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The Local Volatility Factor for Asian Stock Markets

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Industry surveys indicate growing investments in Asian passive investment equity products commonly motivated by the expected economic growth of the region relative to the rest of the world and the resulting equity premium. Investors are typically interested more in regional and country cap-weighted indices and ETFs tracking such indices rather than sector or style indices (see Amenc et al. (2012)).

On the other hand, investors and asset managers increasingly use OTC or exchange-traded volatility derivatives using volatility indices as underlyings to alleviate losses during market downturns, based on the negative correlation between equity returns and volatility which has been well-documented in the academic literature. From an investor perspective, the negative correlation presents hedging and diversification opportunities. In addition, negative correlation and high volatility are particularly pronounced in stock market downturns, offering protection against stock market losses when it is most needed and when other forms of diversification do not provide very effective exposure.

Although the market for volatility derivatives in Asia is still immature, it has been slowly developing. Hong Kong and Japan launched implied volatility futures contracts in 2012 and Australia and Korea have revealed plans to launch such contracts in the near future. However, given that US VIX is the most popular implied volatility index with VIX futures easily available, an important question is whether an exposure to a local model-free option-implied (MFOI) volatility indicator has better hedging properties than an exposure to US VIX. On one hand, the academic literature finds empirical support for the presence of local volatility factors in Asian equity markets implying that investors would be better off with an exposure to a local MFOI volatility index. On the other hand, there is also evidence of spillover effects from the US to the Asian markets suggesting that in times of market turbulence an exposure to VIX can reduce risk.

In contrast to most of the academic studies which are model dependent (e.g. GARCH-type volatility models or vector-auto-regressive models), we study these questions directly with MFOI volatility indices. In Asia, there are three such indicators with more than 9 years of history – the Hong Kong (VHSI), the Japanese (VNKY), and the Korean (VKOSPI) indicators. MFOI volatility indices are available in India and Australia but have insufficient history. Our approach is to compare the hedging properties of hypothetical exposures to these three Asian MFOI volatility indices to the hedging properties of an exposure to VIX assuming an exposure to an Asian country-specific or regional equity index. We include in the study 12 local markets and 9 regional equity indices.[1]

As far as hedging costs are concerned, we do not compare the costs of achieving the volatility exposures. In any event, the volatility futures markets in Hong Kong and Japan are rather illiquid and any such comparison would favour VIX strongly. Our main objective is to verify if an exposure to a local MFOI volatility index provides fundamental benefits to investors which

1 - The local markets are Australia, China, Hong Kong, Japan, Korea, India, Indonesia, Malaysia, Singapore, the Philippines, Taiwan, and Thailand. The regional equity indices are MSCI All Country Asia ex Japan, MSCI Asia All Country Asia Pacific ex Japan, MSCI Asia APEX 50, MSCI All Country Far East ex Japan, MSCI Emerging Market Far East, MSCI Emerging Market Asia, MSCI Pacific, MSCI Pacific ex Japan and MSCI All Country Pacific ex Japan.

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could be a driver of higher demand for volatility derivative products in the future.

The empirical analysis in the paper is based on both conditional in-sample and out-of-sample analysis. We find strong evidence for a very significant local volatility factor in the Asian market index returns captured by VHSI, VNKY, and VKOSPI. In particular, stand-alone and multivariate analysis reveals that the relationship between the Asian equity index returns and the aforementioned MFOI volatility indices is significantly stronger than the relationship between Asian equity index returns and VIX. The multivariate analysis suggests either a weaker or insignificant relationship between the Asian equity market returns and the US VIX in the presence of Asian volatilities, implying that the Asian volatility indices can absorb the information content of the VIX.

Our conclusions are even stronger during the financial crisis of 2008 (the sample being from September 2008 to February 2009) which is surprising bearing in mind the spillover effects reported in the academic literature. A model selection algorithm shows a preference for an exposure to Asian MFOI volatility indices rather than an exposure to VIX which, in spite of all deficiencies of step-wise selection, does indicate a strong presence of an Asian volatility factor.

In addition to the in-sample analysis, we carry out an out-of-sample analysis with two hedging horizons of 5 and 15 days, which correspond to the average holding period of VIX futures, in two versions – using daily and weekly data for parameter estimation. The out-of-sample analysis confirms the conclusions from the in-sample analysis for both horizons.

There are two implications of this work for investors with an exposure to Asian equity markets and for Asian volatility derivative markets. Firstly, an exposure to VIX is efficient most likely in very brief periods around significant volatility spillovers from the US market. Generally, an exposure to VIX for hedging an exposure to Asian equity markets is significantly less efficient than an exposure to an Asian MFOI volatility indicator. Secondly, and in relation to the previous point, from a practical perspective constructing an exposure to an Asian MFOI volatility indicator is presently very difficult because of the limited liquidity of the volatility futures market. Nevertheless, the results suggest that investors can greatly benefit in the future as the market grows further and liquidity increases, especially if their horizon is from a few days up to one week.

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Volatility is a statistical measure of the dispersion of returns for a given security or market index. In other words, volatility refers to the amount of uncertainty or risk about the size of changes in an underlying security or index value. Higher volatility means that the underlying value can potentially be spread out over a larger range of values, signalling a higher riskiness for investors holding the security or index. Indeed, a high volatility means that the price of the security can change dramatically in either direction over a given interval of time. Lower volatility means that the value of a security or index does not fluctuate dramatically, but it changes at a steadier pace over a period of time.

While volatility is unambiguously formally defined as the standard deviation or variance of returns from a given stock or market index, we distinguish between *historical* and *implied* volatility measures. Historical volatility measures are obtained by estimating the standard deviation of returns or more complex GARCH-type models from a past sample of equity returns. One advantage of these measures is that they can be estimated directly from time-series of individual stock or stock index returns. One drawback is that they are not directly observable, and are dependent on a sample of past returns.

More recently, implicit volatility estimates have been obtained from option prices. One advantage of these measures is that they are more forward-looking compared to historical volatility measures since they reflect market's expectations about future volatility. Some of these measures are referred to as model-free option implied (MFOI) volatility measures to emphasise the fact that they do not depend on any modelling but are extracted directly from option prices. The most popular volatility index is the VIX, which is built from prices of equity index options on the S&P500.

Regarding volatility products, VIX futures were listed by CBOE in 2004 and VIX options – in 2006. In Europe, Deutsche Boerse started publishing its own volatility index on DAX options in late 1994 and introduced the world's first equity volatility futures in 1998. While this pioneering product was not a success – most likely due to a lag in the education of market makers with respect to the pricing and uses of volatility instruments – EUREX subsequently managed to reintroduce and develop volatility derivatives in Europe around the VSTOXX futures and options. In 2008, India's National Stock Exchange launched its version of the VIX. In 2010, the Korea Exchange (VKOSPI), the Australian Stock Exchange (S&P/ASX 200 VIX), and Nikkei (Nikkei 225 VI) introduced their indices. Hong Kong Exchanges and Clearing (HKEx) followed suit in 2011 (VHSI) and was the first to start trading futures contracts on its volatility index (February 20, 2012), with the Osaka Securities Exchange launching a week later.

Investors and asset managers increasingly use OTC or exchange-traded volatility derivatives using volatility indices as underlyings to alleviate losses during market downturns, based on the negative correlation between equity returns and volatility which has been well-documented in the academic literature. There are two theoretical explanations

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for it, the leverage effect (see Black (1976)) and volatility feedback effect (see Poterba and Summers (1986)). The leverage effect hypothesises that market downturn increases the leverage of the firm and thus the risk of the stock. While the volatility feedback effect assumes that the volatility is incorporated in the stock prices, a positive volatility shock would increase the future required return on stock and stock prices are expected to fall simultaneously. From an investor perspective, the negative correlation presents hedging and diversification opportunities in case trading in volatility is possible. In addition, negative correlation and high volatility are particularly pronounced in stock market downturns, offering protection against stock market losses when it is most needed and when other forms of diversification do not provide very effective exposure (see Hill and Rattray (2004) or Szado (2009) for recent references).

Given the need for investors in different regions to obtain downside protection, one question of theoretical and practical importance is whether a single volatility factor that can explain a dominant fraction of changes in volatility levels across different regions and segments of the worldwide equity markets exists, or whether distinct regional volatility indices/products are needed for distinct regions in the world.

This question is quite relevant for Asian equity markets. Industry surveys indicate growing investments in Asian passive investment equity products commonly motivated by the expected economic growth of the region relative to the rest of the world and the resulting equity premium. Investors are typically interested more in regional and country cap-weighted indices and ETFs tracking such indices rather than sector or style indices (see Amenc et al (2012)). Therefore, as far as demand for volatility is concerned, it is of interest if an exposure to local Asian MFOI volatility indices provides better hedging properties than an exposure to the US VIX both for country-specific and broad regional equity exposures.

Research on stock market volatility offers insights into the existence of regional and country-specific factors in stock market volatility. In volatility spillover literature, studies have found that stock market volatility can be decomposed into local, regional and global volatility. Besides spillovers from the US market, Ng (2000) and Miyakoshi (2003) find evidence for regional volatility spillovers from regional market, Japan, to other Asian markets. Worthington and Higgs (2004) find volatility spillovers among the developed and emerging Asian stock markets. This literature indicates that during market crises, an exposure to US VIX could provide protection.

Other studies, however, indicate that the volatility of some countries in Asia, such as India and China, is specific and generally decoupled from the volatility of US and Europe (see Padhi (2011) and Wang (2011)). In a more recent study, Gang et al. (2012) discuss the VIX and the Hong Kong MFOI volatility, VHSI. They noted differences in the relationship between the two MFOI volatility indicators and the corresponding index returns and also changes in the relationship around the financial crisis.

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Thus, in spite of volatility spillovers, because of the relative fragmentation of the equity markets in Asia, it is possible that an exposure to Asian MFOI volatility can have better hedging properties than an exposure to VIX. Further on, Loh, Martellini, and Stoyanov (2013) report strong evidence for a local volatility factor in equity markets that have MFOI volatility indicators. In Asia however, there are local markets for which such indicators are unavailable and, thus, a reasonable question is whether Asian MFOI volatility indices or VIX are better proxies for the local volatility factors. Finally, regional equity indices have no associated MFOI volatility measures and the same question applies to them.

The objective of this paper is to compare the hedging properties of an exposure to Asian MFOI indicators and an exposure to US VIX. The general assumption is that an investor already has an exposure to the local markets proxied by the main cap-weighted equity indices of the corresponding markets, or an exposure to a broad regional index proxied by MSCI Asian regional indices. We consider MSCI indices for two reasons – firstly, because of their popularity among institutional investors and, secondly, because of their influence on the retail market through the ETF products tracking them. We choose the Asian MFOI volatility indicators with more than 9 years of data – the Hong Kong (VHSI), the Japanese (VNKY), and the Korean (VKOSPI) indicators. VHSI and VNKY are of particular interest also because of the volatility futures launched in 2012 which, although not sufficiently liquid, provide a way of constructing the exposure. Still, our focus is not on the implementation, but on the presence or absence of a strong local volatility factor. Although the Indian and the Australian markets have their own MFOI volatility indices, they are not included in the study because of their relatively short histories.

We carry out an in-sample and an out-of-sample empirical analysis for 12 local markets – Australia, China, Hong Kong, Japan, Korea, India, Indonesia, Malaysia, Singapore, the Philippines, Taiwan and Thailand – and 9 regional MSCI indices including emerging market and all country indices including and excluding Japan.[2] The in-sample analysis covers the entire period from January 2003 to December 2012 but also focuses on the period of the financial crisis of 2008, from September 2008 to February 2009. The out-of-sample analysis is carried out assuming two different hedging horizons of 5 and 15 days based on the average holding period of US VIX futures.

