Risk-On / Risk-Off: Financial market response to investor fear

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Abstract:

This article examines the relationship between changes in the level of investor fear (measured by VIX) and financial market returns. We document a statistically significant relationship, across asset classes, consistent with a flight to quality as investor fear increases. As VIX increase there is a decline in stock markets, bond yields, and high-yielding currencies (AUD and NZD), while the USD appreciates. Returns become more sensitive to changes in the level of investor fear during the financial crisis of 2008-09, when investor fear spikes sharply. Analysis of market returns subsequent to periods of extreme levels of investor fear suggests some predictive ability for future returns, and it is suggested that this may be used to develop a profitable trading strategy. Taken together, the results confirm that financial market returns are closely related to prevailing levels of investor fear.

Keywords: VIX, Investor Fear, Financial Markets, Financial Crisis

1. Introduction

"Risk-On" and "Risk-Off" are terms commonly used by market commentators, and the media, in an effort to explain price movements in financial markets[1]. Essentially, the commentary attributes market fluctuations to changes in the level of investor risk aversion. We empirically test such assertions using implied volatility indices as a proxy for risk aversion.

Volatility indices, such as the VIX and A-VIX [2], are calculated using options traded on the largest and most liquid stock market indices in their respective countries, and express a consensus view about expected future stock market volatility. Since portfolio insurers tend to be the largest constituents in the underlying option market it is likely that put buyers drive changes in implied volatility. Demand for put options increases, driving VIX higher, when risk aversion is higher, and it is this relationship that provides VIX with its colloquial reference as the "fear gauge" (Whaley, 2000).

The prior literature has considered the relationship between VIX and stock market returns. Fleming et al. (1995), Whaley (2000), Giot (2005) and Fernandes et al. (2014) report a

[1] For instance: "Bernanke's 'Risk-On, Risk-Off' Monetary Policy" (Wall Street Journal, 18/01/12) and "Shades of grey still colour equity trading" (Financial Times, 05/03/15).

[2] The Chicago Board of Exchange implied volatility index (VIX) and Australian Securities Exchange implied volatility index (A-VIX).

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large negative contemporaneous relationship between implied volatility and stock market returns. Whaley (2009) demonstrates that this relationship is asymmetric as the VIX increases by a larger proportion when the stock market falls than it decreases when stocks rise. The leverage effect of Black (1976) can explain this result: Given a fixed level of debt, a firm will become more leveraged as its stock price declines, and this induces higher volatility in equity returns. However, Hasanhodzic and Lo (2011) suggest that the effect is stronger than can be explained by leverage alone, and so investor risk perception should also be considered. Brunnermeier et al. (2008) and Bekaert et al. (2013) utilize VIX as a proxy for the level of investor risk aversion.

There appears to be a link between investor fear in the US and global stock markets. Corredor et al. (2013) show that this sentiment measure has a significant influence on returns across markets, while Tsai (2014) reports that information transmission between stock markets in developed countries is highly correlated with VIX. Lim et al. (2014) note that stock market returns are increasingly sensitive to changes in VIX during the financial crisis of 2008-09. One explanation for this is offered by Smales (2014) who finds that investor fear is negatively related to the sentiment of newswire messages. When there is a greater prevalence of negative news, as occurred during the financial crisis, then investor fear increases and stock returns fall further.

Understanding the relationship between investor sentiment and non-equity markets has received relatively little attention in the literature. There is some evidence that the volatility of the exchange rate may be explained by stock market volatility of the two countries concerned (Zapatero, 2011), and also that global stock returns and exchange rates are strongly linked (Katechos, 2011). Smales and Kininmonth (2016) suggest that this relationship differs according to the level of interest rate differential and perceived safe-haven status. With regards interest rates, Bekaert et al. (2013) describe a strong positive correlation between VIX and real interest rates that is linked to the monetary policy stance.

This article expands our understanding on the relationship between investor fear and financial market returns. In doing so, we are the first to consider how investor fear is linked across different asset classes, and also across different countries. The empirical study seeks to answer two related questions: First, are financial market returns related to changes in the level of investor fear (VIX)? Second, is this relationship impacted by financial crisis, and in what way? The answer to such questions is important for investors across asset classes and has implications for trading and optimal asset allocation.

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The key findings may be summarized as follows. Using VIX as a proxy for the level of investor fear, we find a statistically significant link between investor fear and returns in the stock, bond, and currency markets. The results are consistent with a flight to quality as investor fear increases. As VIX increases there is a decline in stock markets, bond yields, and high-yielding currencies (AUD and NZD), while the USD appreciates. A dynamic model confirms the results in a VAR setting. During the financial crisis of 2008-09, when investor fear spikes sharply, returns become more sensitive to changes in the level of investor fear. Analysis of market returns subsequent to periods of extreme levels of investor fear suggests some predictive ability for future returns. Taken together, the results confirm that financial market returns are closely related to prevailing levels of investor sentiment.

The remainder of this paper is organised as follows: Section 2 outlines the data used in this paper and section 3 discusses our empirical results. Section 4 considers whether VIX is able to forecast financial market returns and section 5 concludes the paper.

