines the first two strategies – upon option expiry, we look at the index with the lowest possible z-score, and use the z-score to size the trade. In other words, we relax both the index and the sizing constraints on the basic volatility selling strategy.

Figure 8. Performance of the combined strategy – at every stage, we chose the best possible index using overlay #1, and then size the straddles using overlay #2. The cumulative P&L in each case has been converted to USD.



Source: Citi Research

The results are in Figure 8 – as before, we back test using 1M ATM straddles on the appropriate index with variable notional on each leg (as determined by the sizing algorithm). The cumulative P&L is converted to USD at prevailing exchange rates. The improvement in Sharpe ratio exceeds that of any individual overlay.

Conclusions

We have presented two simple techniques to improve the performance of the basic volatility selling strategy presented in [Profiting from the Credit Volatility Premium: Selling credit volatility can be consistently profitable even after paying bid-ask](#). Instead of repeatedly selling fixed size 1M ATM straddles on a single index upon option expiry, we show that if we are opportunistic in selecting the “best” possible index as well as size of the straddles, we can improve the performance of the basic strategy significantly.

RISKS

When buying calls and puts (or receivers and payers) the maximum loss is the premium paid. When selling calls (or receivers), the maximum potential loss would occur as the index spread decreases but is limited by the index spread being floored at zero. For puts (or payers), the maximum potential loss (amount below the strike) would eventuate should the index price fall to zero. Sector index options are cash settled. Credit index options are physically settled. The above calculations do not include any additional fees or transaction costs. Note that ratio writing would leave the writer uncovered in one leg of the trade.

OPTIONS RISK DISCLOSURE — PLEASE READ CAREFULLY

This section discusses possible options strategies that you may choose to employ in conjunction with the company securities discussed herein. If you choose to engage in the options transactions discussed within this document, you must have an approved options account and will be subject to certain criteria which may ultimately prevent you from engaging in certain option strategies. It is important for you as an investor to know and understand that Options do involve risk and sometimes, significant risk, therefore may not be appropriate for all investors. If you buy options, the maximum loss is the premium. If you sell put options, the risk is the entire notional below the strike. If you sell call options, the risk is unlimited. The actual profit or loss from any trade will depend on the price at which the trades are executed. The prices used herein are historical and may not be available when you order is entered. Commissions and other transaction costs are not considered in these examples.

Please speak to your Financial Advisor to ensure you have a full understanding of the risk and reward of the strategy you are considering. Strategies that are opened or closed differently than what is discussed in this document could have a significantly different outcome from what is described. It should be noted that certain Index options might have special settlement dates or settlement requirements that are different from traditional equity options. Commissions, taxes, and margin costs have not been included but will affect the outcome of any option transaction and should be considered. However, they can have a significant impact on the profitability of options transactions and should be considered carefully before entering into any option strategy. Because of the importance of tax considerations to all option transactions, the investor considering options should consult with his/her tax advisor as to how their tax situation is affected by the outcome of contemplated options transactions. Certain options trades/strategies must be executed in a margin account. Transactions executed in a margin account can require the investor to periodically deposit additional collateral into the account in order to maintain the positions. The preceding language is not a full description of all possible risks associated with options trading.

For a more complete description on the uses and risks of options, please see the document titled Characteristics and Risks of Standardized Options. If you would like an additional copy of this document please contact Citigroup Global Markets Inc., Options Department, 390 Greenwich Street, New York, NY 10013. Options are not suitable for all investors. Before entering into any transaction using listed options, investors should read and understand the current Options Clearing Corp. Disclosure Document (Characteristics and Risks of Standardized Options) at <http://www.theocc.com/about/publications/character-risks.jsp>, http://www.theocc.com/components/docs/January_2011_ODD_Definitive_Supplement.pdf,

http://www.theocc.com/components/docs/March_2011_ODD_Definitive_Supplement.pdf, and
http://www.theocc.com/components/docs/January_2012_ODD_Definitive_Supplement.pdf

Investing in options other than Standardized Options may entail additional risks.