The main conclusion from the empirical study is that both the in-sample and the out-of-sample analysis provide strong evidence for a local volatility factor. An exposure to Asian MFOI volatility is more efficient at partially hedging an exposure to a country-specific or regional equity index. The difference is much more pronounced for investors with shorter hedging horizons of a few days up to a week. The conclusion is even stronger for the period of the financial crisis of 2008.

One implication of these results is that an exposure to VIX is efficient in the context of an Asian equity portfolio most likely in very brief periods around significant volatility spillovers from the US market.

2 - MSCI All Country Asia ex Japan, MSCI Asia All Country Asia Pacific ex Japan, MSCI Asia APEX 50, MSCI All Country Far East ex Japan, MSCI Emerging Market Far East, MSCI Emerging Market Asia, MSCI Pacific, MSCI Pacific ex Japan, MSCI All Country Pacific ex Japan.

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Another implication is that investors can benefit in the future should the market of Asian volatility derivatives continue growing further.

The paper is organised in the following way. In Section 2, we discuss the notion of MFOI volatility indicator and the CBOE implementation, we provide a review of the academic literature on Asian implied volatility and volatility spillover, and we discuss the available volatility indices and volatility derivative products in Asia. Section 3 describes the data. Sections 4 and 5 provide the in-sample analysis for the country-specific and regional indices, respectively. Section 6 includes the out-of-sample analysis and Section 7 concludes. Details about the implementation of MFOI volatility indicators in Asia are included in Appendix 1.

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2. Landscape of Asian Model-Free Option-Implied Volatility Indices

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The MFOI volatility has become widely accepted as a forward-looking estimate of volatility. CBOE pioneered the VIX index in 1993 as the model-dependent 30-day Black-Scholes option-implied volatility of the at-the-money option of the S&P100 index. In 2003, the methodology was updated with the model-free estimation and the reference equity market index was changed to the S&P500 index. Other stock exchanges followed suit across the world. In Europe, MFOI volatility is available in Germany, France, the Netherlands, Switzerland, the UK, and the Eurozone. In Asia, since 2008 MFOI volatilities of the corresponding main equity market indices have been introduced by the National Stock Exchange of India, Korean Exchange, Osaka Securities Exchange, Hong Kong Stock Exchange, and Australian Securities Exchange and data have been backfilled in some cases starting from the beginning of the 2000s and, in the case of Japan, from 1989.

Since most of the option-implied volatility indicators are based on the methodology behind VIX, we briefly summarise it in Appendix 1 and also provide the deviations from the methodology of the indicators in Asia. In a nutshell, VIX is calculated from two sets of out-of-the-money calls and puts which bracket a maturity of 30 days with the illiquid options having been removed. Then, two option-implied variances are calculated for each maturity term using a formula that, essentially, calculates the price of a portfolio of these options (see Appendix 1). Finally, VIX is computed as the square-root of a weighted average of the two variances matching a constant 30-day time to maturity. As a consequence, VIX is often interpreted as the market expectation of the volatility over the next 30-days.[3]

3 - See, for example, the CBOE whitepaper (2009).

The precision of the CBOE methodology has recently become a topic of research. Jiang and Tian (2007) discuss the CBOE implementation in detail and report several problems which can lead to economically significant errors. They demonstrate that the approach adopted by CBOE is identical to the MFOI volatility published originally by Britten-Jones and Neuberger (2000) and note that its calculation requires out-of-the-money puts and calls with a continuum of strike prices ranging from 0 to infinity and, as a consequence, the method by CBOE introduces several sources of errors. Jiang and Tian (2007) calculate that for low levels of volatility (around 10%), the CBOE methodology overestimates the true implied volatility by about 7% and for high values of volatility (around 45%), the CBOE methodology underestimates the true implied volatility by about 4%. The authors also calculate that the overestimation and underestimation of VIX can be up to 79 and 198 index points, respectively and has a potential economic impact on the entire volatility derivative market as it implies mispricing of VIX futures, options, and variance swaps.

Although imperfections in the CBOE methodology may have an impact on the estimated level of volatility with the corresponding implications for the volatility derivatives, they do not seem to exercise a substantially adverse effect on the empirical relationship between the returns of the corresponding market index and VIX. Andersen and Bondarenko (2007) report a significant predictive power of VIX, of improved versions of VIX, and also of the Black-Scholes implied volatility. Apart from this paper, there is a significant body of literature on the power of option-implied

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volatility measures to predict realised volatility implying rich information content useful for both practitioners and academics (see Poon and Granger (2003) for a detailed survey of the academic literature).

Apart from the flaws of the CBOE methodology, we have to point out that the MFOI volatility is not the same quantity as the volatility of the return distribution of the underlying asset. In fact, the model-free implied variance is the variance of the risk-neutral distribution rather than the physical distribution. Theoretically, the risk-neutral distribution is derived by adjusting the physical distribution for the risk premia demanded by investors. As a consequence, option-implied variance measures incorporate this adjustment and deviate from realised variance measures. In fact, empirical studies report a positive difference between the two, which is also known as variance premium (see Bollerslev et al. (2009)).[4] Bakshi and Madan (2006) establish a connection between the variance premium,[5] investors' level of risk-aversion, and higher-order moments of the physical distribution, in particular the skewness and kurtosis. The theory and the empirical analysis indicate that positive variance premium is due to the presence of risk aversion, a negatively skewed and leptokurtic physical distribution. As a consequence, the temporal structure of the spread between the MFOI volatility and the volatility of the physical distribution can be linked to the dynamics of skewness, kurtosis, and the level of risk-aversion which can also vary with time.

In this section, we proceed with a brief overview of the academic literature on empirical studies of volatility in Asia. We then continue with an overview of the existing volatility indices and volatility products in Asia.

2.1. Studies on volatility in Asia

Studies on Asian implied volatility have generally found that implied volatility is better than historical volatility in forecasting future volatility which is consistent with similar empirical studies for the US market. Fung (2007) found that implied volatility is superior to variables such as volume and open interest of index options and futures, lagged realised volatility, and the arbitrage basis of futures index in forecasting future volatility. In this study, implied volatility is proxied by a simple average of the six nearest to the at-the-money Hang Seng index call and put options as a volatility measure. Similarly, Yu et al. (2010) found that implied volatility (stock index options from both the over-the-counter-market and the exchange) is superior to either historical volatility or a GARCH-type volatility forecast in predicting future volatility. In the Taiwan stock market, Yang and Liu (2012) found that model-free implied volatility outperforms the historical volatility and the GARCH volatility forecast as an indicator of future stock market volatility. On the other hand, the study of Wong and Tu (2009) on the Taiwan market finds that Black-Scholes implied volatility provides better forecasts than GARCH volatility. In contrast, Bhabra et al. (2001) studied Korean implied volatility for the period of July 1997 to March 1998. Their results indicate that option traders reacted to the Korean economic crisis rather than predicting its onset. They attributed this observation as a reflection of the option market immaturity in 1997.

4 - The variance premium is formally defined as the difference between the variance of the risk-neutral distribution and the variance of the physical distribution. See Bollerslev *et al.* (2009) for additional information.

5 - Bakshi and Madan (2006) consider the variance risk premium expressed as percentage of the variance of the physical distribution which proves more convenient to study the relationship with risk-aversion and higher-order moments.

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Due to the lack of an option market in China, Liu and Rangan (2011) used covered warrants to compute implied volatility. They found that the implied volatility has very little information content on future volatility possibly due to regulatory issues, high leverage and low trading costs and a market dominated by retail investors.

Several studies have documented the asymmetric effect, long memory, seasonal pattern and structural change in the volatility of Asian stock market. Chiang and Doong (2001) found asymmetric effect on conditional volatility of daily data, but no asymmetric effect on the monthly data for seven Asian stock markets.[6] They also documented a significant relationship between stock return and unexpected volatility for the Hong Kong, Malaysia, Singapore and Taiwan stock markets.

Most of the studies on volatility spillover to Asian stock markets have focused on volatility spillover from US markets (Ng (2000) and Miyakoshi (2003)) and volatility spillover among Asian markets (Worthington and Higgs (2004), Chuang et al. (2007), and Lee (2007)). These studies used GARCH-type volatility model except Chuang et al. (2007), which used a vector-autoregression model. Recent work by Padhi (2011) examined the implied volatility linkages among the Asian, American and European stock markets. The US implied volatility index is found to have a substantial impact over the variations of implied volatility indices in Germany, Hong Kong, Japan and Korea. Some countries, however, such as India are found to have a significant specific component. The explanation provided in the paper is the relative low degree of integration of the Indian equity market with the global financial system. Using different methods and broad indices of twelve Asian stock markets[7], Wang (2011) confirms that volatility in Asia can be driven by local factors.

2.2. Volatility indices and products in Asia

Due to the lack of uniformly well-developed stock index option markets in the regions, CBOE-style implied volatility indices are only available for six of the Asian stock markets, namely, Australia, Hong Kong, India, Japan, South Korea and Taiwan. See Table 1 for more details. These volatility indexes do not cover the Asian crisis period and the earliest data is available from 2001. Volatility futures contracts have been available for the option-implied volatility of the Hang Seng Index and the Nikkei 225 Index since February 2012 while Australia and South Korea stock exchanges have revealed plans to launch such products.

6 - Hong Kong, South Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand.
7 - The Asian countries are: Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan and Thailand.
8 - The table has been produced using different sources – Australia Stock Exchange, Hong Kong Stock Exchange, National Stock Exchange of India, Osaka Stock Exchange, Korea Stock Exchange, and the Bloomberg database.
9 - The start date is based on the availability of data from Bloomberg Database.

Table 1. Asian MFOI volatility indices and products[8]

Country	Bloomberg Ticker	Underlying Index	Provider	Start of historical data[9]	Methodology	Launched date for futures contract
Australia	SPAVIX	SP/ASX 200 Index	S&P, ASX	2 Jan 2008	CBOE	
China/Hong Kong	ASCNCHIX	FTSE/Xinhua 25 Index, Hang Seng Index	AlphaShares	3 Jan 1999	CBOE	
Hong Kong	VHSI	Hang Seng Index	HKEX	2 Jan 2001	CBOE	20 Feb 2012
India	INVIXN	Nifty 50 Index	NSE	1 Nov 2007	CBOE	
Japan	VNKY	Nikkei 225 Index	OSE	4 Jan 2001	CBOE	27 Feb 2012
South Korea	VKOSPI	KOSPI 200 Index	KSE	2 Jan 2003	CBOE	

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Taiwan Stock Exchange has recently launched an implied volatility index based on the CBOE methodology. Data for this index, however, are not available in Bloomberg.

Among the Asian stock index options underlying the construction of MFOI volatility indices, KOSPI 200 and S&P CNX Nifty have liquidity[10] greater than the S&P 500. Although the Nikkei 225 index option was launched in 1989 and the Hang Seng index option was launched in 1993, they are not as liquid as KOSPI 200 which was launched much later in 1997. See Table 2 for further details. Despite having a high volume of contracts traded for KOSPI 200 options, the variety of contracts with different strike price is lesser compared to S&P 500 index options.