2. Data

We investigate the relationship between the fear gauge and returns in stock markets, government bond markets, and foreign exchange markets at the daily level.

Implied Volatility Index (VIX)

The Chicago Board Options Exchange (CBOE) implied volatility index (VIX) estimates the level of implied volatility in S&P 500 index (SPX) options. VIX is computed on a real-time basis by averaging the weighted prices of SPX puts and calls over a wide range of strike prices, and represents expected market volatility over the next 30 calendar days. The VIX is quoted in percentage points and translates, approximately, to the expected movement in the S&P 500 Index over the next 30-day period, which is then annualized. For example, if VIX is 20, this represents an expected annualized change of 20% over the next 30 days; thus one can infer that the options market expects the S&P 500 index to move up / down by 5.77% (20%/√12) over the next 30-day period. Portfolio insurers, who routinely buy index puts, are the largest constituents of the S&P 500 Index option market. Hence, it is likely that it is put buyers who help to drive changes in implied volatility (VIX). More (fewer) put options are bought when investors have higher (lower) levels of risk aversion – so implied volatility (VIX) will increase when fear increases. By interpreting VIX in this way, we are able to use it as a proxy for market sentiment.

In January 2008, the Australian Securities Exchange introduced a similar gauge to measure market sentiment in Australia. Denoted as A-VIX, this real-time volatility index is calculated using the level of implied volatility on S&P/ASX 200 Index options.

Daily settlement prices for VIX and A-VIX are obtained from DataStream for the sample period from 02 January 2001to 30 June 2015. Table 1 provides descriptive statistics for VIX; the mean level over the whole sample period is 20.58, with a peak of 80.86 occurring in October 2008 (the peak of the financial crisis), and a low of 9.89 in January 2007. The average daily percentage change in VIX is 0.014. A-VIX appears to have similar characteristics, with a slightly higher mean of 21.12, and an average percentage change of 0.008. As is the case with many financial variables, both measures of percentage change are leptokurtic.

<Insert Table 1>

Stock, Bond, and Currency Markets

We obtain daily settlement prices for a range of U.S., Australian, and New Zealand markets from DataStream for a sample period that coincides with that of VIX. The settlement prices are then used to create a series of daily percentage changes (returns). Australian and New Zealand markets are used in addition to US markets for three reasons. First, the markets are well established and have readily available data. Second, there has been an Australian equivalent of VIX (the A-VIX) since January 2008 which makes comparison possible. Third, Australian and New Zealand currencies, and bonds, have had high yields relative to US markets during the sample period and have attracted a significant proportion of international investment that is likely to be influenced by levels of investor fear.

We focus on key indicators of stock, bond, and currency markets in each country. For stock markets we choose indices that capture a large proportion (at least 80%) of the market capitalisation in each country (S&P500, ASX200, NZX50[3]). For bond markets, we consider yields on 10-year bonds issued by the federal government of each country. Finally, for currency markets we focus on the trade-weighted-index (TWI) for each currency[4]. Descriptive statistics are provided in Table 1. On average, stock markets have increased and bond yields have declined

[3] The S&P500 accounts for approximately 80% of U.S. market capitalisation, the ASX200 covers approximately 80% of the Australian stock market value, and the NZX50 covers approximately 90% of the New Zealand stock market.

[4] This is calculated by the Reserve Bank of Australia. www.rba.gov.au

during the sample period. In general, yields are higher in Australia and New Zealand, but more volatile in the US. While the Australian dollar (AUD) and New Zealand dollar (NZD) have appreciated over time, the US dollar (USD) has declined. Returns in all three markets exhibit high levels of kurtosis (fat-tails) commonly noted for financial market returns.

3. Empirical results

Relationship between investor fear and financial markets

We are interested in understanding how levels of investor fear (proxied by VIX) relate to returns across different types of financial markets (stock, bond, and currency markets). Figure 1 illustrates the relationships that are to be investigated. As levels of investor fear surge (VIX jumps) there are sharp declines in stock markets and bond yields that is illustrative of a flight to quality. The relationship for currencies is more nuanced. The relatively high-yielding AUD and NZD have an inverse relationship with investor fear, declining sharply as VIX spikes (particularly during the financial crisis of 2008-09). On the other hand, the USD tends to appreciate when VIX jumps. Again, the currency movements in relation to VIX changes are consistent with a flight to quality.

<Insert Figure 1>

This relationship is investigated more formally using a simple regression model of the form:

$$\%\Delta Mkt_{j,t} = \beta_0 + \beta_1 \%\Delta VIX_{i,t-k} + \varepsilon_t$$

Where $\%\Delta Mkt_{j,t}$ is the percentage change for market j on day t, $\%\Delta VIX_{i,t-k}$ is the percentage change in the VIX of type i (either VIX or A-VIX) on day t-k (where k = 0 or 1 in order to correctly align the daily movements in the financial market and VIX[5]). ε_t is the heteroscedasticity-consistent (Newey-West) standard error, where the appropriate number of lags are chosen according to AIC. The results for the whole sample period are presented in Table 2, with the results with $\%\Delta VIX$ as the dependent variable reported in Panel A, the results with $\%\Delta A\text{-}VIX$ as the dependent variable in Panel B.

