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Research article

US Implied Volatility as A predictor of International Returns

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Abstract: This study provides evidence of the US implied volatility's effect on international equity markets' returns. This evidence has two main implications: i) investors may find that foreign equity returns adjusting to US implied volatility may not provide true diversification benefits, and ii) foreign equity returns may be predicted using US implied volatility. Our sample includes US volatility index (VIX) and major equity indexes in twenty countries for the period between January, 2000 through July, 2017. VIX leads eighteen of the international markets and Granger causes seventeen of the markets after controlling for the S&P-500 index returns and the 2007/2008 US financial crisis. US investors looking to diversify US risk may find that international equities may not provide intended diversification benefits. Our evidence provides support for predictability of international equity returns based on US volatility.

Keywords: diversification; implied volatility; VIX; forecasting

1. Introduction

Portfolio theory suggests that investors can lower their risk and increase their returns through diversification. Different security types (ex. bonds, commodities, real estate and etc.) as well as international equities are commonly used to diversify equity portfolios (Solnik and Noetzlin, 1982; Qrauer and Hakansson, 1987; Levy and Lerman, 1988; Eichholtz, 1996; Benartzi and Thaler, 2001).

Despite research evidence for the benefits of diversification, investors are reported to be rather reluctant to truly diversify their portfolios. For instance, French and Poterba (1991) show that investors in the US, Japan and the UK prefer to invest in their own domestic markets. More recently, Goetzmann and Kumar (2008) show that US investors are not too keen on diversification and often tend to own under-diversified portfolios. However, "...benefits from international diversification are so large that they should rapidly resuscitate the development in the U.S. of successful international mutual funds..." (Solnik, 1995).