The Hong Kong Stock Exchange was the first Asian stock exchange to launch volatility index futures, followed by Osaka stock exchange. Looking at Table 3, we can see that the HSI volatility futures contract is generally illiquid. On the first month of the trading the total number of contracts traded was 69 while the contract with open interest was 11. Although trading picked up after the first month, liquidity remains thin.

Osaka Stock Exchange launched trading of Nikkei 225 volatility index futures a week after HSI volatility index futures were launched. The liquidity for Nikkei 225 volatility index futures is also thin. The total number of contract traded in first month is 166 while contract with open interest is 23. Liquidity for Nikkei 225 volatility index futures has recently increased with the total number of contract traded in December 2012 at 2,411.

Other volatility derivatives such as variance swaps are available for KOSPI 200, Nikkei 225, ASX 200 and HSI.[11] However, there is little liquidity in Asian variance swaps and HSI variance swaps is the most liquid in relative terms.[12] Variance swaps are traded over the counter (OTC) and little information on the product is available.

10 - The liquidity of the index option market is based on the number of contracts traded.
11 - Based on variance swaps available in Bloomberg Database.
12 - See Veerappan and Han (2012).
13 - Source: http://www.futuresindustry.com. The average notional value is calculated by multiplying the number of contracts traded by the multiplier and then by the corresponding average index value and average exchange rate where the averaging has been done on the daily values in 2011.

Table 2. Top 20 Equity index futures and options contracts[13]

	Rank	Contract	Index Multiplier	Number of contracts traded, 2011	Average Notional Value (USD), 2011
Options	1	KOSPI 200 Options, KRX	KRW 100,000	3,671,662,258	86,136,713,743,212
	2	S&P 500 Index Options, CBOE	USD 100	197,509,449	25,037,062,712,471
	3	Euro Stoxx 50 Index Options, Eurex	EUR 10	369,241,952	13,426,186,189,265
	4	S&P CNX Nifty Index Options, NSE India	INR 100	868,684,582	9,930,331,813,352
	5	DAX 30 Options, Eurex	EUR 5	67,616,997	3,101,026,508,585
	6	TA-25 Index Options, TASE	NIS 100	87,133,824	2,928,128,944,826
	7	Taiex Options, Taiex	TWD 50	125,767,624	1,744,931,959,539
	8	Volatility Index Options, CBOE	USD 100	97,988,951	237,158,536,348
Futures	1	Euro Stoxx 50 Futures, Eurex	EUR 10	408,860,002	14,866,757,372,670
	2	KOSPI 200 Futures, KRX	KRW 500,000	87,274,461	10,237,236,891,643
	3	S&P CNX Nifty Index Futures, NSE India	INR 100	123,144,880	1,407,725,594,369
	4	Nikkei 225 Mini Futures	100 Yen	117,905,210	1,394,514,995,202

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Table 3. Monthly Statistics –HSI and Nikkei 225 volatility index futures.[14]

	Month	Contract Volume		Open Interest
		Average Daily	Total	
HSI Volatility Index Futures	2012 02	9	69	11
	2012 03	10	220	39
	2012 04	11	196	129
	2012 05	16	353	27
	2012 06	5	115	77
	2012 07	4	74	29
	2012 08	7	169	54
	2012 09	4	81	69
	2012 10	10	196	41
	2012 11	2	42	4
	2012 12	1	11	8
Nikkei 225 Volatility Index Futures	2012 02	55	166	23
	2012 03	134	2,824	734
	2012 04	18	352	10
	2012 05	4	92	28
	2012 06	40	838	226
	2012 07	44	915	297
	2012 08	53	1,216	269
	2012 09	55	1,041	429
	2012 10	70	1,544	514
	2012 11	74	1,560	752
	2012 12	127	2,411	1,739

14 - Source: Hong Kong Stock Exchange and Osaka Stock Exchange.

3. Data

3. Data

The daily stock indices were obtained from DataStream and the implied volatility indices was obtained from Bloomberg. Countries under study include Australia (S&P/ASX 200), China (Shanghai Stock Exchange Composite), Hong Kong (Hang Seng), Japan (TOPIX), Korea (KOSPI), India (S&P BSE 100), Indonesia (Jakarta Stock Exchange Composite), Malaysia (FTSE Bursa Malaysia KLCI), Singapore (Strait Times), the Philippines (Philippines Composite), Taiwan (Taiwan Stock Exchange Weighted) and Thailand (Bangkok SET). We also selected 9 regional MSCI indices including emerging market and all country indices including and excluding Japan, see the details in Table 4. These regional indices are also benchmark indices with a number of ETFs tracking their performance. The implied volatilities selected for the study because of data availability are VHSI, VNKY, and VKOSPI and, also, the US VIX. The sample period runs from January 2003 to December 2012 because VKOSPI is only available from January 2003.

Table 5 shows descriptive statistics for the data. We consider changes in the MFOI volatility indices rather than levels because, firstly, the increments represent a proxy for the P&L of a strategy invested in volatility futures which is a common approach for constructing an exposure to the volatility index. Secondly, using increments instead of values deals with the issue of persistence (strong autocorrelation) and is a common approach in time-series analysis; see for example Hamilton (1994).

15 - Source: MSCI documentation.

Table 4. The country indices included in the regional MSCI indices.[15]

Regional Index	Bloomberg Code	Country indices included in the regional index
MSCI All Country Asia ex Japan	MXASJ	China, Hong Kong, India, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand.
MSCI Asia All Country Asia Pacific ex Japan	MXAPJ	Australia, Hong Kong, New Zealand, Singapore, China, India, Indonesia, Korea, Malaysia, the Philippines, Taiwan and Thailand.
MSCI Asia APEX 50	MXAPEXA	Captures the performance of the 50 largest stocks in the Asia ex Japan region.
MSCI All Country Far East ex Japan	MXFEJ	China, Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand.
MSCI Emerging Market Far East	MXMF	China, Indonesia, Korea, Malaysia, the Philippines, Taiwan and Thailand.
MSCI Emerging Market Asia	MXMS	China, India, Indonesia, Malaysia, Korea, Thailand, Taiwan and the Philippines.
MSCI Pacific Index	MXPC	Australia, Hong Kong, Japan, New Zealand and Singapore.
MSCI Pacific ex Japan	MXPCJ	Australia, Hong Kong, New Zealand and Singapore.
MSCI All Country Pacific ex Japan	MXPFJ	Australia, China, Hong Kong, Indonesia, Korea, Malaysia, New Zealand, the Philippines, Singapore, Taiwan, and Thailand

3. Data

Table 5. Descriptive statistics for log-returns and change in implied volatilities for sample period of January 2003 to December 2012.

Country Return	Mean (annualised)	Standard deviation (annualised)	Skewness	Kurtosis
Australia	0.0026	0.1735	-0.4655	8.8251
China	0.0033	0.2585	-0.2473	6.8804
Hong Kong	0.0054	0.2492	0.0339	12.7561
India	0.0111	0.2548	-0.2757	11.2494
Indonesia	0.0143	0.2265	-0.6782	10.2207
Japan	0.0001	0.2185	-0.4464	11.6733
Korea	0.0070	0.2325	-0.5006	8.9507
Malaysia	0.0060	0.1222	-1.0810	17.2803
Philippines	0.0107	0.2062	-0.6136	11.1882
Singapore	0.0054	0.1928	-0.1999	8.3653
Taiwan	0.0032	0.2105	-0.3640	6.1253
Thailand	0.0084	0.2164	-0.9226	16.6535

Regional Return	Mean (annualised)	Standard deviation (annualised)	Skewness	Kurtosis
MSCI All Country Asia ex Japan	0.0068	0.2202	-0.3022	9.1961
MSCI Asia All Country Asia Pacific ex Japan	0.0067	0.2182	-0.5684	9.6570
MSCI Asia APEX 50	0.0065	0.2395	-0.0151	9.9582
MSCI All Country Far East ex Japan	0.0066	0.2246	-0.2299	9.9973
MSCI Emerging Market Far East	0.0068	0.2378	-0.2357	10.4596
MSCI Emerging Market Asia	0.0071	0.2303	-0.3251	9.3124
MSCI Pacific Index	0.0034	0.2078	-0.3880	8.5467
MSCI Pacific ex Japan	0.0063	0.2317	-0.8007	11.4013
MSCI All Country Pacific ex Japan	0.0066	0.2214	-0.5410	9.9424

Change in MFOI volatility	Mean (annualised)	Standard deviation (annualised)	Skewness	Kurtosis
VHSI	-0.0074	27.1423	1.9448	25.7226
VNKY	-0.0356	30.4601	2.2887	39.0075
VKOSPI	-0.1134	27.2579	2.3592	35.4811
VIX	-0.0406	28.7255	0.5832	23.1753

3. Data

4. Local and Global Volatility Factors for Asian Equity Market Indices

4. Local and Global Volatility Factors for Asian Equity Market Indices

A common argument articulated by finance professionals is that in times of significant market crashes, equity volatility increases across all markets. Therefore, investors across the world can use the most liquid volatility derivatives market to buy protection rather than opt for local volatility derivative products in case they are available. The most liquid such market is that of VIX derivatives and, as the argument goes, buying a VIX product is supposed to provide sufficient protection. This is supposed to hold true for investors based in both developed and emerging markets and there is general support coming from empirical research; see Poon and Granger (2003)[16].

In Asia, there are both developed and emerging markets and, to check the relevance of the argument, we look at the literature on the volatility spillover mechanism. In spite of the general nature of the argument outlined above, it turns out to be incomplete because the transmission mechanism of volatility spillover has been found to be generally from developed to emerging markets. Beirne et al. (2009) study 41 different emerging markets including 12 Asian ones and conclude that the volatility of matured markets significantly affects the conditional volatility of emerging markets; the exceptions in Asia being China, India and the Philippines. The analysis is based on a multivariate GARCH model and the matured markets volatility is defined through a weighted average of the variances of the US, Japan, and Europe – represented by Germany, France, Italy and the UK.

Finally, although only indirectly connected to our analysis, Bollerslev et al. (2012) discuss the predictability of aggregate stock market returns by the variance risk premium. The empirical study covers only developed markets[17] and confirms that the US market is predictable over a 3-5 month horizon and the same conclusion holds for the other markets although the degree of predictability is lower. The degree of predictability appears to improve by constructing a "global" variance premium by cap-weighting the variance premiums of the developed markets included in the analysis. Since the US has the largest weight in the weighted average, it can be argued that the US variance premium is the largest contributor to the improved predictability.

These empirical papers suggests that although we can make the case for using VIX derivatives as a protection in times of severe market crashes, if investors are significantly exposed to emerging markets they may be left unprotected to market-specific events or, in case the spillover mechanism is not pronounced, the protection may be inadequate (e.g. India or China). Market specific events, in case there is no spillover, may leave investors unprotected even in developed markets. Two notable examples include the European debt crisis, which has been unfolding over the past few years and is an example of a specific endogenous volatility factor, and the catastrophic earthquake in Japan in March 2011, which is an example of a specific exogenous volatility factor.

In this section, we check for presence of local volatility factors using only MFOI

16 - Poon and Granger (2003) note that it is a stylised fact of volatility that correlation among volatility is stronger than correlation among returns and both tend to increase during bear market and financial crises.

17 - The markets covered are France, Japan, Germany, Switzerland, the UK and the US.