<Insert Table 2>

[5] This is necessary owing to the time difference between US trading hours and AU/NZ trading hours. i.e. changes in VIX relevant to AU/NZ markets will occur on the prior US trading day.

We consider Panel A first. For stock markets the relationship is negative and well-defined at the 1% level. We interpret this as stock markets declining when investor fear (VIX) increases. The magnitude of the estimated coefficient for the S&P500 is more than double that for the other markets. This relationship is consistent with that noted by Whaley (2000, 2009). A similar relationship is found for bond yields; as VIX increases bond yields fall (implying that bond prices increase). Finally, in the currency market, the estimated relationship is significant and negative for the AUD and NZD which implies that they depreciate as VIX increases, while the USD has a significant positive relationship and appreciates when VIX increases. The identified relationships in the currency market are consistent with Smales and Kininmonth (2016). Taken together, the results for the three markets are consistent with a 'flight to quality' as risk appetite falls when investor fear increases.

The relationships identified in Panel B are identical to those in Panel A in terms of estimated significance and direction. However, there are some important differences to note. First, for US stock and bond markets, the magnitude of the estimated coefficients, and the explanatory power of the regression are significantly higher when VIX is used as the dependent variable. There is little difference for USD. Second, when A-VIX is used as the dependent variable, the adjusted R^2 and magnitude of estimated coefficients are significantly higher for Australian stock, bond, and currency markets. Third, for the New Zealand markets there is little difference whether VIX or A-VIX is used as the dependent variable.

Finally, regardless of whether VIX or A-VIX is used, the explanatory power of the regression is highest when stock markets are considered. This makes intuitive sense given that the two measures are based on the implied volatility of stock options. However, it is interesting that the investor fear gauge has power in explaining changes in bond and currency markets, and this helps to validate the notion that VIX (A-VIX) is useful in determining risk appetite across different markets.

Influence of the Global Financial Crisis

The times series shown in Figure 1 illustrates a sharp increase in investor fear (VIX) and corresponding fluctuations in financial markets during the global financial crisis of 2008-09. Given this change in investor sentiment associated with the market declines, it is likely that such periods are particularly important in understanding changes in risk appetite (and flight to quality) and so we seek to examine this period in more detail.

We repeat our analysis, concentrating on the period of the global financial crisis which we define as 1st January 2008 to 30th June 2009[6] – this coincides with the recessionary period defined by the National Bureau of Economics Research. The estimated coefficients are reported in Table 3.

<Insert Table 3>

The sign of the relationship remains the same in all cases; negative and significant for all stock markets, all bond markets and the AUD and NZD, while it is positive and significant for the USD. More importantly, the magnitude of the response to changes in market sentiment sharply increases during the period of the financial crisis. On average, the estimated coefficients for stock markets are 85% larger during this period as compared to the whole sample, and the difference is statistically significant. Interestingly, the largest increase in the estimated coefficients occurs in the currency markets, with the smallest increase occurring in the bond markets. It also appears that changes in VIX have a statistically significant impact on a wider variety of markets than do changes in A-VIX. This suggests that VIX is a relatively more important measure of investor fear during the crisis period.

The results indicate that the financial crisis resulted in extreme levels of investor fear that caused a change in the relationship between VIX and returns in financial markets, likely as a result of changes in risk appetite. During the crisis, returns in financial markets apparently became more sensitive to changes in the level of investor fear.

Dynamic Model

To correctly model the dynamics of the financial markets considered here, the dependencies and interdependencies should be explicitly accounted for. We incorporate this by specifying a ten-dimensional model for the endogenous variables (VIX, 3 stock markets, 3 bond markets, 3 currencies) in a Vector Auto-Regression (VAR) framework.

<Insert Table 4>

[6] We consider the identification of issues in the subprime mortgage funds of BNP Paribas that occurred in August 2007, the Bear Sterns collapse of March 2008, and the Lehman Brothers failure of September 2008 as alternate start dates and find that the results are qualitatively similar to those reported here.

Table 4 reports estimates[7] of the VAR model and the results can be summarized as follows: First, there is significant own return dynamics with positive returns in the lagged period stimulating negative returns in the current period (consistent with auto-correlation of asset returns found elsewhere in the literature). Second, consistent with the analysis reported in the previous section there is a significant negative relationship between changes in VIX and asset returns, apart from USD_TWI which has positive relationship. This relationship is reversed for the S&P500 and this makes intuitive sense given the strong relationship between VIX and US stock market returns. Third, consistent with international finance theory, there is a positive relationship between yields and currency returns. Fourth, lagged returns in US stock and bond markets are significantly and positively related with current period returns in the associated Australian and New Zealand markets, while the relationship is negative for currency markets. Fifth, yields in Australian and New Zealand bonds are negatively related to previous day stock returns in their home markets. Finally, there is a negative link between changes in the level of the AUD and NZD and stock market returns, but this is not significant for the US. This may be explained by the relative importance of export industries in the different markets.