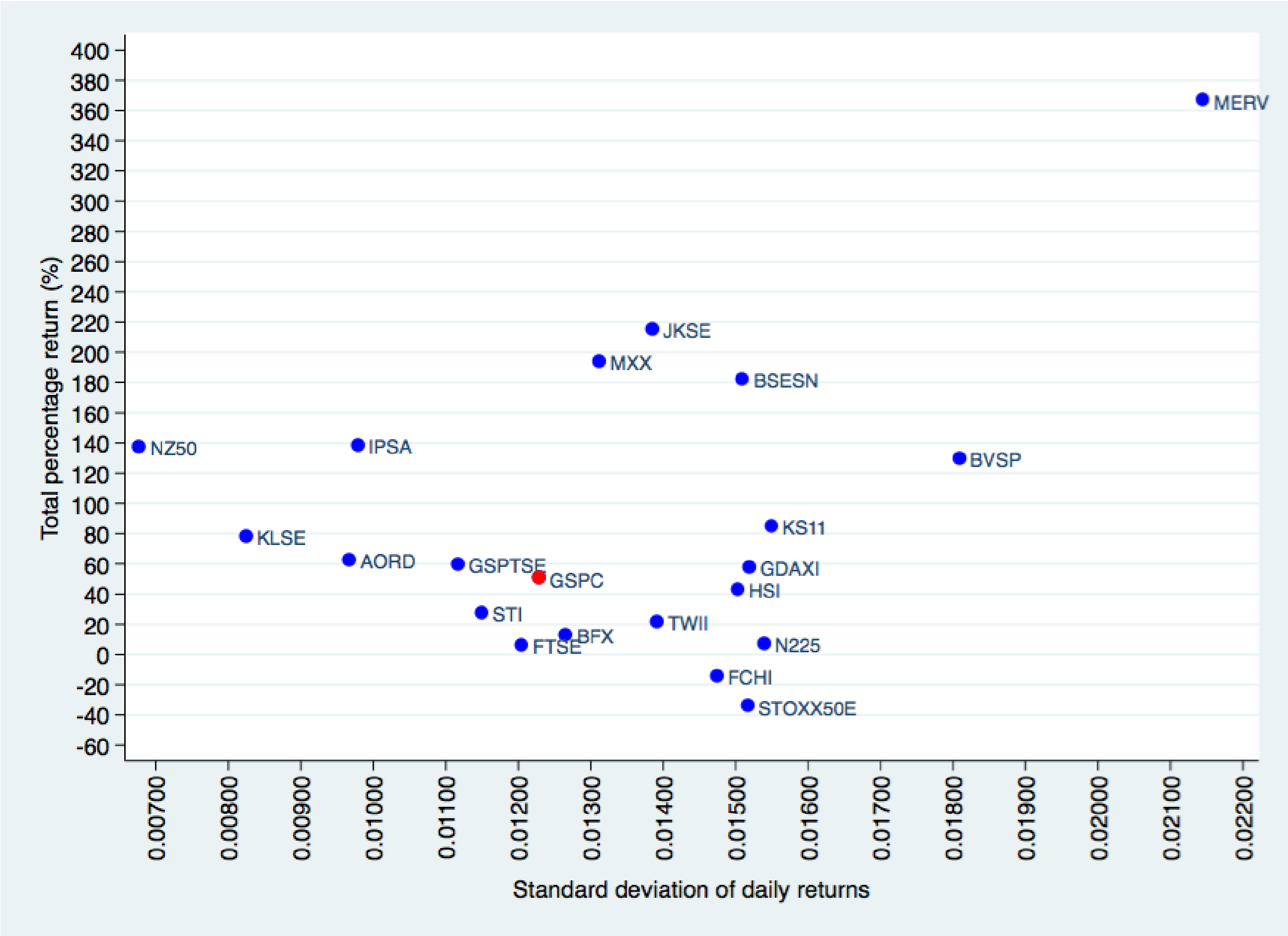

Figure 1. Risk and return chart for all indexes included in the study. Period begins with January, 2000 and ends on July, 2017. End of day closing values for indexes are obtained from Yahoo! Finance (via `http://finance.yahoo.com`) and confirmed by the data obtained from Google Finance (via `http://google.com/finance`). Index names and notations are used as provided by Yahoo! Finance. Daily (*d*) returns are calculated as log difference of daily closing values.

There are many international investment opportunities that would be appealing to investors. Comparisons of twenty international indexes along with the S&P-500 index are provided in Figure 1. It is evident that at least five of these indexes provide higher returns than S&P-500 at a lower risk. There are indexes that offer much higher returns at a slight increase in risk. Why then, investors under-diversify, especially internationally? According to Goetzmann and Kumar (2008), the reasoning could be related to over-confidence or investor bias for domestic investment choices.

We are not arguing that there is no international diversification. In fact, we note that there is a growing population of international mutual funds and ETFs as predicted by Solnik (1995). For instance, a US ETF, EEM (iShares MSCI Emerging Markets ETF),* has assets totaling about $32 billion. Similarly, another popular US ETF, EFA (iShares MSCI EAFE ETF),† has assets totaling

*More information is available via `https://finance.yahoo.com/quote/EEM?p=EEM`
†More information is available via `https://finance.yahoo.com/quote/EFA?p=EFA`

about \$76 billion. Many of the US corporations have international operations that provide US investors with international risk and return exposure (Agmon and Lessard, 1977; Choi, 1989; Nance et al., 1993).

We therefore question whether the reasoning behind under-diversification through international equities is because of the quick adjustments in international returns for US implied volatility. In other words, if international equity returns adjust to US risk quickly, then the investors may be perceiving these markets as highly integrated with the US and thus not offering potential diversification benefits. While in the long run, several of these markets prove to be valuable diversification alternatives, future looking investments may ignore past performances and focus on short-term market reactions.

Equity indexes from twenty countries are evaluated with this study for the period that begins with January, 2000 and ends on July, 2017. **US implied volatility leads seventeen of the twenty international index returns** with two trading days lag. Statistically significant coefficients for the lags of one and two trading days are all negative. **It is therefore evident that international equity returns adjust quickly to US implied volatility**.

Earnings yield (i.e. earnings to price, E/P, ratio) is an important measure of risk and return trade off (Basu, 1983; Rogers, 1988; Jaffe et al., 1989; Dicle, 2017). It is based on the idea that stocks, like bonds, provide returns to investors. The earnings per share (realized or expected) for a stock divided by the trading price of the stock results in a measure similar to the bond yield. Within the concept of earnings yield, as risk increases, stock price would be expected to decrease to adjust for risk. This is not a violation of the risk-return tradeoff theory. In fact, Dicle (2017) argues that investors, assuming rational behavior, try to maximize return for given level of risk. At the time of their investment, investors predict the future return and risk levels. Thus, ex-ante, the risk-return tradeoff would be intact. However, ex-post, the risk and return levels can be quite different than the predicted levels. During the investment period, the prices can adjust to changes in risk and they can deviate significantly from their predicted levels. Thus, the return response for increased risk would be negative. This is the response we report with international indexes' returns to US implied volatility. **Given this evidence, investors looking to diversify their US equity risk with international equities may find that US risk is adjusted in international equity returns**.

In addition to the diversification implication, the evidence also has implications for predictability of returns. Based on the earnings yield adjustments of returns to volatility, it may be possible to predict international equity returns using US implied volatilities.

Random walk theory posits that the security prices do not follow a predictable pattern (Fama, 1965b; Horne and Parker, 1967; Levy, 1967; Jensen and Benington, 1970; Malkiel, 1999). It would imply that neither historic returns or returns of other assets should be able to predict future returns. It would also mean that securities in other countries would have no predictive power. Similarly, market efficiency theory argues that security prices reflect all available information (Fama, 1965a; Malkiel and Fama, 1970; Fama, 1998). Thus, if there is any information that would help investors to predict future prices then, according to the market efficiency theory, it would already be priced. Accordingly, it would not be possible to predict future prices.