4. Local and Global Volatility Factors for Asian Equity Market Indices

volatility indicators rather than the traditional model-dependent approaches. More generally, we apply the following commonly used model to illustrate the contemporaneous relationship between option-implied volatility and market returns,

Eq. 1

$$r_t = a + b\Delta Vol_t + \varepsilon_t$$

where r_t denotes the market index returns observed at time t and ΔVol_t denotes the change in volatility observed at time t (see, for example, in Ang et al. (2006)). The rationale behind this model is that large negative returns of the market index are expected to be coincidental with big positive changes of the option implied volatility. As a consequence, any volatility strategy (e.g. volatility futures) with a positive exposure to ΔVol_t can be used as a hedge a positive exposure to the market index returns. We apply this model for 12 Asian-Pacific markets using Hong Kong, Japan, Korea and US option-implied volatility indices. Given that US stock market opens after the Asian stock markets close, lagged US VIX is used in the regression.

The results for the stand-alone regressions are provided in Table 6.

Table 6 shows that stock return and VHSI have the highest correlation for most countries. In contrast, VIX has the lowest correlation with Asian return with the exception of the Philippines. In Australia and Taiwan, the market index return has the highest correlation with VKOSPI followed by VHSI. In the case of Japan, the market index return has the highest correlation with local implied volatility, VNKY, followed by VKOSPI. In Korea, the market index return has the highest correlation with its own implied volatility, VKOSPI, followed by VHSI. Overall, the regression results strongly suggest presence of local/Asian volatility. The adjusted R^2 for Hong Kong, Japan and Korea which have the local implied volatility is also much higher than those that do not have local implied volatility. The adjusted R^2 for Hong Kong, Japan and Korea ranges from 0.4092 to 0.4326. This shows that the local implied volatility has a high explanatory power regarding the variation of local market index return. The results also imply the inadequacy of hedging Asian returns with US VIX, ceteris paribus.

As a second step, we extend Eq. 1 to the following multivariate regression model:

Eq. 2

$$r_t = a + b\Delta HSI_t + c\Delta VNKY_t + d\Delta VKOSPI + e\Delta VIX_{t-1} + \varepsilon_t$$

The results from multivariate regression reported in Table 7 show that for the cases of Hong Kong, Korea and Japan, the highest exposure is to the local implied volatility. The adjusted R^2 values for these three countries are also higher than for the countries without a local implied volatility. In addition, the lagged change in VIX is not statistically significant for Hong Kong and Korea, while the exposure to it in the case of Japan is more than 3 times smaller than the exposure to the local MFOI volatility index.

For those Asian countries which do not have a local MFOI volatility indicator, the exposures to VHSI and VKOSPI are more significant than the exposures to

4. Local and Global Volatility Factors for Asian Equity Market Indices

Table 6. The results from the stand-alone regressions for the sample period from January 2003 to December 2012. The first row reports the regression coefficient, the second row reports its p-value and third row reports the adjusted R^2.

	Δ VHSI	Δ VNKY	Δ VKOSPI	Lagged Δ VIX
Australia	-0.3178*	-0.3157*	-0.3478*	-0.2863*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.2465	0.3057	0.2981	0.2213
China	-0.2303*	-0.2107*	-0.2313*	-0.1148*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.0554	0.0599	0.0585	0.0149
Hong Kong	-0.5833*	-0.3994*	-0.5007*	-0.3063*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.4092	0.2372	0.3003	0.1182
India	-0.3909*	-0.2223*	-0.3254*	-0.1794*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.1667	0.0682	0.1170	0.0385
Indonesia	-0.3909*	-0.2225*	-0.3257*	-0.2431*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.1667	0.0683	0.1171	0.0885
Japan	-0.3935*	-0.4552*	-0.4472*	-0.3373
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.2349	0.4167	0.3075	0.1889
Korea	-0.4208*	-0.3806*	-0.5569*	-0.2530*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.2353	0.2435	0.4326	0.0933
Malaysia	-0.1782*	-0.1529*	-0.1744*	-0.1306*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.1447	0.1429	0.1487	0.0890
Philippines	-0.2659*	-0.2196*	-0.2568*	-0.3426*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.1232	0.1088	0.1148	0.2136
Singapore	-0.3776*	-0.2759*	-0.3524*	-0.1899*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.2621	0.1945	0.2476	0.0738
Taiwan	-0.3252*	-0.2994*	-0.3764*	-0.2417*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.1673	0.1884	0.2367	0.1032
Thailand	-0.3275*	-0.2001*	-0.2814*	-0.1677*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.1674	0.0792	0.1231	0.0450

4. Local and Global Volatility Factors for Asian Equity Market Indices

Table 7. The results from the multivariate regression for the sample period from January 2003 to December 2012.

	Δ VHSI	Δ VNKY	Δ VKOSPI	Lagged Δ VIX	Adjusted R^2	F-Tests P value
Australia	-0.0610*	-0.1392*	-0.1571*	-0.1382*	0.4280	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
China	-0.1027*	-0.0915*	-0.1123*	-0.0168	0.0861	0.0000
	(0.0004)	(0.0002)	(0.0001)	(0.4611)		
Hong Kong	-0.4272*	-0.0639*	-0.1689*	-0.0263	0.4620	0.0000
	(0.0000)	(0.0003)	(0.0000)	(0.1050)		
India	-0.3199*	0.0157	-0.1299*	-0.0077	0.1829	0.0000
	(0.0000)	(0.4969)	(0.0000)	(0.7164)		
Indonesia	-0.2327*	-0.0628*	-0.1366*	-0.0563*	0.2510	0.0000
	(0.0000)	(0.0012)	(0.0000)	(0.0016)		
Japan	-0.0589	-0.3099*	-0.1537*	-0.0860*	0.4809	0.0000
	(0.0008)	(0.0000)	(0.0000)	(0.0000)		
Korea	-0.0619*	-0.0867*	-0.4560*	-0.0140	0.4599	0.0000
	(0.0015)	(0.0000)	(0.0000)	(0.3593)		
Malaysia	-0.0752*	-0.0555*	-0.0679*	-0.0483*	0.2051	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
Philippines	-0.0878*	-0.0234	-0.0694*	-0.2543*	0.2570	0.0000
	(0.0000)	(0.1686)	(0.0005)	(0.0000)		
Singapore	-0.2241*	-0.0528*	-0.1755*	-0.0125	0.3392	0.0000
	(0.0000)	(0.0005)	(0.0000)	(0.3703)		
Taiwan	-0.1009*	-0.0969*	-0.2246*	-0.0692*	0.2970	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
Thailand	-0.2552*	0.0066	-0.1028*	-0.0068	0.1786	0.0000
	(0.0000)	(0.7303)	(0.0000)	(0.7059)		

VIX. The only exception is the Philippines whereby the lagged change in VIX has the highest coefficient. For Australia, the coefficient of the lagged change in VIX is -0.1382, but for the other Asian countries, the lagged change in VIX is either statistically insignificant or economically insignificant. An additional observation is that when we compare the stand-alone regression and multivariate regression, the coefficient for US VIX changes from a statistically significant one to a statistically insignificant one for most of the countries. This observation highlights the possibility that Asian volatility indices may be absorbing the information in the US VIX.

We repeat the regression in Eq. 1 using a shorter sample period, from September 2008 to February 2009, to see if the effect of Asian implied volatility remains prominent during the financial crisis of 2008. Table 8 shows the results for the stand-alone regressions for the subprime crisis period.

The results suggest that in Hong, Japan and Korea, the local implied volatility remains quite significant with a higher explanatory power. More generally, the explanatory power of the Asian MFOI volatility indices improves for all markets. Likewise the explanatory power of US VIX also improves for almost all markets

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Table 8. The results from the stand-alone regression for the sample period from September 2008 to February 2009. The first row reports the regression coefficient, the second row reports its p-value, and the third row reports the adjusted R^2.

	Δ VHSI	Δ VNKY	Δ VKOSPI	Lagged Δ VIX
Australia	-0.3304*	-0.3623*	-0.3224*	-0.2727*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3298	0.4216	0.4221	0.2990
China	-0.2302*	-0.2426*	-0.1758*	-0.0934
	(0.0001)	(0.0001)	(0.0004)	(0.0710)
	0.1441	0.1667	0.1220	0.0235
Hong Kong	-0.6096*	-0.4577*	-0.4521	-0.2165*
	(0.0000)	(0.0000)	(0.0000)	(0.0041)
	0.4892	0.2618	0.3598	0.0729
India	-0.4036*	-0.1942*	-0.2915*	-0.1516*
	(0.0000)	(0.0115)	(0.0000)	(0.0118)
	0.3041	0.0648	0.2201	0.0528
Indonesia	-0.3007*	-0.2884*	-0.2540*	-0.2064*
	(0.0000)	(0.0000)	(0.0000)	(0.0004)
	0.1958	0.1976	0.2017	0.1154
Japan	-0.5134*	-0.5317*	-0.4142*	-0.3899*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.4712	0.5758	0.4073	0.3511
Korea	-0.4205*	-0.4225*	-0.4401*	-0.2012*
	(0.0000)	(0.0000)	(0.0000)	(0.0014)
	0.3210	0.3103	0.4944	0.0910
Malaysia	-0.1483*	-0.1248*	-0.1293*	-0.0877*
	(0.0000)	(0.0000)	(0.0000)	(0.0004)
	0.2298	0.2018	0.2731	0.1116
Philippines	-0.3636*	-0.2628*	-0.2203*	-0.3416*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3827	0.2258	0.1854	0.4462
Singapore	-0.3588*	-0.2883*	-0.3003*	-0.1160*
	(0.0000)	(0.0000)	(0.0000)	(0.0313)
	0.3002	0.2090	0.3262	0.0353
Taiwan	-0.2869*	-0.2696*	-0.2387*	-0.2005*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.2492	0.2372	0.2475	0.1698
Thailand	-0.3617*	-0.2272	-0.2597*	-0.1330*
	(0.0000)	0.0001	(0.0000)	(0.0143)
	0.3359	0.1488	0.2314	0.0477

but VIX remains inferior to the Asian MFOI volatility indices with the only exception of the Philippines. The increase in the explanatory power of VIX is most pronounced for the Philippines and Japan. Overall, the stand-alone regression results show that during the US subprime crisis period, the local volatility factor remains dominant in spite of the improvement in the explanatory power of the models with the US VIX.

4. Local and Global Volatility Factors for Asian Equity Market Indices

Table 9. The results from the multivariate regression for the sample period from September 2008 to February 2009.