Overall, the dynamic analysis confirms the effects already identified via standard regression models. The results clearly demonstrate the significant impact of changes in investor fear (VIX) on financial markets, and also emphasise the importance of US markets in driving international market returns.

4. Forecasting financial market returns using VIX

The analysis in the previous section identified a well-defined relationship between VIX and financial market returns. We now investigate whether it is possible to use this relationship to forecast financial returns. Baker and Wurgler (2006) consider the cross-section of stock returns and report that when sentiment is low (equivalent to high levels of investor fear in this study) then subsequent returns are relatively high. Conversely, when sentiment is high then stock markets tend to produce relatively low subsequent returns.

We translate this into the language of our study to hypothesize that stock returns will be higher (lower) in the periods subsequent to high (low) levels of investor fear. If we associate higher stock returns with risk-seeking behaviour from investors (a 'risk-on' state), then we would

[7] The optimal number of lags is determined to be 1 using Akaike Information Criterion.

also expect increasing bond-yields and an appreciation in the AUD and NZD (depreciation in the USD), in periods subsequent to high levels of VIX. The converse would be expected in the periods following low levels of VIX.

We investigate whether our hypothesis holds by looking at the financial market returns in the 5-, 20-, 60-, and 120-trading days[8] subsequent to VIX closing at low (bottom quintile) and high (top quintile) levels[9]. The results are reported in Table 5[10].

<Insert Table 5>

Panel A details the results for stock markets. The results are consistent with the hypothesis, with returns higher on average (although not significantly so) in the period following high levels of investor fear. Note that, in general, the average return is still positive for each holding period subsequent to a low level of VIX. The average percentage changes for currency markets are reported in Panel C. When VIX is high, on average, the following period sees the USD depreciate, while the AUD and NZD appreciate. Again, this is consistent with our hypothesis.

The results for bond yields reported in Panel B are particularly interesting. In the period subsequent to high levels of investor fear bond yields decrease, while bond yields increase in the period after low levels of investor fear, and this is true across all three countries. This conflicts with our stated hypothesis, but is at least partically consistent with Bekaert et al. (2013). This is explained by the fact that there was sustained demand for government bonds during the sample period as high-levels of VIX (particularly in 2008-09 and 2012) coincided with central banks reducing target rates to historic lows, and a surge in global liquidity. Indeed, when VIX is high, large falls in bond yields may provide an explanation for the subsequent returns in stock and bond markets. The lower yields, that coincide with increased global liquidity, allow investors to leverage-up in order to buy stocks and enter into currency carry-trades (sell low-yielding USD, and buy high-yielding AUD and NZD). Conversely, if low levels of investor fear induce higher yields then leverage will be decreased, thus reducing demand for stocks and the carry-trade.

Taken together, the results reported in Table 5 suggest that it is possible to create a profitable trading strategy whereby investors enter into risky assets (buy stocks, sell USD, buy

[8] This is equivalent to 1-week, 1-month, 3-month, and 6-month holding intervals.
[9] The bottom quintile is bounded by 13.42, while the top quintile is bounded by 25.66.
[10] Qualitatively similar results are reported using the bottom/top decile to indicate low and high levels, and also using A-VIX in place of VIX.

AUD & NZD) when VIX is at a high-level (a 'risk-on' strategy), and sell risky assets when VIX is at low-levels ('risk-off').

5. Conclusion

This paper seeks to consider the relationship between investor fear and financial market returns. The prior literature indicates a strong, negative relationship holds for investor fear and stock market returns, but this study provides evidence that investor fear influences returns across asset classes, and across different countries.

Using VIX as a proxy for investor fear, we present empirical evidence that demonstrates a statistically significant link between investor fear and returns in the stock, bond, and currency markets. As investor fear (VIX) increases there is a decline in stock markets, bond yields, and high-yield currencies (AUD and NZD), while the USD appreciates. Such results are consistent with a flight to quality when investor fear increases.

The results are more pronounced during the financial crisis of 2008-09, when investor fear increases sharply, and reaches its highest levels. Analysis of market returns subsequent to periods of low/high investor fear suggests that VIX has some predictive ability for future returns. It is possible that investors can exploit this result to enter into leveraged strategies to buy risky assets when VIX is high, and should sell risky assets when VIX is low. Taken together, the results confirm that financial market returns are closely related to prevailing levels of investor sentiment.