There is however extensive research into prediction of returns. For instance, evaluating mean reversion, Poterba and Summers (1988) find that "stock returns exhibit positive serial correlation over short periods and negative correlation over longer intervals". Further evidence of return predictability is offered by Fama and French (1988) analyzing return autocorrelations, by Fama and French (1988b) based on dividend yields, by Fama and French (1989b) based on economic conditions and business-cycles and by Campbell and Shiller (1988) using excess volatility. In fact, in his survey Cochrane (1999) notes that "Now we recognize that stock and bond returns have a substantial predictable component at long horizons". Lewellen (2004) provides evidence of return predictability using dividend yield as well as earnings yield. In a similar analyisis, Campbell and Yogo (2006) provide evidence of return predictability with variables such as earnings to price ratio (i.e. earnings yield), dividend to price ratio (i.e. dividend yield) and measures of interest rates. Our earnings yield discussion about returns adjusting to volatility draws directly from the findings of Lewellen (2004) and Campbell and Yogo (2006) that are based on yield variables. As yields would be expected to react to changes in risk so would the returns. Return reaction to risk is not solely based on risk to return trade-off but also based on earnings yield explanation for stocks. On a contrasting note however Hjalmarsson (2010) provide evidence against the predictive power of yield based variables (i.e. earnings yield). Their evidence is in favor of predictability using interest rate measures similar in part to the findings of Campbell and Yogo (2006).

There is also evidence that international returns can be predicted with US equity returns. For instance, Rapach et al. (2013) "...show that lagged U.S. returns predict returns in numerous non-U.S. industrialized countries substantially better than the countries' own economic variables...".[‡] There could be many reasons for the US markets to lead the markets in other countries and therefore to have predictive power over foreign equity returns. For instance, Rapach et al. (2013) "...posit that many investors focus more intently on the U.S. market...". They also recognize that the explanations that are based on risk could also be the reasons for the US markets' lead. Similarly, Morana and Beltratti (2008) find strong evidence for the correlations across equity markets in terms of returns as well as volatility. They also report that these comovements have a positive trend. These findings are in line with earlier evidence (Karolyi and Stulz, 1996; Ang and Bekaert, 1999; Ball and Torous, 2000). In fact, Ang and Bekaert (1999) report "high volatility-high correlation regime which tends to coincide with a bear market". Similarly, Ball and Torous (2000) report dynamically changing correlation structures.

Evidence of the relationship between international return correlations and volatility is provided by Solnik et al. (1996) among others. In fact, they conclude that benefits of international diversification are reduced because of the increased correlations across countries. Ramchand and Susmel (1998) confirm these findings and report increased correlations between the US markets and other international markets during the times of high volatility.

It is therefore well established that several yield based variables can predict returns. It is also established that there is high correlation between international equity returns and in fact these correlations are higher during the times of high volatility. Based on these correlations, US equity returns predict international equity returns and this predictability would be expected to be higher with higher volatility. We argue that the foreign equity markets' returns respond not only to the contemporaneous US returns but also to the US implied volatility. In effect, this is to argue that US implied volatility can predict international equity returns.

Supporting evidence, in part, to our argument is provided by Sarwar (2012a) in terms of US

[‡]A detailed summary of the literature on prediction of returns for the US markets as well as for the international markets is provided by Rapach et al. (2013a, b).

implied volatilities and US market returns. He reports contemporaneous (not predictive) and negative correlations between the volatility and returns. The negative coefficients are further evidence of the earnings yield argument. Sarwar (2012b) extends these findings to evaluate US implied volatility and returns for equities in Brazil, Russia, India, and China (BRIC). Similarly he reports negative contemporaneous correlations for BRIC countries. Furthermore, he confirms the earlier findings by Ramchand and Susmel (1998) that volatility-return relationship is stronger during times of high volatility. Evaluation of the US volatility (VIX) vs. international equity returns is extended to several European markets by Sarwar (2014). Previously reported negative contemporaneous relationship is further confirmed for the European countries. In support of our argument that international equity returns adjust to US volatility, Sarwar (2014) finds that VIX can predict equity returns in the analyzed European counties. However, this predictive ability is limited to the financial crisis periods. Interestingly, the coefficients for the leads and lags provided in Sarwar (2014) (Table 3) have mixed signs. Any proof for our argument would require all negative coefficients for all countries. We also note that since it is well established in the literature that US returns predict foreign equity returns, controlling for US market returns within these estimations would provide more robust results for the predictive power of the VIX. More recent study Sarwar and Khan (2017) extend a similar analysis to emerging markets and report similar results.

Our contribution to the related literature is unique for multiple reasons: i) we analyze lead and lag relationships as well as causality, ii) list of countries analyzed is the most extensive in the related literature, iii) sample period includes the 2007/2008 US financial crisis which is controlled using a binary variable, iv) empirical analysis recognizes the predictive power of the S&P-500 which is controlled in all estimations, and finally, v) empirical analysis recognizes the robustness of GARCH(1,1) model for the lead-lag relationship even in the case of implied volatilities. We also believe that in light of the evidence for the predictive power of S&P-500, any analysis of predictive power for any other variable would fall short of robustness. In fact, a general market model for estimating market correlations would require S&P-500 as the market portfolio.

Our evidence is also unique because: i) the results point to overwhelming return reaction to US implied volatility, ii) estimated coefficients between implied volatility and returns are consistently negative, and iii) there is consistent and almost uniform Granger causality from US implied volatility towards international returns.

This evidence is important for investors who are looking to diversify US volatility as they create doubt for the importance of international equity markets as a diversification vehicle. It also provides strong support for predictability of returns as well as for the earnings yield arguments.