	Δ VHSI	Δ VNKY	Δ VKOSPI	Lagged Δ VIX	Adjusted R^2	F-Tests P value
Australia	-0.0211	-0.0994	-0.1663*	-0.1569*	0.5351	0.0000
	(0.7299)	(0.1591)	(0.0041)	(0.0010)		
China	-0.1463	-0.0919	-0.0586	-0.0077	0.1820	0.0009
	(0.1055)	(0.3625)	(0.4725)	(0.9093)		
Hong Kong	-0.5327*	-0.0322	-0.1444	0.0931	0.5095	0.0000
	(0.0000)	(0.7789)	(0.1203)	(0.2193)		
India	-0.3571*	0.2563*	-0.2046*	-0.0397	0.3235	0.0000
	(0.0005)	(0.0274)	(0.0310)	(0.5915)		
Indonesia	-0.1563	0.0093	-0.0931	-0.0836	0.2076	0.0004
	(0.0743)	(0.9249)	(0.2421)	(0.2046)		
Japan	-0.2160*	-0.3092*	-0.0405	-0.0656	0.6204	0.0000
	(0.0027)	(0.0002)	(0.5302)	(0.2155)		
Korea	-0.1205	-0.0327	-0.3625*	0.0104	0.4856	0.0000
	(0.1737)	(0.7464)	(0.0000)	(0.8752)		
Malaysia	-0.0570	0.0097	-0.0754*	-0.0394	0.2773	0.0000
	(0.1594)	(0.8256)	(0.0374)	(0.1687)		
Philippines	-0.2377*	0.0534	0.0001	-0.2418*	0.5532	0.0000
	(0.0002)	(0.4492)	(0.9985)	0.0000		
Singapore	-0.2336*	0.0219	-0.1875*	0.0364	0.3843	0.0000
	(0.0044)	(0.8011)	(0.0095)	(0.5187)		
Taiwan	-0.1509	-0.0191	-0.1145	-0.0690	0.2987	0.0000
	(0.0596)	(0.8283)	(0.1076)	(0.2338)		
Thailand	-0.3427*	0.0640	-0.0777	0.0624	0.3552	0.0000
	(0.0000)	(0.4535)	(0.2601)	(0.2960)		

Table 9 shows the result for multivariate regression for the subprime crisis period. It is striking that in spite of the significant stand-alone regressions with VIX, the multivariate model suggests that the relationship between the Asian equity index returns and the changes in VIX becomes insignificant as soon as the Asian MFOI volatility indices are added. The only exceptions are Australia and the Philippines and this result is quite surprising bearing in mind the existing literature on volatility spillovers from the 2008 financial crisis. In fact, a comparison between Table 7 and Table 9 suggests that the changes in US VIX become less significant in the presence of Asian MFOI volatility indices during the period of the financial crisis, from September 2008 to February 2009.

To check if this observation holds when the regression model changes, we run a stepwise regression on the same set of data. The step-wise regression is a model selection algorithm which selects from a given set of variables those that best explain the dependent variable. It runs, essentially, a sequence of regressions in which the set of independent variables expands if the newly added variable improves the model, or shrinks if a given variable does not contribute. In this case, the independent variables are the

4. Local and Global Volatility Factors for Asian Equity Market Indices

changes in all MFOI volatility indices; we run the stepwise selection algorithm and let it select a subset that best explains the returns of the corresponding equity index. Like any other model-selection approach, the results should be interpreted carefully because they depend on the particular sample, i.e. generalizing conclusions drawn for a particular sample could be misleading.

Table 10 includes the results for stepwise regression. They indicate that for the period from September 2008 to February 2009 the preferred variable for most of the Asian markets is VHSI followed by VKOSPI. In contrast, VIX is rarely selected as an explanatory variable. These conclusions should be taken as a confirmation of the presence of a local factor, rather than a general preference for a particular Asian MFOI indicator.

A visual comparison of the performance of the market, the local MFOI indicator and VIX for Hong Kong, Korea, and Japan is provided in Figure 1. A look at the stock indices and their respective implied volatility indices show that local implied volatilities and the US VIX move in tandem. The local implied volatilities visually appear to have captured the event in the US market.

Table 10. The results from the stepwise regression for the sample period from September 2008 to February 2009.

	Δ VHSI	Δ VNKY	Δ VKOSPI	Lagged Δ VIX	Adjusted R^2	F-Tests P value
Australia	-	-	-0.2544*	-0.1702*	0.5200	0.0000
			(0.0000)	(0.0000)		
China	-0.2302*	-	-	-	0.1441	0.0001
	(0.0001)					
Hong Kong	-0.6096*	-	-	-	0.4892	0.0000
	(0.0000)					
India	-0.4036*	-	-	-	0.3041	0.0000
	(0.0000)					
Indonesia	-0.3007*	-	-	-	0.1958	0.0000
	(0.0000)					
Japan	-0.2548*	-0.3681*	-	-	0.6202	0.0000
	(0.0001)	(0.0000)				
Korea	-	-	-0.4401*	-	0.4944	0.0000
			(0.0000)			
Malaysia	-	-	-0.1136*	-0.0419	0.2901	0.0000
			(0.0000)	(0.0793)		
Philippines	-0.2148*	-	-	-0.2401*	0.5502	0.0000
	(0.0000)			(0.0000)		
Singapore	-0.2008*	-	-0.1763*	-	0.3558	0.0000
	(0.0087)		(0.0044)			
Taiwan	-0.1918*	-	-0.1196*	-	0.2821	0.0000
	(0.0062)		(0.0396)			
Thailand	-0.3617*	-	-	-	0.3359	0.0000
	(0.0000)					

4. Local and Global Volatility Factors for Asian Equity Market Indices

Figure 1. The stock index and the corresponding MFOI volatility index of Hong Kong, Japan and Korea.

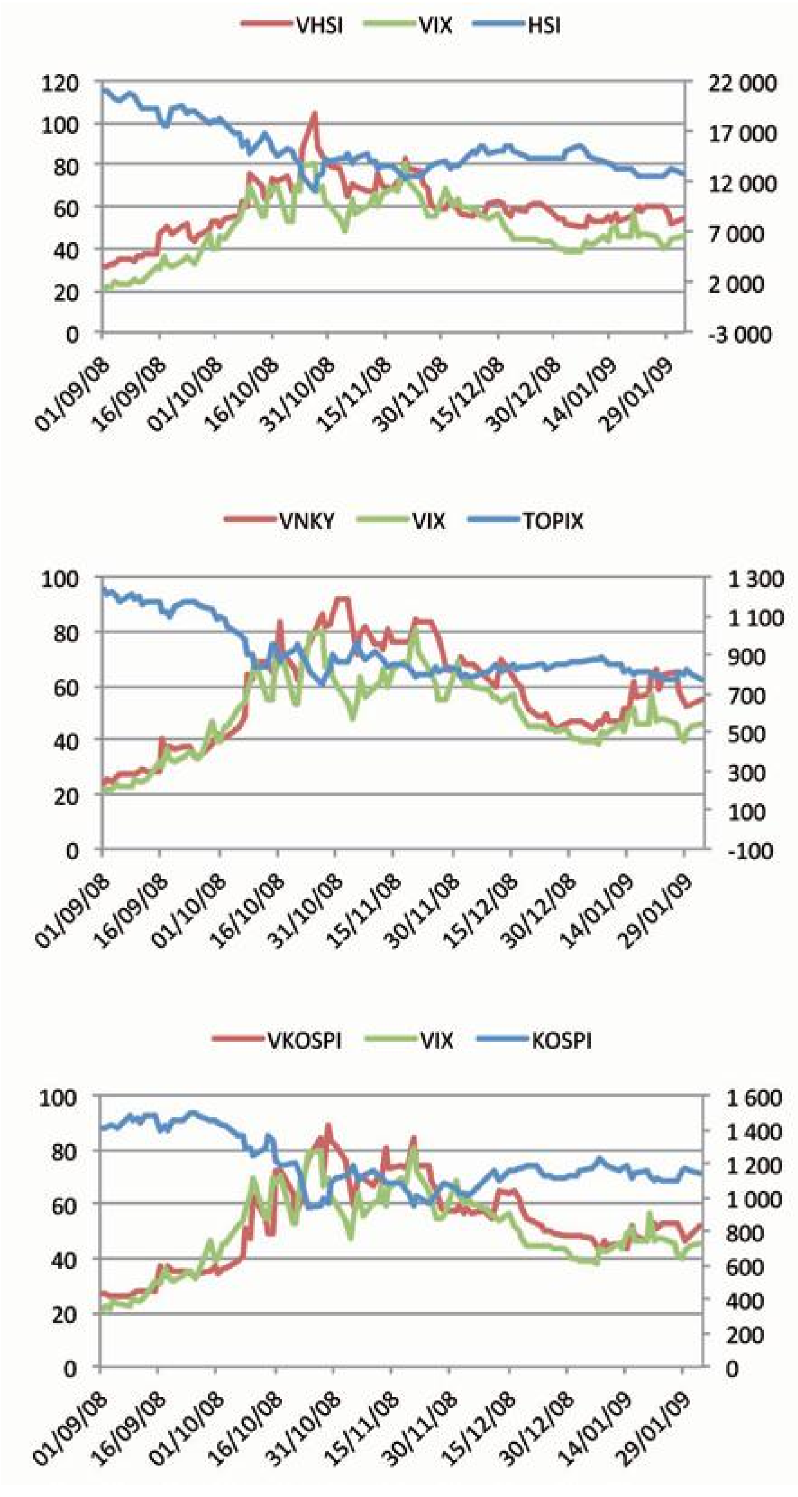

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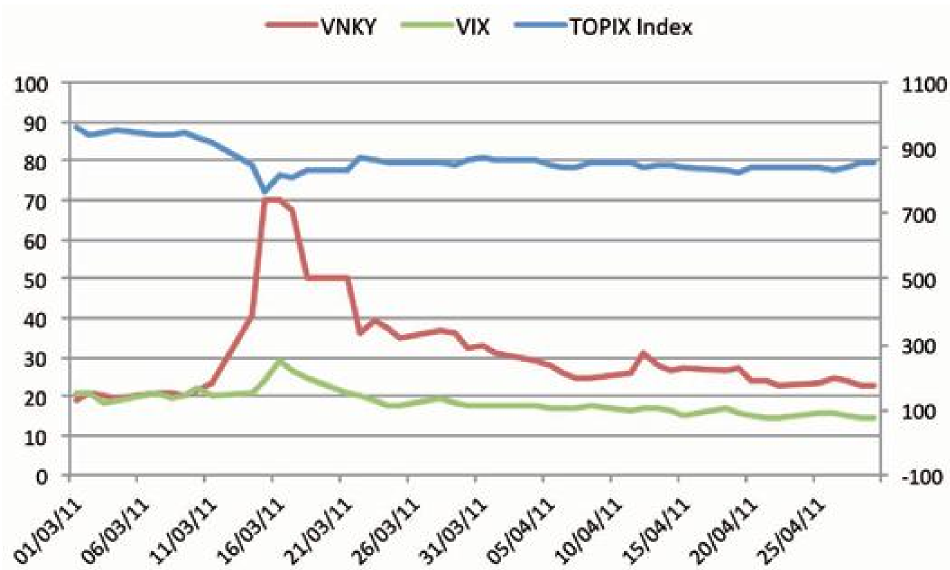
Figure 1 shows the plots of stock and volatility indices of Hong Kong, Japan and Korea. We can see that the local volatility index is reflective of the US VIX during the subprime crisis. This indicates that the local implied volatility is efficient in capturing the volatility spillovers from the US market. This observation is consistent with the multivariate regression results in Table 9 and Table 10.

Finally, for some specific event, it can be easily demonstrated that an exposure to VIX would provide very limited protection. Figure 2 shows the TOPIX index, VNKY Index, and the US VIX from January 2011 to May 2011. This period covers the March 2011 earthquake and the Fukushima disaster which followed. Clearly the earthquake and its aftermath had significant implications for the Japanese economy and caused a spike in volatility captured by Japan local implied volatility, VNKY index. In contrast, the increase in VIX was very small, see Figure 2.

Figure 2. Japan stock index (TOPIX), Japan implied volatility (VNKY Index) and US implied volatility (VIX) from 01-Mar-2011 to 29-Apr-2011 which includes the earthquake of 11-Mar-2011 which led to the Fukushima disaster.



Thus, although the US VIX may be a factor driving global volatility in times of severe market crashes that may spill over from developed to emerging markets, there is clear case to be made that the volatility of Asian markets has a specific component which has important consequences for investors in that an exposure to VIX may not deliver the expected level of protection in Asia.