Appendix A-1

Analyst Certification

The research analyst(s) primarily responsible for the preparation and content of this research report are named in bold text in the author block at the front of the product except for those sections where an analyst's name appears in bold alongside content which is attributable to that analyst. Each of these analyst(s) certify, with respect to the section(s) of the report for which they are responsible, that the views expressed therein accurately reflect their personal views about each issuer and security referenced and were prepared in an independent manner, including with respect to Citigroup Global Markets Inc and its affiliates. No part of the research analyst's compensation was, is, or will be, directly or indirectly, related to the specific recommendation(s) or view(s) expressed by that research analyst in this report.

IMPORTANT DISCLOSURES

Analysts' compensation is determined based upon activities and services intended to benefit the investor clients of Citigroup Global Markets Inc. and its affiliates ("the Firm"). Like all Firm employees, analysts receive compensation that is impacted by overall firm profitability which includes investment banking revenues.

For important disclosures (including copies of historical disclosures) regarding the companies that are the subject of this Citi Research product ("the Product"), please contact Citi Research, 388 Greenwich Street, 28th Floor, New York, NY, 10013, Attention: Legal/Compliance [E6WYB6412478]. In addition, the same important disclosures, with the exception of the Valuation and Risk assessments and historical disclosures, are contained on the Firm's disclosure website at https://www.citivelocity.com/cvr/eppublic/citi_research_disclosures. Valuation and Risk assessments can be found in the text of the most recent research note/report regarding the subject company. Historical disclosures (for up to the past three years) will be provided upon request.

NON-US RESEARCH ANALYST DISCLOSURES

Non-US research analysts who have prepared this report (i.e., all research analysts listed below other than those identified as employed by Citigroup Global Markets Inc.) are not registered/qualified as research analysts with FINRA. Such research analysts may not be associated persons of the member organization and therefore may not be subject to the NYSE Rule 472 and NASD Rule 2711 restrictions on communications with a subject company, public appearances and trading securities held by a research analyst account. The legal entities employing the authors of this report are listed below:

Citigroup Global Markets Inc

Anindya Basu

OTHER DISCLOSURES

For securities recommended in the Product in which the Firm is not a market maker, the Firm is a liquidity provider in the issuers' financial instruments and may act as principal in connection with such transactions. The Firm is a regular issuer of traded financial instruments linked to securities that may have been recommended in the Product. The Firm regularly trades in the securities of the issuer(s) discussed in the Product. The Firm may engage in securities transactions in a manner inconsistent with the Product and, with respect to securities covered by the Product, will buy or sell from customers on a principal basis.

Securities recommended, offered, or sold by the Firm: (i) are not insured by the Federal Deposit Insurance Corporation; (ii) are not deposits or other obligations of any insured depository institution (including Citibank); and (iii) are subject to investment risks, including the possible loss of the principal amount invested. Although information has been obtained from and is based upon sources that the Firm believes to be reliable, we do not guarantee its accuracy and it may be incomplete and condensed. Note, however, that the Firm has taken all reasonable steps to determine the accuracy and completeness of the disclosures made in the Important Disclosures section of the Product. The Firm's research department has received assistance from the subject company(ies) referred to in this Product including, but not limited to, discussions with management of the subject company(ies). Firm policy prohibits research analysts from sending draft research to subject companies. However, it should be presumed that the author of the Product has had discussions with the subject company to ensure factual accuracy prior to publication. All opinions, projections and estimates constitute the judgment of the author as of the date of the Product and these, plus any other information contained in the Product, are subject to change without notice. Prices and availability of financial instruments also are subject to change without notice. Notwithstanding other departments within the Firm advising the companies discussed in this Product, information obtained in such role is not used in the preparation of the Product. Although Citi Research does not set a predetermined frequency for publication, if the Product is a fundamental research report, it is the intention of Citi Research to provide research coverage of the/those issuer(s) mentioned therein, including in response to news affecting this issuer, subject to applicable quiet periods and capacity constraints. The Product is for informational purposes only and is not intended as an offer or solicitation for the purchase or sale of a security. Any decision to purchase securities mentioned in the Product must take into account existing public information on such security or any registered prospectus.