2. Data

Following the common practice of using publicly available (for all investors and academics) data (Christensen and Prabhala, 1998; Aggarwal et al., 1999) in the volatility literature, we also obtain our data from public sources. Data include twenty international equity indexes ($Index_d$), the implied volatility index (VIX_d) for the S&P-500 index and the S&P-500 index itself ($SP500_d$). Frequency of the data is daily (d) for all variables. The time span begins with January 2000 except for Chile (2002) and New Zealand (2003). Ending period is July, 2017. End of day closing values for the indexes are obtained from Yahoo! Finance[§] (YF) and confirmed by the data obtained from Google Finance.[¶] Index names and symbols are used as provided by YF. End of day closing values for the implied volatility index (VIX) are obtained from Chicago Board Options Exchange (CBOE).[‖]

Daily returns are calculated as log difference of daily closing values and denoted with Δ. A binary variable, $Crisis_d$ is created to control for the 2007/2008 US financial crisis. This variable is assigned a value of one for the period January 1^{st}, 2007 through March 9^{th}, 2009 and zero otherwise. Since the financial crisis began on February 28^{th}, 2007[**], our crisis binary variable begins with the calendar year of 2007. Also, since the financial crisis began to fade on December 19^{th}, 2008[††], our crisis variable extends a few more months to mark the lowest point S&P-500 index has seen after the financial crisis began.

Descriptive statistics for the variables are provided in Table 1. Based on the augmented Dickey-Fuller (Dickey and Fuller, 1979; Fuller, 2009) unit root tests, all variables are stationary at their log difference returns.

3. Econometric Models and Empirical Results

The lead-lag relationship between the VIX and the international markets' returns is evaluated using a Granger non-causality model (Granger, 1969). Just as causality is important to establish for the US volatility effect (i.e. the Wald test results), the sign of the effect is also important. A positive coefficient would mean flight from US volatility towards international markets. A negative coefficient would mean international returns adjusting for US expected risk (i.e. earnings yield). Thus, we estimate the lead-lag coefficients using a GARCH model (Engle, 1982; Bollerslev,1986) and then estimate the Granger model for the causal relationships. For the GARCH model, both GARCH and ARCH terms are used as one (i.e. GARCH (1,1)) following Hansen and Lunde (2005) and estimated as follows:

$$\begin{aligned} \Delta Index_d &= \beta_0 + \beta_1 \Delta Index_{d-1} + \beta_2 \Delta Index_{d-2} + \beta_3 \Delta VIX_{d-1} + \beta_4 \Delta VIX_{d-2} \\ &\quad + \beta_5 \Delta SP500_d + \beta_6 Crisis_d + \epsilon_d \\ \sigma_d^2 &= \alpha_0 + \alpha_1 \epsilon_{d-1}^2 + \alpha_2 \sigma_{d-1}^2 \text{ where } \epsilon_d | \delta_{d-1} \sim N(0, \sigma_d^2) \end{aligned} \tag{1}$$

Equation 1 is estimated for each of the twenty international equity indexes. $\Delta Index$ is assigned a different index for each of the estimations. Table 2 provides the results for the estimation of the Equation 1 for each of the twenty indexes.

The autoregressive components for index returns ($\Delta Index_{d-1}$) for almost all of the indexes are statistically significant at 5% or better. The sign however is not as uniform. While seven of the indexes have positive autoregressive coefficients, ten have negative coefficients.

The effect of contemporaneous S&P-500 index returns ($\Delta SP500_d$) is statistically significant at 1% and positive for all of the indexes tested. These results suggest the importance of the US markets' returns over the international markets' returns. Countries such as Brazil, Argentina and Germany have the highest coefficients with the S&P-500 index. On the other hand, Malaysia, Indonesia and

[§]Available via `http://finance.yahoo.com`
[¶]Available via `http://google.com/finance`
[‖]Available via `http://cboe.com`
[**]"Freddie Mac Tightens Standards" available on `http://www.nytimes.com/2007/02/28/business/28mortgage.html`
[††]"Bush announces auto rescue" available on `http://money.cnn.com/2008/12/19/news/companies/auto_crisis/`

Taiwan have the lowest coefficients. The statistical significance of the S&P-500 index returns prove that omission of this variable in econometric models of implied volatility would clearly lead to omitted variable bias.

Interestingly, the results for the binary variable for the the 2007/2008 US financial crisis (*Crisis*) are quite insignificant. We posit that the lack of statistical significance for the US financial crisis binary variable is due to having S&P-500 index as a control variable. The impact of the 2007/2008 crisis on international equity returns is captured by the market model that includes the daily US market returns.

In terms of the US volatility index (ΔVIX), eighteen of the twenty indexes are statistically significant at 5% or better for the one day lag (ΔVIX_{d-1}). All significant coefficients are negative which implies return adjustment (earnings yield) by international equities for US implied volatility. Similarly for two days lag (ΔVIX_{d-1}), eleven of the twenty indexes are statistically significant at 1% level and negative.