The analysis carried out in this section has been in-sample. We extend our analysis further by evaluating the out-of-sample effectiveness of different implied volatilities hedges in the next section.

5. Local and Global Volatility Factors for Regional Asian Equity Indices

5. Local and Global Volatility Factors for Regional Asian Equity Indices

The results in Section 4 show that the Asian MFOI volatility indices capture a significant local volatility factor for Asian market index returns. It would be interesting to find out if the same conclusion holds for Asian regional indices. Intuitively, since regional indices are essentially portfolios constructed from the equity markets included in the empirical analysis in Section 4, we would expect to see an exposure to a local volatility factor to have better hedging properties than an exposure to VIX.

In this section, we repeat the one-dimensional and the multi-dimensional models for Asian MSCI indices in Eq. 1 and Eq. 2. The results would have important implications for institutional but also retail investors who invest in the regional indices either directly or by means of ETFs tracking those indices.

The results from the one-dimensional model in Eq. 1 are provided in Table 11. The returns of the regional indices exhibit a higher beta in absolute value to the changes in the Asian MFOI volatility

Table 11. The results from the stand-alone regression model in Eq. 1 based on the daily data in the period from January 2003 to December 2012. The first row reports the regression coefficient, the second row reports its p-value and third row reports the adjusted R^2.

Regional Indices	ΔVHSI	Δ VNKY	Δ VKOSPI	Lagged Δ VIX
MSCI All Country Asia ex Japan	-0.4867*	-0.3788*	-0.4964*	-0.2925*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3625	0.2833	0.3826	0.1450
MSCI All Country Asia Pacific ex Japan	-0.4910*	-0.4004*	-0.4947*	-0.3296*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3769	0.3218	0.3891	0.1875
MSCI Asia APEX 50	-0.5251*	-0.4014*	-0.5351*	-0.3011*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3542	0.2662	0.3736	0.1297
MSCI All Country Far East ex Japan	-0.4918*	-0.3922*	-0.5108*	-0.3000*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3562	0.2918	0.3891	0.1464
MSCI Emerging Market Far East	-0.4983*	-0.4119*	-0.5421*	-0.3189*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3261	0.2856	0.3905	0.1476
MSCI Emerging Market Asia	-0.4912*	-0.3922*	-0.5203*	-0.4912*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3373	0.2766	0.3839	0.3373
MSCI Pacific	-0.3835*	-0.4083*	-0.4252*	-0.3259*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.2541	0.3655	0.3151	0.2017
MSCI Pacific ex Japan	-0.4942*	-0.4161*	-0.4742*	-0.3617*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3413	0.3072	0.3179	0.1986
MSCI All Country Pacific ex Japan	-0.4953*	-0.4118*	-0.5052*	-0.3271*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3727	0.3302	0.3936	0.2097

5. Local and Global Volatility Factors for Regional Asian Equity Indices

indices and a higher R^2 in those regressions than in the case of VIX. There is some degree of variation among the different Asian indices but it is much smaller than the corresponding variation on a country level. The most significant variation is between the universe that includes Japan (MSCI Pacific), in which case the VNKY beta and the corresponding R^2 are more significant, and those that exclude Japan, in which case the exposure to VNKY appears less significant.

The regional index with the highest R^2 in a VIX model is MSCI Emerging Markets Asia which is an interesting outlier in the table but the multivariate analysis and a further out-of-sample analysis indicates that it is not reliable.

The results from the multivariate model in Eq. 2 is provided in Table 12 and confirm the observations based on Table 11. The exposure to VNKY is higher in absolute value only for MSCI Pacific which includes Japan. The exposure to VIX is the smallest with only one exception although statistically significant in all cases. Finally, the VIX exposure of MSCI Emerging Asia is much smaller than its exposure to VHSI and VKOSPI which means that the relatively good stand-alone model with VIX does not translate into a VIX exposure as high as the rest. Finally, all betas are statistically significant meaning that the changes in all of the MFOI volatility indicators contain information relevant to the returns of the regional Asian indices.

Table 12. The results from the multivariate regression for the sample period from January 2003 to December 2012.

Regional Indices	Δ VHSI	Δ VNKY	Δ VKOSPI	Lagged Δ VIX	Adjusted R^2	F-Tests P Value
MSCI All Country Asia ex Japan	-0.2471*	-0.0891*	-0.2537*	-0.0561*	0.4863	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0001)		
MSCI All Country Asia Pacific ex Japan	-0.2306*	-0.1161*	-0.2240*	-0.0966*	0.5128	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
MSCI Asia APEX 50	-0.2710*	-0.0927*	-0.2827*	-0.0449*	0.4742	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0039)		
MSCI All Country Far East ex Japan	-0.2362*	-0.1001*	-0.2666*	-0.0586*	0.4900	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
MSCI Emerging Market Far East	-0.2089*	-0.1063*	-0.3063*	-0.0727*	0.4754	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
MSCI Emerging Market Asia	-0.2261*	-0.0919*	-0.2852*	-0.0677*	0.4731	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
MSCI Pacific	-0.0813*	-0.2307*	-0.1708*	-0.1101*	0.4574	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
MSCI Pacific ex Japan	-0.2287*	-0.1467*	-0.1633*	-0.1314*	0.4593	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
MSCI All Country Pacific ex Japan	-0.2218*	-0.1259*	-0.2311*	-0.1016*	0.5168	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)		

5. Local and Global Volatility Factors for Regional Asian Equity Indices

It would be interesting to see if the statistical relationships change during the financial crisis of 2008 and, in particular, the relationship with VIX.

The results from the one-dimensional and the multivariate models during the financial crisis of 2008 are provided in Table 13 and Table 14. The results from the one-dimensional models show an increase in the explanatory power of the models and confirm the previous results that an exposure to an Asian volatility factor has better hedging properties than an exposure to VIX even during the financial crisis. The same observation about the performance of VNKY relative VHSI and VKOSPI in universes including and excluding Japan holds although the differences are less pronounced.

The results from the multivariate model show many insignificant coefficients. In fact, the VIX coefficients are insignificant for all regional indices, which is in line with the country results in Section 4. The implication is that even during the financial crisis an exposure to the Asian MFOI volatility index would have performed better than an exposure to VIX

Table 13. The results from the stand-alone regression model for the sample period from September 2008 to February 2009.

Regional Indices	ΔVHSI	ΔVNKY	ΔVKOSPI	Lagged ΔVIX
MSCI All Country Asia ex Japan	-0.4712*	-0.4180*	-0.4058*	-0.2347*
	(0.0000)	(0.0000)	(0.0000)	(0.0001)
	0.417	0.3363	0.4239	0.1324
MSCI All Country Asia Pacific ex Japan	-0.5159*	-0.4803*	-0.4355*	-0.2970*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.4628	0.4126	0.4510	0.1980
MSCI Asia APEX 50	-0.5137*	-0.4503*	-0.4379*	-0.2309*
	(0.0000)	(0.0000)	(0.0000)	(0.0004)
	0.4032	0.3157	0.4001	0.1030
MSCI All Country Far East ex Japan	-0.4765*	-0.4407*	-0.4168*	-0.2395*
	(0.0000)	(0.0000)	(0.0000)	(0.0001)
	0.4024	0.3503	0.4189	0.1292
MSCI Emerging Market Far East	-0.4791*	-0.4629*	-0.4315*	-0.2590*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3675	0.3481	0.4068	0.1371
MSCI Emerging Market Asia	-0.4722*	-0.4318*	-0.4158*	-0.2506*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.3894	0.3329	0.4154	0.1409
MSCI Pacific	-0.4610*	-0.5014*	-0.3860*	-0.3495*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.4533	0.565	0.4217	0.3407
MSCI Pacific ex Japan	-0.5747*	-0.5488*	-0.4646*	-0.3580*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.4693	0.4404	0.4166	0.2348
MSCI All Country Pacific ex Japan	-0.5233*	-0.5010*	-0.4456*	-0.3054*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
	0.456	0.4279	0.4497	0.1997

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for a regional Asian index although the crisis was born in the US.

Table 14. The results from the multivariate regression model for the sample period from September 2008 to February 2009.

	Δ VHSI	Δ VNKY	Δ VKOSPI	Lagged Δ VIX	Adjusted R^2	F-Tests P Value
MSCI All Country Asia ex Japan	-0.2674*	-0.0662	-0.1921*	-0.0070	0.4759	0.0000
	(0.0022)	(0.4970)	(0.0161)	(0.9128)		
MSCI All Country Asia Pacific ex Japan	-0.2665*	-0.1217	-0.1584*	-0.0560	0.5379	0.0000
	(0.0015)	(0.1948)	(0.0376)	(0.3627)		
MSCI Asia APEX 50	-0.3152*	-0.0939	-0.1991*	0.0300	0.4560	0.0000
	(0.0017)	(0.4001)	(0.0286)	(0.6825)		
MSCI All Country Far East ex Japan	-0.2589*	-0.1030	-0.1900*	0.0003	0.4683	0.0000
	(0.0044)	(0.3120)	(0.0222)	(0.9967)		
MSCI Emerging Market Far East	-0.2258*	-0.1163	-0.2084*	-0.0202	0.4391	0.0000
	(0.0206)	(0.2921)	(0.0207)	(0.7803)		
MSCI Emerging Market Asia	-0.2409*	-0.0686	-0.2086*	-0.0267	0.4516	0.0000
	(0.0090)	(0.5078)	(0.0140)	(0.6949)		
MSCI Pacific	-0.1673*	-0.2897*	-0.0602	-0.0793	0.6059	0.0000
	(0.0158)	(0.0004)	(0.3389)	(0.1251)		
MSCI Pacific ex Japan	-0.2990*	-0.1886	-0.0984	-0.0937	0.5541	0.0000
	(0.0009)	(0.0606)	(0.2202)	(0.1540)		
MSCI All Country Pacific ex Japan	-0.2606*	-0.1515	-0.1543*	-0.0549	0.5383	0.0000
	(0.0024)	(0.1162)	(0.0477)	(0.3839)		

5. Local and Global Volatility Factors for Regional Asian Equity Indices

6. Hedging Effectiveness of Asian and US Implied Volatilities for Asian Local Market and Regional Returns

6. Hedging Effectiveness of Asian and US Implied Volatilities for Asian Local Market and Regional Returns

To evaluate the hedging effectiveness of VHSI, VNKY, VKOSPI and VIX on Asian local market and regional returns, we follow the spot hedging strategy outlined by Deng et al. (2012) applied for volatility futures. The methodology relies on a linear regression of the type in Eq. 1 in which, instead of changes in a volatility indicator, the authors consider the changes of the SPVXSP index which calculates the value of a one-month constant maturity VIX volatility futures portfolio. The authors use weekly data in a rolling time-window of six months to fit the model and then measure the effectiveness of the hedge out-of-sample over the next week. They repeat this process over a period of seven years.