Investing in non-U.S. securities, including ADRs, may entail certain risks. The securities of non-U.S. issuers may not be registered with, nor be subject to the reporting requirements of the U.S. Securities and Exchange Commission. There may be limited information available on foreign securities. Foreign companies are generally not subject to uniform audit and reporting standards, practices and requirements comparable to those in the U.S. Securities of some foreign companies may be less liquid and their prices more volatile than securities of comparable U.S. companies. In addition, exchange rate movements may have an adverse effect on the value of an investment in a foreign stock and its corresponding dividend payment for U.S. investors. Net dividends to ADR investors are estimated, using withholding tax rates conventions, deemed accurate, but investors are urged to consult their tax advisor for exact dividend computations. Investors who have received the Product from the Firm may be prohibited in certain states or other jurisdictions from purchasing securities mentioned in the Product from the Firm. Please ask your Financial Consultant for additional details. Citigroup Global Markets Inc. takes responsibility for the Product in the United States. Any orders by US investors resulting from the information contained in the Product may be placed only through Citigroup Global Markets Inc.

Important Disclosures for Bell Potter Customers: Bell Potter is making this Product available to its clients pursuant to an agreement with Citigroup Global Markets Australia Pty Limited. Neither Citigroup Global Markets Australia Pty Limited nor any of its affiliates has made any determination as to the suitability of the information provided herein and clients should consult with their Bell Potter financial advisor before making any investment decision.