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Table 1
Descriptive Statistics

		Volatility Index		Stock Markets			Government Bond Yields			Currency Markets		
		VIX	A-VIX	S&P500	ASX200	NZX50	US10Y	AU10Y	NZ10Y	USD_TWI	AUD_TWI	NZD_TWI
Level	Mean	20.582	21.118	1300.08	4457.86	2397.68	3.601	4.998	5.424	93.061	92.626	104.477
	Std. Dev.	9.175	9.223	308.57	946.76	393.29	1.070	1.016	0.994	12.222	11.737	12.293
	Max.	80.860	66.721	2130.82	6828.70	3317.18	5.540	6.780	7.010	124.941	117.276	128.893
	Min.	9.890	9.309	676.53	2700.40	1688.19	1.430	2.280	3.090	75.535	66.658	75.806
Change (%Δ)	Mean	-0.014	-0.008	0.013	0.014	0.012	-0.020	-0.016	-0.014	-0.003	0.007	0.009
	Std. Dev.	6.503	6.393	1.261	1.044	0.731	1.952	1.406	1.034	0.453	0.734	0.695
	Max.	49.601	56.904	10.957	5.628	5.815	8.923	7.802	11.621	2.277	5.444	4.016
	Min.	-35.059	-24.191	-9.470	-10.261	-8.759	-18.497	-6.782	-8.636	-4.149	-8.766	-6.263
	Skewness	0.656	0.783	-0.198	-0.739	-0.762	-0.116	0.208	0.432	-0.221	-1.507	-0.856
	Kurtosis	6.948	7.508	11.806	11.943	12.537	7.071	5.610	12.215	6.562	23.514	9.977
	Jarque-Bera	2622.0	1755.7	11774.5	12220.6	13807.3	2519.8	1058.7	12974.5	1952.1	65145.7	7820.7
	No. Observations	3638	1851	3638	3571	3554	3638	3638	3636	3638	3638	3638

Note: This table provides descriptive statistics for the variables utilized in this study. The first two columns refer to the CBOE S&P500 volatility index (*VIX*) and the ASX200 volatility index (*A-VIX*). The next three columns refer to leading stock indices in the U.S. (*S&P500*), Australia (*ASX200*), and New Zealand (*NZX50*). Columns 6 to 8 display information for the yield on 10-year government bonds in the same three countries (*US10Y*, *AU10Y*, and *NZ10Y*). The final three columns refer to the trade-weighted index for U.S. dollar (*USD_TWI*), Australian dollar (*AUD_TWI*), and New Zealand dollar (*NZD_TWI*). In each case, the first four rows shows data for the *level*, while the remaining rows of information are for the daily percentage *change*, which is the main focus of the empirical analysis.
Sample Period: January 2001 - June 2015

Table 2

Regression: Relationship between changes in VIX and financial asset prices

	Stock Markets			Bond Yields			Currency TWI		
	ΔS&P500	ΔASX200	ΔNZX50	ΔUS10Y	ΔAU10Y	ΔNZ10Y	ΔUSD_TWI	ΔAUD_TWI	ΔNZD_TWI
Panel A - Explanatory variable: %Δ VIX									
%ΔVIX	-0.145 ***			-0.096 ***					
	(0.014)			(0.008)					
%ΔVIX(-1)		-0.070 ***	-0.041 ***		-0.047 ***	-0.037 ***	0.005 ***	-0.025 ***	-0.019 ***
		(0.006)	(0.007)		(0.006)	(0.004)	(0.001)	(0.004)	(0.003)
Adj. R2	0.556	0.189	0.135	0.102	0.046	0.054	0.005	0.048	0.033
Durbin-Watson	2.170	2.292	1.930	1.999	2.129	2.050	2.056	2.147	2.026
No. Observations	3637	3569	3552	3637	3636	3635	3636	3636	3636
Panel B - Explanatory variable: Δ%A-VIX									
Δ%A-VIX	-0.022 ***	-0.130 ***	-0.045 ***	-0.018 **	-0.070 ***	-0.025 ***	0.006 ***	-0.037 ***	-0.028 ***
	(0.005)	(0.014)	(0.007)	(0.009)	(0.007)	(0.006)	(0.002)	(0.007)	(0.005)
Adj. R^2	0.010	0.451	0.146	0.002	0.071	0.017	0.007	0.072	0.054
Durbin-Watson	2.337	2.150	1.921	2.033	2.121	2.130	2.031	2.198	2.069
No. Observations	1850	1850	1822	1850	1850	1850	1850	1850	1850

Note: This table reports the estimated coefficients for the regression described in Eq.(1), where the daily changes in financial assets are explained by a constant (not reported) and changes in the volatility index (*VIX*). In panel A, the explanatory variable is percentage changes in the CBOE S&P500 Implied Volatlity Index (*%Δ VIX*). To correctly align the daily movements in VIX and asset prices a lagged variable (*%Δ VIX(-1)*) is used for Australian and New Zealand assets. In Panel B the explanatory variable is percentage changes in the ASX200 Implied Volatility Index (*%ΔA-VIX*). Newey-West standard errors, with lags chosen using AIC, are reported in parentheses.

Sample Period for %ΔVIX: January 2001 - June 2015. Sample Period for %ΔA-VIX: January 2008 - June 2015.