We adopt the same basic idea. We use, however, the changes in the MFOI volatility index directly as a proxy. To examine the effectiveness of the different volatilities as a hedge for the Asian returns we run the following regression:

Eq. 3

$$r^{i}_{t-m} = \alpha^{i,j} + \beta^{i,j}\Delta Vol^{j}_{t-m} + \varepsilon^{i,j}_{t-m}, \quad m = 0, 1, \dots, M$$

where M denotes the number of observations used for estimation, r^i denotes the returns of the equity market index of country i, ΔVol^j is the change in implied volatilities (VHSI, VNKY, VKOSPI and lagged VIX) and – is the error term. Each country return is regressed against the four different implied volatility and the coefficients estimated are the hedge ratios. The hedge ratio is estimated using data from the previous 125 days, thus the hedging is an ex-ante hedging strategy. The hedged return is constructed as follows:

Eq. 4

$$Hr^{i,j}_{t+k} = r^{i}_{t+k} - \beta^{i,j}\Delta Vol^{j}_{t+k}, \quad k = 1, \dots, h$$

where β^{i}_{t} is estimated from the regression using the previous 125 days data, and $Hr^{i,j}_{t+k}$ is the return of the hedged return at time $t + k$ using implied volatility j in which h denotes the hedging horizon. After calculating the hedged return, the time window is rolled forward setting t to $t + h$ and the process is repeated. Both Eq. 3 and Eq. 4 are based on daily data.

We use a hedging horizon of $h = 5$ and 15 days. A rationale for this choice is the average turnover times for VIX futures contracts calculated in a recent paper by Alexander and Korovilas (2012). The authors report that the average number of days a VIX contract is held has decreased from about 30 days in 2004 to about 5-15 days for the next-month and the mid-term contracts. The main difference between the two horizons is that the relationship between the market index return and the change in the MFOI volatility indicator is estimated less frequently for the longer horizon.

We compare the hedging effectiveness of the different volatilities on each country return by expressing the variance of the hedged and unhedged returns as follows:

Eq. 5

$$HE^{i,j} = 1 - var\left(Hr^{i,j}_{t}\right)/var\left(r^{i}_{t}\right)$$

HE measures, essentially, the reduction of return variance due to the hedge. An *HE* equal to zero implies that the beta in Eq. 3 is equal to zero which means no hedging benefit. Conversely, if *HE* is equal to 1, then the return of the market index can be completely replicated by the exposure to the change in the corresponding volatility indicator and, therefore, can be hedged completely.

6. Hedging Effectiveness of Asian and US Implied Volatilities for Asian Local Market and Regional Returns

Table 15. The estimated HE measure using different implied volatilities based on daily data in the period from January 2003 to December 2012.

Daily data	A 5-day Hedging Horizon					A 15-day Hedging Horizon			
	VHSI	VNKY	VKOSPI	VIX		VHSI	VNKY	VKOSPI	VIX
Australia	0.2278	**0.3234**	0.2654	0.2200		0.2166	0.3213	0.2314	0.2048
China	0.0367	0.0574	0.0487	0.0036		0.0307	0.0592	0.0421	-0.0121
Hong Kong	**0.4310**	0.2502	0.2917	0.1191		**0.4298**	0.2608	0.2878	0.1063
India	**0.1642**	0.0512	0.0966	0.0386		**0.1519**	0.0492	0.0951	0.0352
Indonesia	**0.2110**	0.1293	0.1852	0.0904		**0.2101**	0.1134	0.1610	0.0894
Japan	0.1909	**0.4591**	0.2466	0.1844		0.1855	**0.4567**	0.2270	0.1920
Korea	0.2455	0.2613	**0.4367**	0.0896		0.2454	0.2561	**0.4273**	0.0890
Malaysia	0.1256	**0.1691**	0.1415	0.1069		0.1263	**0.1629**	0.1268	0.1002
Philippines	0.1166	0.1458	0.1063	**0.2336**		0.1126	0.1535	0.0932	**0.2294**
Singapore	**0.2679**	0.2257	0.2393	0.0805		**0.2629**	0.2289	0.2264	0.0710
Taiwan	0.1650	0.2034	**0.2154**	0.0958		0.1604	**0.2021**	0.1904	0.0831
Thailand	**0.1633**	0.0714	0.0820	0.0342		**0.1553**	0.0753	0.0756	0.0325

Table 15 shows the hedging effectiveness computed according to Eq. 5 using different implied volatilities and hedging horizons of 5 and 15 days. The highest estimated *HE* is included in bold. Comparing the hedging effectiveness of the different MFOI volatility indices, we can see that the local implied volatilities provide more effective hedges than VIX and this effect is quite robust with respect to the change in hedging horizon, implying that the estimated betas are relatively robust. For countries that do not a have local implied volatility, except the Philippines, an exposure to VIX is least effective which is consistent with the one-dimensional regression results using the full sample.

There is a degree of flexibility in fitting the model in Eq. 3 because the estimation can be based on weekly or daily data. There are two reasons why it could make sense to go for a lower frequency. Firstly, according to Alexander and Korovilas (2012), the average holding period for the most liquid next month VIX futures contract is 5 days which implies that some investors are willing to hold the contract for more than 5 days. While for the rest using daily data is the only option, for those investors it could make sense to use weekly data directly in case the daily data seems too noisy. Secondly, over longer periods of time, equity markets and their volatilities are generally more integrated which could imply a less prevalent local volatility factor and better hedging properties of VIX.

The results based on weekly data are provided in Table 16. Although is it clear that the significance of VIX has generally increased compared to the daily results in Table 15, especially in the cases of Australia, Hong Kong, India, Singapore and Thailand, the Asian volatility factor is still stronger. Nevertheless, for three countries – Australia, India and Singapore – an exposure to VIX appears to be a reasonable alternative. However, this is not the case for the markets with their own MFOI volatility index – Hong Kong, Korea, and Japan.

Finally, we calculate the hedging effectiveness of exposures to the

6. Hedging Effectiveness of Asian and US Implied Volatilities for Asian Local Market and Regional Returns

Table 16. The estimated HE measure using different implied volatilities based on weekly data in the period from January 2003 to December 2012.

Weekly data	A 1-week Hedging Horizon					A 3-week Hedging Horizon			
	VHSI	VNKY	VKOSPI	VIX		VHSI	VNKY	VKOSPI	VIX
Australia	0.2318	0.2343	**0.2687**	0.2494		0.2125	0.1798	**0.2756**	0.2509
China	0.0448	-0.0356	-0.0313	-0.0264		0.0269	-0.0418	-0.0741	-0.0538
Hong Kong	**0.3380**	0.2098	0.2345	0.1987		**0.3376**	0.2100	0.1974	0.1950
India	0.1543	0.1389	**0.1633**	0.1356		**0.1365**	0.1267	0.1001	0.1238
Indonesia	0.1608	0.2222	**0.2857**	0.0826		0.1433	0.1998	**0.2620**	0.1148
Japan	0.1110	**0.3112**	0.0698	0.1311		0.0719	**0.2846**	-0.0375	0.1533
Korea	0.2909	0.1948	**0.4216**	0.0950		0.2675	0.1720	**0.3998**	0.1074
Malaysia	0.1236	0.1293	**0.2040**	0.0709		0.1134	0.1291	**0.1966**	0.0662
Philippines	0.0354	0.0393	**0.1787**	0.0543		0.0374	-0.0014	**0.1653**	0.0516
Singapore	0.2194	**0.2736**	0.2261	0.2131		0.2033	**0.2758**	0.1667	0.2230
Taiwan	**0.1735**	0.0905	0.1699	0.1144		**0.1445**	0.0486	0.1377	0.1066
Thailand	0.2053	0.2254	**0.2266**	0.1220		0.2082	0.2111	**0.2166**	0.1311

Table 17. The estimated HE measure using different implied volatilities based on daily data in the period from January 2003 to December 2012.

Daily data	A 5-day Hedging Horizon					A 15-day Hedging Horizon			
	VHSI	VNKY	VKOSPI	VIX		VHSI	VNKY	VKOSPI	VIX
MSCI All Country Asia ex Japan	0.3477	0.2737	**0.3495**	0.1406		**0.3435**	0.2703	0.3384	0.1320
MSCI Asia All Country Asia Pacific ex Japan	**0.3595**	0.3173	0.3565	0.1813		**0.3605**	0.3124	0.3361	0.1705
MSCI Asia APEX 50	0.3412	0.2569	**0.3429**	0.1259		**0.3379**	0.2560	0.3343	0.1162
MSCI All Country Far East ex Japan	0.3431	0.2832	**0.3582**	0.1416		0.3395	0.2797	**0.3472**	0.1338
MSCI Emerging Market Far East	0.3120	0.2770	**0.3578**	0.1417		0.3080	0.2724	**0.3476**	0.1343
MSCI Emerging Market Asia	0.3212	0.2660	**0.3486**	0.1412		0.3166	0.2613	**0.3382**	0.1326
MSCI Pacific	0.2286	**0.3577**	0.2604	0.2006		0.2337	**0.3517**	0.2284	0.1996
MSCI Pacific ex Japan	**0.3263**	0.3138	0.2822	0.1911		**0.3283**	0.3049	0.2261	0.1775
MSCI All Country Pacific ex Japan	0.3567	0.3271	**0.3626**	0.1846		**0.3587**	0.3218	0.3417	0.1744

corresponding MFOI volatility indicators for the regional Asian indices. As far as methodology is concerned, we follow the same steps as the ones for the country specific market indices.

The hedging effectiveness for hedging horizons of 5 and 15 days based on daily data is provided in Table 17. Like the regression results, the hedging effectiveness across the Asian MFOI volatility indicators is very similar for both horizons. The hedging effectiveness of an exposure to VIX is much lower. The numbers are quite stable across the two horizons implying that the corresponding estimated betas are relatively robust.

The results based on weekly data are provided in Table 18. The hedging properties of an exposure to VIX improve but remain inferior to those of an exposure to an Asian MFOI volatility index.

The results in both pairs of tables – Table 15-Table 16 and Table 17-Table 18 – indicate that using lower frequency data leads to an increase in the overall significance of

6. Hedging Effectiveness of Asian and US Implied Volatilities for Asian Local Market and Regional Returns

VIX which, although still inferior to the Asian volatility indices, could become a viable alternative in some isolated cases. Particularly for those cases, but also generally, an important determinant would be the cost of implementation of the exposure. If the approach involves volatility derivative products such as volatility futures, then the implementation cost materialises as the cost of rolling over the portfolio and generally increases with the holding period and depends on the liquidity and the maturity of the volatility futures market. If the intended holding period is, however, a few days up to one week, then the daily results show better properties for an exposure to an Asian MFOI volatility indicator. Therefore, investors with relatively shorter hedging horizons of a few days up to a week would particularly benefit from the further growth and development of Asian volatility derivative markets.

Table 18. The estimated HE measure using different implied volatilities based on weekly data in the period from January 2003 to December 2012.