The Citigroup legal entity that takes responsibility for the production of the Product is the legal entity which the first named author is employed by. The Product is made available in **Australia** through Citigroup Global Markets Australia Pty Limited. (ABN 64 003 114 832 and AFSL No. 240992), participant of the ASX Group and regulated by the Australian Securities & Investments Commission. Citigroup Centre, 2 Park Street, Sydney, NSW 2000. The Product is made available in Australia to Private Banking wholesale clients through Citigroup Pty Limited (ABN 88 004 325 080 and AFSL 238098). Citigroup Pty Limited provides all financial product advice to Australian Private Banking wholesale clients through bankers and relationship managers. If there is any doubt about the suitability of investments held in Citigroup Private Bank accounts, investors should contact the Citigroup Private Bank in Australia. Citigroup companies may compensate affiliates and their representatives for providing products and services to clients. The Product is made available in **Brazil** by Citigroup Global Markets Brasil - CCTVM SA, which is regulated by CVM - Comissão de Valores Mobiliários, BACEN - Brazilian Central Bank, APIMEC - Associação dos Analistas e Profissionais de Investimento do Mercado de Capitais and ANBID - Associação Nacional dos Bancos de Investimento. Av. Paulista, 1111 - 11º andar - CEP. 01311920 - São Paulo - SP. If the Product is being made available in certain provinces of **Canada** by Citigroup Global Markets (Canada) Inc. ("CGM Canada"), CGM Canada has approved the Product. Citigroup Place, 123 Front Street West, Suite 1100, Toronto, Ontario M5J 2M3. This product is available in **Chile** through Banchile Corredores de Bolsa S.A., an indirect subsidiary of Citigroup Inc., which is regulated by the Superintendencia de Valores y Seguros. Agustinas 975, piso 2, Santiago, Chile. The Product is distributed in **Germany** by Citigroup Global Markets Deutschland AG ("CGMD"), which is regulated by Bundesanstalt fuer Finanzdienstleistungsaufsicht (BaFin). CGMD, Reuterweg 16, 60323 Frankfurt am Main. Research which relates to "securities" (as defined in the Securities and Futures Ordinance (Cap. 571 of the Laws of Hong Kong)) is issued in **Hong Kong** by, or on behalf of, Citigroup Global Markets Asia Limited which takes full responsibility for its content. Citigroup Global Markets Asia Ltd. is regulated by Hong Kong Securities and Futures Commission. If the Research is made available through Citibank, N.A., Hong Kong Branch, for its clients in Citi Private Bank, it is made available by Citibank N.A., Citibank Tower, Citibank Plaza, 3 Garden Road, Hong Kong. Citibank N.A. is regulated by the Hong Kong Monetary Authority. Please contact your Private Banker in Citibank N.A., Hong Kong, Branch if you have any queries on or any matters arising from or in connection with this document. The Product is made available in **India** by Citigroup Global Markets India Private Limited, which is regulated by Securities and Exchange Board of India. 1202, 12th Floor, FIFC, G Block, Bandra Kurla Complex, Bandra East, Mumbai - 400051 Corporate Identity Number: U99999MH2000PTC126657 Tel:+9102261759999 Fax:+9102261759961. The Product is made available in **Indonesia** through PT Citigroup Securities Indonesia. 5/F, Citibank Tower, Bapindo Plaza, Jl. Jend. Sudirman Kav. 54-55, Jakarta 12190. Neither this Product nor any copy hereof may be distributed in Indonesia or to any Indonesian citizens wherever they are domiciled or to Indonesian residents except in compliance with applicable capital market laws and regulations. This Product is not an offer of securities in Indonesia. The securities referred to in this Product have not been registered with the Capital Market and Financial Institutions Supervisory Agency (BAPEPAM-LK) pursuant to relevant capital market laws and regulations, and may not be offered or sold within the territory of the Republic of Indonesia or to Indonesian citizens through a public offering or in circumstances which constitute an offer within the meaning of the Indonesian capital market laws and regulations. The Product is made available in **Israel** through Citibank NA, regulated by the Bank of Israel and the Israeli Securities Authority. Citibank, N.A. Platinum Building, 21 Ha'arba'ah St, Tel Aviv, Israel. The Product is made available in **Italy** by Citigroup Global Markets Limited, which is authorised by the PRA and regulated by the FCA and the PRA. Via dei Mercanti, 12, Milan, 20121, Italy. The Product is made available in **Japan** by Citigroup Global Markets Japan Inc. ("CGMJ"), which is regulated by Financial Services Agency, Securities and Exchange Surveillance Commission, Japan Securities Dealers Association, Tokyo Stock Exchange and Osaka Securities