Now that we established the lead-lag coefficients between US implied volatilities and international equity returns, we turn our attention to causality. The Granger non-causality model is estimated as follows:

$$\Delta VIX_d = \gamma_0 + \gamma_1 \Delta VIX_{d-1} + \gamma_2 \Delta VIX_{d-2} + \gamma_3 \Delta Index_{d-1} + \gamma_4 \Delta Index_{d-2} + \gamma_5 \Delta SP500_d + \gamma_6 Crisis_d + \epsilon_{1d} \tag{2}$$

$$\Delta Index_d = \omega_0 + \omega_1 \Delta Index_{d-1} + \omega_2 \Delta Index_{d-2} + \omega_3 \Delta VIX_{d-1} + \omega_4 \Delta VIX_{d-2} + \omega_5 \Delta SP500_d + \omega_6 Crisis_d + \epsilon_{2d} \tag{3}$$

Similar to the Equation 1, Equations 2 and 3 are estimated with trading day lags of two. Also, effect of the S&P-500 index returns on international equity returns is controlled with the contemporaneous $SP500_d$ returns. Even though the estimation results for Equation 1 did not provide any evidence of importance for the US financial crisis of 2007/2008, we still control for the crisis using the *Crisis* binary variable. Equations 2 and 3 are estimated as a system using seemingly unrelated regressions.(Zellner, 1962; Geweke, 1982) Causality of US implied volatilities and international equity returns are tested with Wald test (Engle, 1984) as follows:

$$\Delta Index_d \rightarrow \Delta VIX_d : \gamma_3 = \gamma_4 = 0 \tag{4}$$

$$\Delta VIX_d \rightarrow \Delta Index_d : \omega_3 = \omega_4 = 0 \tag{5}$$

The results for Equations 4 and 5 are provided in the Table 3. We find that seventeen of the twenty indexes have a statistically significant (at 5% or better) causal relationship from US implied volatility to international equity markets' returns. This important evidence, coupled with the evidence from Garch (1,1) Equation 1, imply that **international equity markets' returns adjust to US implied volatility with a very short lag**. The responsiveness of these markets to US expected risk shows how integrated these international markets are to the US financial markets. Investors who seek to diversify US risk may not able able to find shelter with international equity markets as they seem to adjust to US risk fairly quickly.

Table 1. Descriptive statistics for the international indexes included in the study. End of day closing values for indexes are obtained from Yahoo! Finance (via `http://finance.yahoo.com`) and confirmed by the data obtained from Google Finance (via `http://google.com/finance`). Index names and notations are used as provided by Yahoo! Finance. Daily (d) returns are calculated as log difference of daily closing values and denoted with Δ. DF-z refers to Augmented Dickey-Fuller unit root test. *, ** and * refer to statistical significance at the 10%, 5% and 1% respectively.**

Country	Index	Notation	First	Mean	Min.	Max.	Stdev.	DF-z	
Argentina	MERVAL	$\Delta MERV_d$	01/03/2000	0.0008	-0.1295	0.1612	0.0215	-61.7973	***
Australia	All ordinaries	$\Delta AORD_d$	01/03/2000	0.0001	-0.0855	0.0536	0.0096	-63.7009	***
Belgium	BEL 20	ΔBFX_d	01/03/2000	0.0001	-0.0832	0.0933	0.0126	-62.3348	***
Brazil	IBOVESPA	$\Delta BVSP_d$	01/03/2000	0.0004	-0.1210	0.1368	0.0181	-64.4290	***
Canada	S&P/TSX composite index	$\Delta GSPTSE_d$	01/03/2000	0.0001	-0.0979	0.0937	0.0112	-66.6040	***
Chile	IPSA	$\Delta IPSA_d$	01/03/2002	0.0004	-0.0724	0.1180	0.0098	-51.7155	***
France	CAC 40	$\Delta FCHI_d$	01/03/2000	-0.0000	-0.0947	0.1059	0.0147	-68.4651	***
Germany	DAX	$\Delta GDAXI_d$	01/03/2000	0.0001	-0.0734	0.1080	0.0151	-67.2659	***
Hong Kong	Hang Seng index	ΔHSI_d	01/03/2000	0.0001	-0.1358	0.1341	0.0150	-66.0974	***
India	S&P BSE SENSEX	$\Delta BSESN_d$	01/03/2000	0.0004	-0.1181	0.1599	0.0151	-60.8319	***
Indonesia	Jakarta composite index	$\Delta JKSE_d$	01/05/2000	0.0005	-0.1131	0.0762	0.0139	-57.6583	***
Japan	Nikkei 225	$\Delta N225_d$	01/05/2000	-0.0000	-0.1211	0.1323	0.0154	-66.8286	***
Malaysia	FTSE Bursa Malaysia	$\Delta KLSE_d$	01/03/2000	0.0002	-0.0998	0.0450	0.0082	-56.3397	***
Mexico	IPC	ΔMXX_d	01/03/2000	0.0004	-0.0827	0.1044	0.0132	-59.2160	***
New Zealand	S&P/NZX 50 index gross	$\Delta NZ50_d$	01/06/2003	0.0003	-0.0494	0.0581	0.0068	-52.7519	***
Singapore	STI Index	ΔSTI_d	01/03/2000	0.0001	-0.0909	0.0753	0.0115	-63.9297	***
South Korea	KOSPI composite Index	$\Delta KS11_d$	01/05/2000	0.0002	-0.1237	0.1128	0.0154	-63.6613	***
Switzerland	ESTX50 EUR	$\Delta STOXX50E_d$	01/03/2000	-0.0001	-0.0901	0.1044	0.0151	-67.0996	***
Taiwan	TSEC weighted index	$\Delta TWII_d$	01/05/2000	0.0000	-0.0994	0.0652	0.0139	-62.1012	***
United Kingdom	FTSE 100	$\Delta FTSE_d$	01/05/2000	0.0000	-0.0926	0.0938	0.0120	-68.4001	***
United States	S&P-500	$\Delta SP500_d$	01/05/2000	0.0001	-0.0947	0.1096	0.0123	-71.0393	***
United States	VIX	ΔVIX_d	01/05/2000	-0.0006	-0.3506	0.4960	0.0666	-71.3406	***