Weekly data	A 1-week Hedging Horizon					A 3-week Hedging Horizon			
	VHSI	VNKY	VKOSPI	VIX		VHSI	VNKY	VKOSPI	VIX
MSCI All Country Asia ex Japan	0.3304	0.3202	**0.3428**	0.2079		0.3177	0.3146	**0.3277**	0.2172
MSCI Asia All Country Asia Pacific ex Japan	0.3206	**0.3492**	0.3240	0.2551		0.3001	**0.3428**	0.2929	0.2568
MSCI Asia APEX 50	**0.3072**	0.2850	0.2945	0.1880		**0.2955**	0.2825	0.2838	0.1970
MSCI All Country Far East ex Japan	0.3314	0.3230	**0.3430**	0.1973		0.3189	0.3159	**0.3320**	0.2062
MSCI Emerging Market Far East	0.3276	0.3081	**0.3487**	0.1729		0.3157	0.2983	**0.3393**	0.1809
MSCI Emerging Market Asia	0.3275	0.3087	**0.3481**	0.1882		0.3156	0.3014	**0.3341**	0.1967
MSCI Pacific	0.1966	**0.2895**	0.1649	0.1837		0.1587	**0.2629**	0.0896	0.1802
MSCI Pacific ex Japan	0.2557	**0.3442**	0.2298	0.3046		0.2250	**0.3296**	0.1701	0.2946
MSCI All Country Pacific ex Japan	0.3205	**0.3523**	0.3209	0.2501		0.2992	**0.3433**	0.2919	0.2503

6. Hedging Effectiveness of Asian and US Implied Volatilities for Asian Local Market and Regional Returns

7. Summary and Conclusions

7. Summary and Conclusions

Although the market for volatility derivatives in Asia is still immature, it has been slowly developing. Hong Kong and Japan launched implied volatility futures contracts in 2012 and Australia and Korea have revealed plans to launch such contracts in the near future. However, given that US VIX is the most popular implied volatility index with the VIX futures easily available, an important question is whether investors need local implied volatility products to get an exposure to a local model-free option-implied (MFOI) volatility indicator or if an exposure to US VIX provides sufficient protection. On one hand, the academic literature finds empirical support for the presence of local volatility factors in Asian equity markets but, on the other, there is also evidence of spillover effects from the US to the Asian markets, suggesting that in times of market turbulence an exposure to VIX can reduce risk. In contrast to most of the academic studies which are model dependent (e.g. GARCH-type volatility models or vector-auto-regressive models), we work directly with MFOI volatility indices. In Asia, there are three such indicators with more than nine years of history - the Hong Kong (VHSI), the Japanese (VNKY), and the Korean (VKOSPI) indicators. MFOI volatility indices are available in India and Australia, but have insufficient history.

The empirical analysis in the paper, based on both conditional in-sample and out-of-sample analysis, finds strong evidence of a local volatility factor in the Asian market index returns captured by VHSI, VNKY, and VKOSPI. In particular, stand-alone and multivariate regression results reveal that the relationship between the Asian equity index returns and the aforementioned MFOI volatility indices is significantly stronger than the relationship between Asian equity index returns and VIX. The multivariate regression results suggest either a weaker or insignificant relationship between the Asian equity market returns and US VIX in the presence of Asian volatilities, implying that the Asian volatility indices can absorb the information content of US VIX.

These conclusions are even stronger during the financial crisis of 2008 (the sample being from September 2008 to February 2009) which is surprising bearing in mind the spillover effects reported in the academic literature. A model selection algorithm shows a preference for an exposure to Asian MFOI volatility indices rather than an exposure to VIX which, in spite of all deficiencies of step-wise selection, does indicate a strong presence of an Asian volatility factor.

In addition to the in-sample analysis, we carry out an out-of-sample analysis with two hedging horizons of 5 and 15 days, which correspond to the average holding period of VIX futures, in two versions - using daily and weekly data for parameter estimation. The out-of-sample analysis confirms the conclusions from the in-sample analysis for both horizons.

A practice followed by institutional investors is to invest in broad regional equity indices. To verify if a local volatility factor is prominent in the returns of broad Asian equity indices we repeat the analysis for nine broad MSCI Asian indices. The universes contain different emerging market and all country indices including and excluding Japan. Again, both the in-sample and the out-of-sample analysis confirm the presence of a significant Asian

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volatility factor captured by VHSI, VNKY and VKOSPI, implying that an exposure to these MFOI volatility indices has better hedging properties than an exposure to VIX.

There are two implications of this work for investors with an exposure to Asian equity markets and for Asian volatility derivative markets. Firstly, an exposure to VIX is efficient most likely in very brief periods around significant volatility spillovers from the US market. Generally, an exposure to VIX for hedging an exposure to Asian equity markets is significantly less efficient than an exposure to an Asian MFOI volatility indicator. Secondly, and in relation to the previous point, from a practical perspective constructing an exposure to an Asian MFOI volatility indicator is presently very difficult because of the limited liquidity of the volatility futures market. Nevertheless, the results suggest that investors can greatly benefit in the future as the market grows further and liquidity increases, especially if their horizon is from a few days up to one week. It should be pointed out that an exposure to MFOI volatility implemented through the volatility futures market comes at a cost driven by the negative volatility premium which implies that the hedging benefits do not come for free.

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Appendices

Appendices

Appendix 1. The CBOE implementation of VIX and modifications in Asia

In this appendix, we describe the steps behind the CBOE implementation of VIX. The full details are available in the CBOE whitepaper (2009). Excluding the China volatility index for which no methodological notes are available, methodologies very similar to that of the CBOE have been adopted for all option-implied volatility indicators in Asia. The CBOE methodology includes the following steps:

a) Selection of options. Two sets of call and put options are selected– the near- and next-term calls and puts written on S&P500. The time to maturity brackets 30 days. For liquidity considerations, the near-term options should have at least one week to expiration and non-zero bid prices.

b) Calculation of option prices and S&P500 forward price. Compute the call and put prices to be used in the VIX calculation as the average of the corresponding bid and ask prices separately for the near- and next-term maturity. Calculate the S&P500 forward price F_0 for a maturity coinciding with that of the options through the put-call parity relationship for both terms,

$$F_0 = K_0 + \exp(-rT)[C(T, K_0) - P(T, K_0)]$$

in which K_0 is computed as the strike price at which the difference between the call and put prices is the smallest. The selected puts (calls) have strikes below (above) F_0.

c) Calculation of the near- and next-term implied variances. Using the out-of-the-money puts and calls for each maturity term T, calculate:

$$\hat{\sigma}^2(T) = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2}\exp(rT)Q(T, K_i) - \frac{1}{T}\left(\frac{F_0}{K_0} - 1\right)^2$$

where F_0 is the forward index level, T is the option time to maturity, K_i is the strike price of the i-th out-of-the-money option (which is a call if $K_i > F_0$ and a put if $K_i < F_0$), K_0 is the first strike price below F_0, $Q(T, K_i)$ is the corresponding option price (the average of the bid and the ask price), r is the risk-free interest rate, and ΔK_i is the strike price increment calculated as

$$\Delta K_i = \frac{K_{i+1} - K_{i-1}}{2}$$

and which is additionally modified for the highest and the lowest strike.

d) Calculation of VIX. The VIX is calculated as the square-root of the weighted average between the two implied variances to match a 30-day time to maturity:

$$VIX^2 = \hat{\sigma}^2(T_0) = \frac{1}{T_0}\left(\frac{T_2 - T_0}{T_2 - T_1}T_1\hat{\sigma}^2(T_1) + \frac{T_0 - T_1}{T_2 - T_1}T_2\hat{\sigma}^2(T_2)\right)$$

where T_0 is the 30-day maturity and T_1 and T_2 denote the near- and the next-term implied variances calculated according to the formula in the previous step.

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Although the algorithm looks complicated, it can be demonstrated (see Jiang and Tian (2007)) that the quantity $\hat{\sigma}^2(T)$ is essentially a numerical approximation of

$$\sigma^2(T) = \frac{2\exp(rT)}{T}\left(\int_0^{F_0} \frac{P(T,K)}{K^2}dK + \int_{F_0}^{\infty} \frac{C(T,K)}{K^2}dK\right)$$

where $P(T, K)$ and $C(T, K)$ denote put and call prices respectively. $\hat{\sigma}^2(T)$ is the model-free implied variance formulated in Britten-Jones and Neuberger (2000). Jiang and Tian (2007) study the size of the approximation error, $\hat{\sigma}^2(T)$-σ^2 (T), depending on the truncation error as determined by the maximum and minimum available K_i and the discretisation error determined by ΔK_i.

The modifications made to the original methodology are listed by volatility index:
1. VKOSPI. The information publically available on the web-site of Korea Exchange implies that a change from the CBOE methodology is in the calculation of K_0 which in this case is strike price closest to the current value of the KOSPI 200 index. Further to that, the options that are considered ineligible for the calculation of the index for reasons not explicitly stated, the Black-Scholes price is used instead. It remains, however, unclear what value for the volatility parameter is used in the Black-Scholes pricing formula. For more information, see the document on the web-site of the Korean Exchange at http://inc.krx.co.kr/attach/eng/sta/VKOSPI_GUIDE_ENG.pdf.

2. India VIX. There are two differences from the CBOE methodology. Firstly, the value F_0 is taken directly from the NIFTY futures market at the corresponding maturity instead of relying on the put-call parity relationship. Secondly, the the option prices $Q(T, K_i)$ are the average of the bid and ask prices only if the bid-ask spread does not is not greater than 30% of the mid-price. If the spread is bigger, the option prices are considered unreliable and an interpolation technique is adopted to infer the option price at that strike from the option prices at the adjacent strikes. The interpolation technique is based on cubic splines the motivation being that the option price viewed as a function of the strike is non-linear and, therefore, a non-linear interpolation method is more appropriate. For additional information, see the document on the web-site of the National Stock Exchange of India at: http://www.nseindia.com/content/vix/white_paper_IndiaVIX.pdf.

3. HSI Volatility Index. According to the methodology available on the web-site of Hang Seng indices, there are two differences from the CBOE methodology. Firstly, after computing the value F_0 according to the CBOE put-call parity relationship, the calls and puts are selected applying two criteria: (i) the strikes of the calls should be no bigger than 120% of F_0 and the strikes of the puts should be no smaller than 80% of F_0 and (ii) the bid prices should be strictly positive. The criterion in (i) may have significant consequences because, in times of market downturns, not only do the prices of options become higher due to the increased volatility, but so does the volatility of the risk-neutral distribution. Therefore, because of the explicit truncation of the extreme strikes, which may become liquid in market downturns, the HSI Volatility Index is expected to underestimate the option-implied volatility in market crashes. Secondly, the term

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$$\frac{1}{T}\left(\frac{F_0}{K_0}-1\right)^2$$

is omitted in the formula employed in HSI Volatility Index. Although the contribution of this term may be small, omitting it would result in a bias from the theoretical quantity.[18] For additional information, see the document on the web-site of Hang Seng Indices at http://www.hsi.com.hk/HSI-Net/static/revamp/contents/en/dl_centre/methodologies/IM_VHSIe.pdf

4. Nikkei 225 Volatility Index. The calculation method follows a discretisation of the quantity $\hat{\sigma}^2(T)$ rather than the formula adopted by CBOE. However, as mentioned above, $\tilde{\sigma}^2(T)$ converges to $\hat{\sigma}^2(T)$ which implies that this difference should not be a source of deviation from the CBOE methodology. It seems there are no other differences from the CBOE methodology. For additional details, see the document available on the web-site of Nikkei Indexes at:
http://indexes.nikkei.co.jp/nkave/archives/file/nikkei_stock_average_volatility_index_guidebook_en.pdf.

5. S&P/ASX 200 Volatility Index. The calculation method follows exactly the CBOE methodology. For additional information, see the information available on the web-site of Australian Securities Exchange at:
http://www.asxgroup.com.au/media/PDFs/20110215_SP-ASX_200_VIX_Derivatives_Consultation.pdf

6. AlphaShares China Volatility Index. No details about the methodology have been officially released by AlphaShares LLC. The information available on the web-site is a statement that the volatility index measures the implied volatility of options written on major China equity indices and can be found at: http://www.alphashares.com/indices.html#Volatility

18 - We assume that the omission is not a result of a typo in the document.

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Nbr of permanent staff	90
Nbr of research associates	20
Nbr of affiliate professors	28
Nbr of PhD in Finance candidates	72
Overall budget	€13,000,000
External financing	€7,550,000
Nbr of conference delegates	1,860
Nbr of participants at research seminars and executive education seminars	868

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Notes

Notes

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