***, **, * denote significance at the 1%, 5%, and 10% levels respectively.

Table 3

Regression: Relationship between changes in VIX and financial asset prices during crisis period

	Stock Markets			Bond Yields			Currency TWI		
	%ΔS&P500	%ΔASX200	%ΔNZX50	%ΔUS10Y	%ΔAU10Y	%ΔNZ10Y	%ΔUSD_TWI	%ΔAUD_TWI	%ΔNZD_TWI
Panel A - Explanatory variable: %ΔVIX									
%ΔVIX	-0.282***			-0.124***					
	(0.019)			(0.025)					
%ΔVIX(-1)		-0.147***	-0.106***		-0.058***	-0.039***	0.015***	-0.061***	-0.044***
		(0.013)	(0.011)		(0.022)	(0.009)	(0.005)	(0.009)	(0.007)
Adj. R2	0.695	0.274	0.381	0.098	0.056	0.039	0.026	0.090	0.074
Durbin-Wat	2.205	2.468	1.974	1.941	2.267	2.191	2.007	2.371	2.170
No. Observa	377	368	368	377	377	377	377	377	377
Panel B - Explanatory variable: %ΔA-VIX									
%ΔA-VIX	-0.024	-0.234***	-0.097***	-0.044*	-0.080***	-0.021*	0.012**	-0.077***	-0.052***
	(0.015)	(0.015)	(0.018)	(0.026)	(0.015)	(0.012)	(0.005)	(0.011)	(0.009)
Adj. R^2	0.001	0.521	0.229	0.008	0.076	0.008	0.014	0.102	0.076
Durbin-Wat	2.374	2.217	1.946	2.014	2.191	2.236	1.982	2.317	2.109
No. Observa	368	368	368	368	368	368	368	368	368

Note: This table reports the estimated coefficients for the regression described in Eq.(1) for the part of the sample defined as recessionary. The daily changes in financial assets are explained by a constant (not reported) and changes in the volatility index (*VIX*). In panel A, the explanatory variable is changes in the CBOE S&P500 Implied Volatlity Index (*%ΔVIX*). To correctly align the daily movements in VIX and asset prices a lagged variable (*%ΔVIX(-1)*) is used for Australian and New Zealand assets. In Panel B the explanatory variable is changes in the ASX200 Implied Volatility Index (*%ΔA-VIX*). Newey-West standard errors, with lags chosen using AIC, are reported in parentheses.

Sample Period for Crisis: January 2008 - June 2009.

***, **, * denote significance at the 1%, 5%, and 10% levels respectively.

Table 4

Dynamic relationship between VIX and financial markets

	$\%\Delta VIX_t$	$\%\Delta S\&P500_t$	$\%\Delta ASX200_t$	$\%\Delta NZX50_t$	$\%\Delta US10Y_t$	$\%\Delta AU10Y_t$	$\%\Delta NZ10Y_t$	$\%\Delta USD\_TWI_t$	$\%\Delta AUD\_TWI_t$	$\%\Delta NZD\_TWI_t$
Intercept	-0.008	0.002	0.003	0.003	-0.044	-0.021	-0.005	0.001	-0.012	0.000
	(0.113)	(0.015)	(0.014)	(0.011)	(0.032)	(0.019)	(0.015)	(0.008)	(0.012)	(0.012)
$\%\Delta VIX_{t-1}$	-0.121 ***	-0.145 ***	-0.030 ***	-0.010 ***	-0.095 ***	-0.018 ***	-0.004 **	0.003 ***	-0.027 ***	-0.023 ***
	(0.017)	(0.002)	(0.002)	(0.002)	(0.005)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)
$\%\Delta S\&P500_{t-1}$	0.314 **	-0.080 ***	0.451 ***	0.292 ***	0.008	0.134 ***	0.080 ***	-0.073 ***	0.210 ***	0.139 ***
	(0.140)	(0.018)	(0.018)	(0.014)	(0.040)	(0.023)	(0.018)	(0.010)	(0.015)	(0.014)
$\%\Delta ASX200_{t-1}$	-0.142	0.014	-0.226 ***	0.030 **	0.023	-0.109 ***	-0.004	-0.011	-0.025 *	-0.031 **
	(0.148)	(0.019)	(0.019)	(0.015)	(0.042)	(0.025)	(0.019)	(0.010)	(0.016)	(0.015)
$\%\Delta NZX50_{t-1}$	0.079	-0.028	-0.018	-0.018	-0.030	-0.101 ***	-0.024	0.022	0.013	0.023
	(0.191)	(0.025)	(0.024)	(0.019)	(0.055)	(0.032)	(0.025)	(0.013)	(0.020)	(0.020)
$\%\Delta US10Y_{t-1}$	-0.164 **	-0.002	-0.004	-0.002	0.014	0.423 ***	0.257 ***	0.029 ***	0.000	0.002
	(0.064)	(0.008)	(0.008)	(0.006)	(0.018)	(0.011)	(0.008)	(0.004)	(0.007)	(0.007)
$\%\Delta AU10Y_{t-1}$	0.195 *	0.009	-0.033 **	-0.014	0.046	-0.229 ***	0.236 ***	-0.001	0.034 ***	0.012
	(0.112)	(0.015)	(0.014)	(0.011)	(0.032)	(0.019)	(0.015)	(0.008)	(0.012)	(0.011)
$\%\Delta NZ10Y_{t-1}$	0.148	0.001	0.004	0.003	0.036	0.043 *	-0.143 ***	0.015	-0.001	0.023
	(0.142)	(0.019)	(0.018)	(0.014)	(0.041)	(0.024)	(0.018)	(0.010)	(0.015)	(0.015)
$\%\Delta USD\_TWI_{t-1}$	-0.063	-0.002	-0.048	0.017	-0.041	0.016	-0.066 *	-0.038 **	-0.036 **	-0.075 ***
	(0.264)	(0.034)	(0.034)	(0.026)	(0.075)	(0.044)	(0.034)	(0.018)	(0.018)	(0.027)
$\%\Delta AUD\_TWI_{t-1}$	-0.182	0.005	-0.070 **	0.038 *	-0.137 **	-0.010	-0.048	0.009	-0.136 ***	-0.049 **
	(0.232)	(0.030)	(0.030)	(0.023)	(0.066)	(0.039)	(0.030)	(0.016)	(0.024)	(0.024)
$\%\Delta NZD\_TWI_{t-1}$	-0.019	-0.025	0.066 **	-0.081 ***	-0.015	0.004	0.032	0.030 **	-0.009	-0.028
	(0.228)	(0.030)	(0.029)	(0.022)	(0.065)	(0.038)	(0.029)	(0.016)	(0.024)	(0.023)
Adj. R^2	0.019	0.562	0.384	0.255	0.103	0.408	0.370	0.032	0.167	0.106
F-Statistsic	4.096	211.553	103.457	57.183	19.881	113.983	97.393	6.480	33.791	20.532
Log likelihood	-10774.4	-4083.4	-4020.4	-3156.6	-6666.1	-4890.1	-4057.1	-1996.1	-3362.9	-3283.2
Determinant resid covariance (dof adj.)		0.293								