Table 2. GARCH(1,1) estimation results for the US implied volatility and international markets' returns. Estimated model is as follows: $\Delta Index_d = \beta_0 + \beta_1 \Delta Index_{d-1} + \beta_2 \Delta Index_{d-2} + \beta_3 \Delta VIX_{d-1} + \beta_4 \Delta VIX_{d-2} + \beta_5 \Delta SP500_d + \beta_6 Crisis_d + \epsilon_d$ and $\sigma_d^2 = \alpha_0 + \alpha_1 \epsilon_{d-1}^2 + \alpha_2 \sigma_{d-1}^2$ where $\epsilon_d | \delta_{d-1} \sim N(0, \sigma_d^2)$. End of day closing values for indexes are obtained from Yahoo! Finance (via `http://finance.yahoo.com`) and confirmed by the data obtained from Google Finance (via `http://google.com/finance`). Index names and notations are used as provided by Yahoo! Finance. Daily (d) returns are calculated as log difference of daily closing values and denoted with Δ. *, ** and * refer to statistical significance at the 10%, 5% and 1% respectively.**

Country	Index	$\Delta Index_{d-1}$	$\Delta Index_{d-2}$	ΔVIX_{d-1}	ΔVIX_{d-2}	$\Delta SP500_d$	Crisis	Constant	χ^2	N
Argentina	$\Delta MERV_d$	0.0733 ***	0.0089	-0.0046	-0.0008	0.8775 ***	-0.0007	0.0008 ***	2,339.38	4,164
Australia	$\Delta AORD_d$	-0.1054 ***	0.0206	-0.0370 ***	-0.0098 ***	0.2415 ***	0.0002	0.0003 ***	1,416.64	3,893
Belgium	ΔBFX_d	-0.0565 ***	-0.0189	-0.0328 ***	-0.0035 *	0.5198 ***	-0.0009 **	0.0004 ***	3,027.19	4,346
Brazil	$\Delta BVSP_d$	-0.0029	-0.0041	-0.0086 ***	0.0045	0.9166 ***	0.0010 *	0.0001	3,368.37	4,214
Canada	$\Delta GSPTSE_d$	0.0163	-0.0165	-0.0097 ***	-0.0013	0.6097 ***	0.0002	0.0001	6,479.54	4,335
Chile	$\Delta IPSA_d$	0.1711 ***	-0.0445 ***	-0.0068 ***	-0.0008	0.3584 ***	0.0003	0.0004 ***	1,733.03	3,758
France	$\Delta FCHI_d$	-0.1342 ***	-0.0486 ***	-0.0414 ***	-0.0092 ***	0.7145 ***	-0.0003	0.0002	4,112.15	4,348
Germany	$\Delta GDAXI_d$	-0.0983 ***	-0.0369 ***	-0.0392 ***	-0.0111 ***	0.7413 ***	0.0001	0.0003 *	4,091.56	4,328
Hong Kong	ΔHSI_d	-0.0521 ***	0.0006	-0.0605 ***	-0.0131 ***	0.2014 ***	0.0004	0.0002	1,003.37	4,198
India	$\Delta BSESN_d$	0.0406 **	-0.0113	-0.0320 ***	-0.0072 ***	0.2432 ***	0.0001	0.0006 ***	793.32	4,195
Indonesia	$\Delta JKSE_d$	0.0798 ***	-0.0171	-0.0377 ***	0.0045 *	0.0967 ***	-0.0003	0.0008 ***	478.03	4,107
Japan	$\Delta N225_d$	-0.0895 ***	0.0273 *	-0.0739 ***	-0.0183 ***	0.1624 ***	-0.0006	0.0003 *	996.37	4,143
Malaysia	$\Delta KLSE_d$	0.1176 ***	0.0164	-0.0238 ***	-0.0021 *	0.0483 ***	0.0004	0.0002 ***	602.95	4,172
Mexico	ΔMXX_d	0.0797 ***	-0.0302 **	-0.0048 **	0.0008	0.6753 ***	-0.0003	0.0004 ***	5,139.27	4,265
New Zealand	$\Delta NZ50_d$	0.0519 ***	0.0264	-0.0013	0.0000	0.2828 ***	-0.0006 **	0.0004 ***	1,246.25	2,801
Singapore	ΔSTI_d	-0.0333 **	0.0044	-0.0373 ***	-0.0063 ***	0.1815 ***	-0.0001	0.0002 *	894.90	4,269
South Korea	$\Delta KS11_d$	-0.0465 ***	-0.0118	-0.0453 ***	-0.0112 ***	0.1914 ***	0.0003	0.0004 **	843.35	4,180
Switzerland	$\Delta STOXX50E_d$	-0.1285 ***	-0.0448 ***	-0.0425 ***	-0.0103 ***	0.7325 ***	-0.0003	0.0001	3,765.37	4,224
Taiwan	$\Delta TWII_d$	0.0020	0.0144	-0.0434 ***	-0.0074 ***	0.1639 ***	-0.0002	0.0003 *	857.67	4,164
United Kingdom	$\Delta FTSE_d$	-0.1329 ***	-0.0530 ***	-0.0357 ***	-0.0084 ***	0.5435 ***	-0.0003	0.0001	3,834.85	4,318