Exchange. Shin-Marunouchi Building, 1-5-1 Marunouchi, Chiyoda-ku, Tokyo 100-6520 Japan. If the Product was distributed by SMBC Nikko Securities Inc. it is being so distributed under license. In the event that an error is found in an CGMJ research report, a revised version will be posted on the Firm's Citi Velocity website. If you have questions regarding Citi Velocity, please call (81 3) 6270-3019 for help. The Product is made available in **Korea** by Citigroup Global Markets Korea Securities Ltd., which is regulated by the Financial Services Commission, the Financial Supervisory Service and the Korea Financial Investment Association (KOFIA). Citibank Building, 39 Da-dong, Jung-gu, Seoul 100-180, Korea. KOFIA makes available registration information of research analysts on its website. Please visit the following website if you wish to find KOFIA registration information on research analysts of Citigroup Global Markets Korea Securities Ltd. <http://dis.kofia.or.kr/fs/dis2/fundMgr/DISFundMgrAnalystPop.jsp?companyCd2=A03030&pageDiv=02>. The Product is made available in Korea by Citibank Korea Inc., which is regulated by the Financial Services Commission and the Financial Supervisory Service. Address is Citibank Building, 39 Da-dong, Jung-gu, Seoul 100-180, Korea. The Product is made available in **Malaysia** by Citigroup Global Markets Malaysia Sdn Bhd (Company No. 460819-D) ("CGMM") to its clients and CGMM takes responsibility for its contents. CGMM is regulated by the Securities Commission of Malaysia. Please contact CGMM at Level 43 Menara Citibank, 165 Jalan Ampang, 50450 Kuala Lumpur, Malaysia in respect of any matters arising from, or in connection with, the Product. The Product is made available in **Mexico** by Acciones y Valores Banamex, S.A. De C. V., Casa de Bolsa, Integrante del Grupo Financiero Banamex ("Accival") which is a wholly owned subsidiary of Citigroup Inc. and is regulated by Comision Nacional Bancaria y de Valores. Reforma 398, Col. Juarez, 06600 Mexico, D.F. In **New Zealand** the Product is made available to 'wholesale clients' only as defined by s5C(1) of the Financial Advisers Act 2008 ('FAA') through Citigroup Global Markets Australia Pty Ltd (ABN 64 003 114 832 and AFSL No. 240992), an overseas financial adviser as defined by the FAA, participant of the ASX Group and regulated by the Australian Securities & Investments Commission. Citigroup Centre, 2 Park Street, Sydney, NSW 2000. The Product is made available in **Pakistan** by Citibank N.A. Pakistan branch, which is regulated by the State Bank of Pakistan and Securities Exchange Commission, Pakistan. AWT Plaza, 1.1. Chundrigar Road, P.O. Box 4889, Karachi-74200. The Product is made available in the **Philippines** through Citicorp Financial Services and Insurance Brokerage Philippines, Inc., which is regulated by the Philippines Securities and Exchange Commission. 20th Floor Citibank Square Bldg. The Product is made available in the Philippines through Citibank NA Philippines branch, Citibank Tower, 8741 Paseo De Roxas, Makati City, Manila. Citibank NA Philippines NA is regulated by The Bangko Sentral ng Pilipinas. The Product is made available in **Poland** by Dom Maklerski Banku Handlowego SA an indirect subsidiary of Citigroup Inc., which is regulated by Komisja Nadzoru Finansowego. Dom Maklerski Banku Handlowego S.A. ul.Senatorska 16, 00-923 Warszawa. The Product is made available in the **Russian Federation** through ZAO Citibank, which is licensed to carry out banking activities in the Russian Federation in accordance with the general banking license issued by the Central Bank of the Russian Federation and brokerage activities in accordance with the license issued by the Federal Service for Financial Markets. Neither the Product nor any information contained in the Product shall be considered as advertising the securities mentioned in this report within the territory of the Russian Federation or outside the Russian Federation. The Product does not constitute an appraisal within the meaning of the Federal Law of the Russian Federation of 29 July 1998 No. 135-FZ (as amended) On Appraisal Activities in the Russian Federation. 8-10 Gasheka Street, 125047 Moscow. The Product is made available in **Singapore** through Citigroup Global Markets Singapore Pte. Ltd. ("CGMSPL"), a capital markets services license holder, and regulated by Monetary Authority of Singapore. Please contact CGMSPL at 8 Marina View, 21st Floor Asia Square Tower 1, Singapore 018960, in respect of any matters arising from, or in connection with, the analysis of this document. This report is intended for recipients who are accredited, expert and institutional investors as defined under the Securities and Futures Act (Cap. 289). The Product is made available by The Citigroup Private Bank in Singapore through Citibank, N.A.,