Note: This table presents evidence on the dynamic relationship between investor fear (*VIX*) and financial markets considered in this study. Estimated coefficients for the VAR specification, with the financial market returns as endogenous variables, are reported along with *t*-statistics (in parentheses). Using AIC the optimal number of lags is determined to be 1.

Sample Period for %ΔVIX: January 2001 - June 2015.

***, **, * denote significance at the 1%, 5%, and 10% levels respectively.

Table 5
Market returns subsequent to high and low levels of VIX

Panel A: Stock Markets	S&P500				ASX200				NZX50			
	5	20	60	120	5	20	60	120	5	20	60	120
VIX Low												
Mean	-0.014	0.276 ***	1.602 ***	4.151 ***	0.060	0.160	1.468 ***	3.204 ***	-0.168 **	-0.109	0.506 **	1.063 ***
S.E.	0.042	0.080	0.120	0.129	0.111	0.210	0.320	0.452	0.078	0.155	0.237	0.353
N	721	710	687	673	721	710	687	673	721	710	687	673
VIX High												
Mean	0.095	0.703 **	2.669 ***	5.690 ***	0.170 ***	0.568 ***	2.636 ***	5.745 ***	0.159 ***	0.543 ***	1.807 ***	3.081 ***
S.E.	0.147	0.273	0.377	0.514	0.048	0.115	0.181	0.211	0.042	0.103	0.186	0.189
N	726	726	726	725	726	726	726	725	726	726	726	725

Panel B: Bond Yields	US10Y				AU10Y				NZ10Y			
	5	20	60	120	5	20	60	120	5	20	60	120
VIX Low												
Mean	0.309 ***	1.010 ***	1.325 ***	1.331 ***	0.122	0.206	0.289	1.173 ***	0.088	0.096	0.123	0.539
S.E.	0.096	0.180	0.372	0.495	0.082	0.164	0.301	0.426	0.067	0.127	0.254	0.361
N	696	681	641	581	696	681	641	581	696	681	641	581
VIX High												
Mean	-0.889 ***	-3.796 ***	-10.579 ***	-17.688 ***	-0.442 ***	-1.853 ***	-5.886 ***	-10.309 ***	-0.362 ***	-1.520 ***	-4.211 ***	-8.193 ***
S.E.	0.202	0.433	0.711	0.967	0.118	0.242	0.468	0.707	0.102	0.230	0.419	0.546
N	697	678	615	541	697	678	615	541	697	678	615	541

Panel C: Currency Markets	USD_TWI				AUD_TWI				NZD_TWI			
	5	20	60	120	5	20	60	120	5	20	60	120
VIX Low												
Mean	0.014	0.140 **	0.475 ***	0.874 ***	-0.080 **	-0.387 ***	-0.973 ***	-1.284 ***	-0.071 *	-0.244 ***	-0.966 ***	-2.639 ***
S.E.	0.029	0.065	0.120	0.186	0.034	0.067	0.115	0.164	0.040	0.092	0.168	0.217
N	696	681	641	581	696	681	641	581	696	681	641	581
VIX High												
Mean	0.001	-0.009	-0.407 **	-0.592 **	0.251 ***	0.862 ***	2.184 ***	3.568 ***	0.249 ***	0.798 ***	0.775 ***	1.326 ***
S.E.	0.044	0.097	0.179	0.274	0.088	0.177	0.359	0.528	0.077	0.158	0.287	0.466
N	697	678	615	541	697	678	615	541	697	678	615	541