Table 3. Granger type causality estimation results for US implied volatility and international markets' returns. Estimated model is as follows: $\Delta VIX_d = \gamma_0 + \gamma_1 \Delta VIX_{d-1} + \gamma_2 \Delta VIX_{d-2} + \gamma_3 \Delta Index_{d-1} + \gamma_4 \Delta Index_{d-2} + \gamma_5 \Delta SP500_d + \gamma_6 Crisis_d + \epsilon_{1d}$ and $\Delta Index_d = \omega_0 + \omega_1 \Delta Index_{d-1} + \omega_2 \Delta Index_{d-2} + \omega_3 \Delta VIX_{d-1} + \omega_4 \Delta VIX_{d-2} + \omega_5 \Delta SP500_d + \omega_6 Crisis_d + \epsilon_{2d}$. Wald tests are as follows: $\Delta Index_d \rightarrow \Delta VIX_d : \gamma_3 = \gamma_4 = 0$ and $\Delta VIX_d \rightarrow \Delta Index_d : \omega_3 = \omega_4 = 0$. End of day closing values for indexes are obtained from Yahoo! Finance (via `http://finance.yahoo.com`) and confirmed by the data obtained from Google Finance (via `http://google.com/finance`). Index names and notations are used as provided by Yahoo! Finance. Daily (d) returns are calculated as log difference of daily closing values and denoted with Δ. *, ** and * refer to statistical significance at the 10%, 5% and 1% respectively.**

Country	Index (y)	VIX (x)	$F_{y \rightarrow x}$		$F_{x \rightarrow y}$	
Argentina	$\Delta MERV_d$	ΔVIX_d	1.6352		3.1867	
Australia	$\Delta AORD_d$	ΔVIX_d	3.2358		433.9916	***
Belgium	ΔBFX_d	ΔVIX_d	4.1014		241.9900	***
Brazil	$\Delta BVSP_d$	ΔVIX_d	6.1516	**	7.0556	**
Canada	$\Delta GSPTSE_d$	ΔVIX_d	27.0668	***	34.9830	***
Chile	$\Delta IPSA_d$	ΔVIX_d	2.3663		17.4938	***
France	$\Delta FCHI_d$	ΔVIX_d	5.6285	*	348.7822	***
Germany	$\Delta GDAXI_d$	ΔVIX_d	4.2677		264.5841	***
Hong Kong	ΔHSI_d	ΔVIX_d	0.1643		580.2403	***
India	$\Delta BSESN_d$	ΔVIX_d	6.0031	**	165.6883	***
Indonesia	$\Delta JKSE_d$	ΔVIX_d	1.0822		235.3652	***
Japan	$\Delta N225_d$	ΔVIX_d	5.9154	*	667.4963	***
Malaysia	$\Delta KLSE_d$	ΔVIX_d	0.2587		293.2344	***
Mexico	ΔMXX_d	ΔVIX_d	8.3291	**	4.1649	
New Zealand	$\Delta NZ50_d$	ΔVIX_d	0.7931		1.6962	
Singapore	ΔSTI_d	ΔVIX_d	1.8026		407.6022	***
South Korea	$\Delta KS11_d$	ΔVIX_d	0.6222		386.3308	***
Switzerland	$\Delta STOXX50E_d$	ΔVIX_d	10.4257	***	312.5596	***
Taiwan	$\Delta TWII_d$	ΔVIX_d	3.3380		330.6689	***
United Kingdom	$\Delta FTSE_d$	ΔVIX_d	9.1058	**	411.4937	***

4. Economic Significance

In terms of the application of financial research it is imperative that our findings are economically significant as well as statistically significant. Our final empirical analysis tests the economic significance of US implied volatility as a predictor of international returns. We employ a simple trading strategy[‡‡] based on our econometric results to test for economic significance.

The trading rule has a buy signal when the US implied volatility (VIX) falls more than 2.5%. As

[‡‡]The strategy provided here is for educational and informational purposes only. It is not financial advice and should not be employed for any purpose other than education and further research. We disclaim any and all liability.