Singapore Branch, a licensed bank in Singapore that is regulated by Monetary Authority of Singapore. Please contact your Private Banker in Citibank N.A., Singapore Branch if you have any queries on or any matters arising from or in connection with this document. This report is intended for recipients who are accredited, expert and institutional investors as defined under the Securities and Futures Act (Cap. 289). This report is distributed in Singapore by Citibank Singapore Ltd ("CSL") to selected Citigold/Citigold Private Clients. CSL provides no independent research or analysis of the substance or in preparation of this report. Please contact your Citigold/Citigold Private Client Relationship Manager in CSL if you have any queries on or any matters arising from or in connection with this report. This report is intended for recipients who are accredited investors as defined under the Securities and Futures Act (Cap. 289). Citigroup Global Markets (Pty) Ltd. is incorporated in the **Republic of South Africa** (company registration number 2000/025866/07) and its registered office is at 145 West Street, Sandton, 2196, Saxonwold. Citigroup Global Markets (Pty) Ltd. is regulated by JSE Securities Exchange South Africa, South African Reserve Bank and the Financial Services Board. The investments and services contained herein are not available to private customers in South Africa. The Product is made available in the **Republic of China** through Citigroup Global Markets Taiwan Securities Company Ltd. ("CGMTS"), 14 and 15F, No. 1, Songzhi Road, Taipei 110, Taiwan and/or through Citibank Securities (Taiwan) Company Limited ("CSTL"), 14 and 15F, No. 1, Songzhi Road, Taipei 110, Taiwan, subject to the respective license scope of each entity and the applicable laws and regulations in the Republic of China. CGMTS and CSTL are both regulated by the Securities and Futures Bureau of the Financial Supervisory Commission of Taiwan, the Republic of China. No portion of the Product may be reproduced or quoted in the Republic of China by the press or any third parties [without the written authorization of CGMTS and CSTL]. If the Product covers securities which are not allowed to be offered or traded in the Republic of China, neither the Product nor any information contained in the Product shall be considered as advertising the securities or making recommendation of the securities in the Republic of China. The Product is for informational purposes only and is not intended as an offer or solicitation for the purchase or sale of a security or financial products. Any decision to purchase securities or financial products mentioned in the Product must take into account existing public information on such security or the financial products or any registered prospectus. The Product is made available in **Thailand** through Citicorp Securities (Thailand) Ltd., which is regulated by the Securities and Exchange Commission of Thailand. 399 Interchange 21 Building, 18th Floor, Sukhumvit Road, Klongtoey Nua, Wattana, Bangkok 10110, Thailand. The Product is made available in **Turkey** through Citibank AS which is regulated by Capital Markets Board. Tekfen Tower, Eski Büyükdere Caddesi # 209 Kat 2B, 23294 Levent, Istanbul, Turkey. In the **U.A.E.**, these materials (the "Materials") are communicated by Citigroup Global Markets Limited, DIFC branch ("CGML"), an entity registered in the Dubai International Financial Center ("DIFC") and licensed and regulated by the Dubai Financial Services Authority ("DFSA") to Professional Clients and Market Counterparties only and should not be relied upon or distributed to Retail Clients. A distribution of the different Citi Research ratings distribution, in percentage terms for Investments in each sector covered is made available on request. Financial products and/or services to which the Materials relate will only be made available to Professional Clients and Market Counterparties. The Product is made available in **United Kingdom** by Citigroup Global Markets Limited, which is authorised by the Prudential Regulation Authority ("PRA") and regulated by the Financial Conduct Authority ("FCA") and the PRA. This material may relate to investments or services of a person outside of the UK or to other matters which are not authorised by the PRA nor regulated by the FCA and the PRA and further details as to where this may be the case are available upon request in respect of this material. Citigroup Centre, Canada Square, Canary Wharf, London, E14 5LB. The Product is made available in **United States** by Citigroup Global Markets Inc, which is a member of FINRA and registered with the US Securities and Exchange Commission. 388 Greenwich Street, New York, NY 10013. Unless specified to the contrary, within EU Member States, the Product is made available by Citigroup Global Markets Limited, which is authorised by the PRA and regulated by the FCA and the PRA.