Note: This table displays the returns experienced in stock markets (Panel A), bond yields (Panel B), and currency markets (Panel C) in the 5, 20, 60, and 120 trading days subsequent to VIX closing in either the low (< 13.42) or high (> 25.66) quintile.
Sample Period: January 2001 - June 2015.
***, **, * denotes whether the mean return is significantly different from zero at the 1%, 5%, and 10% levels respectively.

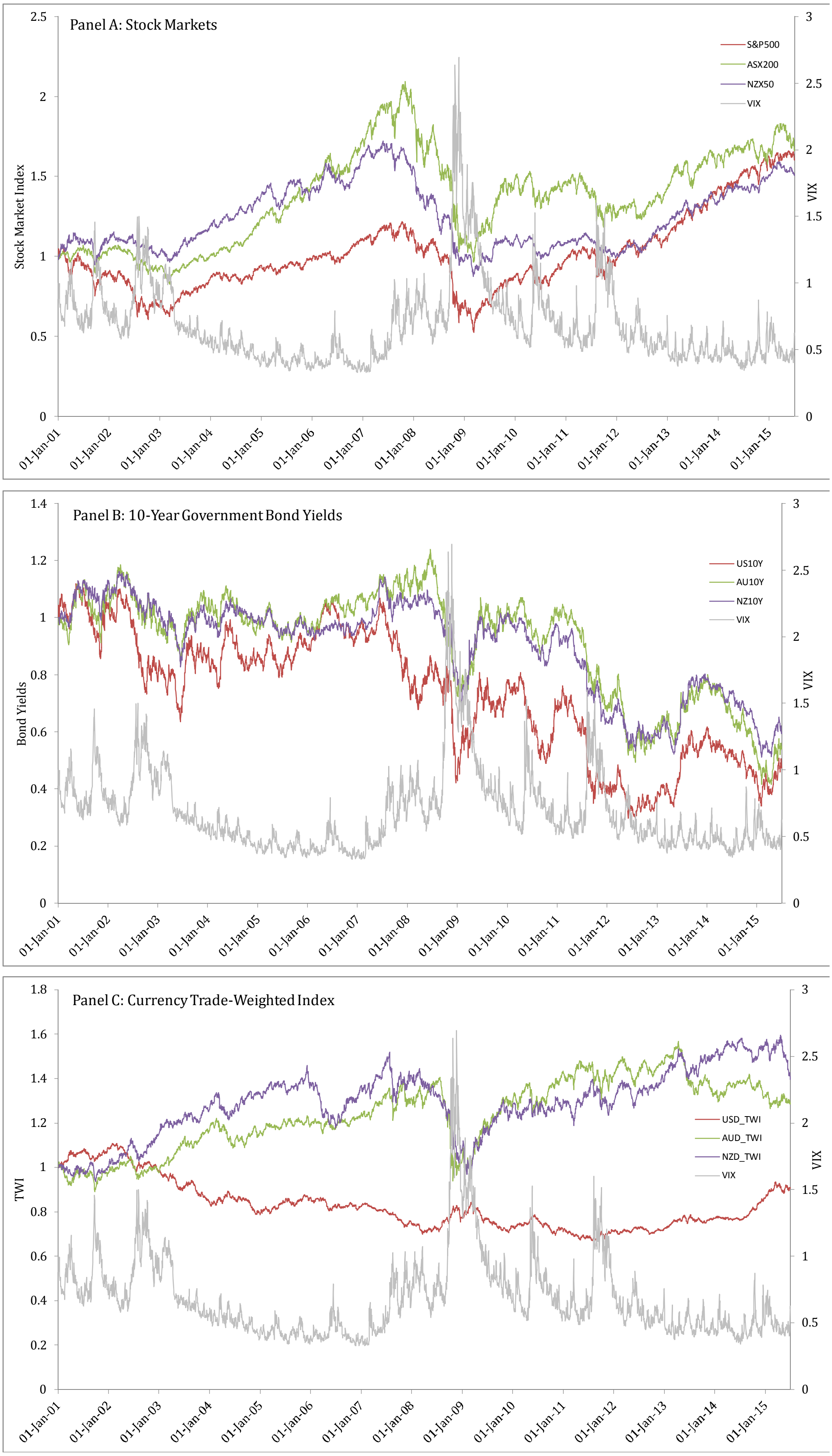

Figure 1. Evolution of financial asset prices and VIX

Note: This figure depicts the evolution of standardised (based on 02-Jan-01 start date) levels in stock market indices, government bond yields, and currency trade-weighted indices (left-axis) against VIX (right-axis) over time.
Sample period: January 2001 - June 2015