Table 4. Results for the t-test of equality ($x - y \neq 0$) between the trading rule (x) and the buy-hold strategy (y). If US implied volatility (VIX) is down for more than 2.5% (log difference return) for a day then the foreign index is bought for the following day. Each position is kept for a single day. Each position's return is calculated as daily log difference return. Annual returns are the totals of all positions' returns for each year. t-test compares the annual total trading rule returns to annual total buy-hold strategy returns. μ refers to average annual returns, σ refers to the standard deviation of annual returns and N refers to the number of years included in the sample. End of day closing values for indexes are obtained from Yahoo! Finance (via `http://finance.yahoo.com`) and confirmed by the data obtained from Google Finance (via `http://google.com/finance`). Index names and notations are used as provided by Yahoo! Finance. *, ** and * refer to statistical significance at the 10%, 5% and 1% respectively.**

		Trading rule (x)			Buy-hold strategy (y)						
Country	Index	μ	σ	N	μ	σ	N	t	$x - y < 0$	$x - y \neq 0$	$x - y > 0$
Argentina	MERV	0.1465	0.1567	18	0.1822	0.3779	18	-0.4047			
Australia	AORD	0.2102	0.0948	18	0.0267	0.1908	18	4.6212		***	***
Belgium	BFX	0.1870	0.0941	18	0.0136	0.2417	18	2.6013		**	***
Brazil	BVSP	0.0862	0.1585	18	0.0829	0.2905	18	0.0673			
Canada	GSPTSE	0.0961	0.0860	18	0.0280	0.1585	18	1.9022		*	**
Chile	IPSA	0.1295	0.0908	16	0.0887	0.1987	16	0.8932			
France	FCHI	0.2241	0.1225	18	-0.0054	0.1922	18	3.4418		***	***
Germany	GDAXI	0.1865	0.1106	18	0.0260	0.2331	18	2.6856		**	***
Hong Kong	HSI	0.4084	0.2095	18	0.0244	0.2381	18	5.0133		***	***
India	BSESN	0.2387	0.1683	18	0.0920	0.3139	18	1.8288		*	**
Indonesia	JKSE	0.2613	0.2044	18	0.1107	0.3196	18	1.9475		*	**
Japan	N225	0.4337	0.1985	18	-0.0033	0.2304	18	5.5651		***	***
Malaysia	KLSE	0.1768	0.1060	18	0.0436	0.1839	18	2.9748		***	***
Mexico	MXX	0.1255	0.1370	18	0.1033	0.1916	18	0.5793			
New Zealand	NZ50	0.0226	0.0723	15	0.0585	0.1510	15	-1.2657			
Singapore	STI	0.2614	0.1461	18	0.0218	0.2374	18	3.9074		***	***
South Korea	KS11	0.3682	0.1865	18	0.0429	0.2805	18	3.9891		***	***
Switzerland	STOXX50E	0.2082	0.1125	18	-0.0163	0.1999	18	3.4946		***	***
Taiwan	TWII	0.2725	0.1649	18	0.0027	0.2910	18	3.9516		***	***
United Kingdom	FTSE	0.2011	0.1150	18	0.0029	0.1445	18	3.6737		***	***

risk goes down, we would expect the yield on the indexes to go down as well. For yield on the index to go down, we would need the stock price to go up. Thus, a drop in the VIX would be expected to produce positive returns. The trading rule is implemented on a daily basis for each of the 18 years included in our study. Trading rule returns are summed into annual returns. To compare the trading rule returns for economic significance, we also calculate the total annual returns for each year as a buy-hold strategy.

Table 4 provides the t-test results comparing total annual returns for the trading rule and for the buy-hold strategy. All of the indexes, except for Argentina, Brazil, Chile, Mexico and New Zealand, show significantly higher returns for the trading rule compared to the buy-hold strategy returns. We note that among the indexes that do not have significantly higher returns, only the returns for Argentina and for New Zealand are actually lower compared to the returns for the buy-hold strategy. For indexes such as Hong-Kong and Japan, average annual returns for the trading strategy are above 40%. These economically significant results are in support of our previous econometric evidence.

5. Concluding Remarks

Is it possible to predict returns? This study provides evidence that, in the case of equity returns in twenty countries, US implied volatility has predictive power. There are two main implications for this finding: i) international equities may not offer much of a diversification benefit for US volatility, ii) returns may be predictable using volatility. We argue that the channel in which returns react to volatility is based on the earnings yield argument. If the earnings yield for stocks is treated similar to bond yields then it would be natural to expect bond like reaction to higher risk for stocks. As risk increases, higher yields would compensate investors for the higher risk. This happens through lower bond prices. Based on the earnings yield argument then higher risk would lead to higher yield which is provided immediately through lower stock prices. Expected result would be negative correlations between risk and returns. This is the evidence we report for US implied volatility and non-US equity market returns.

We believe that the stocks behave similar to bonds reacting to risk. It would be interesting for future research to see if bond price reactions coincide with stock price reactions. It would also be interesting to see which maturity structure of bonds would closely mimic the reactions of the stocks. This would extend our understanding of investment horizon for stocks.

Conflict of Interest

All authors declare no conflicts of interest in this paper.

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