Pursuant to Comissão de Valores Mobiliários Rule 483, Citi is required to disclose whether a Citi related company or business has a commercial relationship with the subject company. Considering that Citi operates multiple businesses in more than 100 countries around the world, it is likely that Citi has a commercial relationship with the subject company.

Many European regulators require that a firm must establish, implement and make available a policy for managing conflicts of interest arising as a result of publication or distribution of investment research. The policy applicable to Citi Research's Products can be found at https://www.citivelocity.com/cvr/eppublic/citi_research_disclosures.

Compensation of equity research analysts is determined by equity research management and Citigroup's senior management and is not linked to specific transactions or recommendations.

The Product is not to be construed as providing investment services in any jurisdiction where the provision of such services would not be permitted.

Subject to the nature and contents of the Product, the investments described therein are subject to fluctuations in price and/or value and investors may get back less than originally invested. Certain high-volatility investments can be subject to sudden and large falls in value that could equal or exceed the amount invested. Certain investments contained in the Product may have tax implications for private customers whereby levels and basis of taxation may be subject to change. If in doubt, investors should seek advice from a tax adviser. The Product does not purport to identify the nature of the specific market or other risks associated with a particular transaction. Advice in the Product is general and should not be construed as personal advice given it has been prepared without taking account of the objectives, financial situation or needs of any particular investor. Accordingly, investors should, before acting on the advice, consider the appropriateness of the advice, having regard to their objectives, financial situation and needs. Prior to acquiring any financial product, it is the client's responsibility to obtain the relevant offer document for the product and consider it before making a decision as to whether to purchase the product. Citi Research generally disseminates its research to the Firm's global institutional and retail clients via both proprietary (e.g., Citi Velocity and Citi Personal Wealth Management) and non-proprietary electronic distribution platforms. Certain research may be disseminated only via Citi's proprietary distribution platforms; however such research will not contain changes to earnings forecasts, target price, investment or risk rating or investment thesis or be otherwise inconsistent with the author's previously published research. Certain research is made available only to institutional investors to satisfy regulatory requirements. Individual Citi Research analysts may also opt to circulate published research to one or more clients by email; such email distribution is discretionary and is done only after the research has been disseminated.

The level and types of services provided by Citi Research analysts to clients may vary depending on various factors such as the client's individual preferences as to the frequency and manner of receiving communications from analysts, the client's risk profile and investment focus and perspective (e.g. market-wide, sector specific, long term, short-term etc.), the size and scope of the overall client relationship with Citi and legal and regulatory constraints. Citi Research product may source data from dataCentral. dataCentral is a Citi Research proprietary database, which includes Citi estimates, data from company reports and feeds from Thomson Reuters.

© 2014 Citigroup Global Markets Inc. Citi Research is a division of Citigroup Global Markets Inc. Citi and Citi with Arc Design are trademarks and service marks of Citigroup Inc. and its affiliates and are used and registered throughout the world. All rights reserved. Any unauthorized use, duplication, redistribution or disclosure of this report (the "Product"), including, but not limited to, redistribution of the Product by electronic mail, posting of the Product on

a website or page, and/or providing to a third party a link to the Product, is prohibited by law and will result in prosecution. The information contained in the Product is intended solely for the recipient and may not be further distributed by the recipient to any third party. Where included in this report, MSCI sourced information is the exclusive property of Morgan Stanley Capital International Inc. (MSCI). Without prior written permission of MSCI, this information and any other MSCI intellectual property may not be reproduced, disseminated or used to create any financial products, including any indices. This information is provided on an "as is" basis. The user assumes the entire risk of any use made of this information. MSCI, its affiliates and any third party involved in, or related to, computing or compiling the information hereby expressly disclaim all warranties of originality, accuracy, completeness, merchantability or fitness for a particular purpose with respect to any of this information. Without limiting any of the foregoing, in no event shall MSCI, any of its affiliates or any third party involved in, or related to, computing or compiling the information have any liability for any damages of any kind. MSCI, Morgan Stanley Capital International and the MSCI indexes are services marks of MSCI and its affiliates. The Firm accepts no liability whatsoever for the actions of third parties. The Product may provide the addresses of, or contain hyperlinks to, websites. Except to the extent to which the Product refers to website material of the Firm, the Firm has not reviewed the linked site. Equally, except to the extent to which the Product refers to website material of the Firm, the Firm takes no responsibility for, and makes no representations or warranties whatsoever as to, the data and information contained therein. Such address or hyperlink (including addresses or hyperlinks to website material of the Firm) is provided solely for your convenience and information and the content of the linked site does not in anyway form part of this document. Accessing such website or following such link through the Product or the website of the Firm shall be at your own risk and the Firm shall have no liability arising out of, or in connection with, any such referenced website.

ADDITIONAL INFORMATION IS AVAILABLE UPON REQUEST
