Expected market returns:

SVIX, realized volatility, and the role of dividends

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Abstract

This note provides a replication of Martin's (*Quarterly Journal of Economics*; 2017) finding that the implied volatility measure SVIX predicts US stock market returns up to twelve-month horizons. I find that this result holds for both S&P 500 and CRSP market returns, regardless of whether returns include or exclude dividends. The predictability largely disappears after the SVIX index is replaced by an exponentially weighted moving average measure of realized volatility, suggesting that SVIX holds incremental forward looking information compared to realized volatility, despite the high correlation between the two volatility measures.

Keywords: Equity premium predictability, dividends, implied and realized volatility

JEL classification: C58, G12, G17

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1 Introduction

In a recent article, Martin (2017) derives a simple expression for the lower bound of the expected equity premium: the excess return on the market portfolio. He shows analytically that this lower bound on the expected equity premium is equal to the risk-neutral conditional variance of market returns, scaled by the gross risk-free rate. Martin (217) also develops a novel option-implied measure of the risk-neutral conditional variance: $SVIX^2_{t,k}$, which is derived from the prices of call and put options on the underlying market index, which expire in k periods. SVIX can be substituted into the theoretical expression of the equity premium's lower bound to obtain predictions of excess market returns:

$$R^e_{t+1:t+k} \geq R_{f,t} \times SVIX^2_{t,k}, \tag{1}$$

where $R^e_{t+1:t+k}$ is the cumulative excess (i.e.: in deviation of the risk-free rate) market return realized over the months $t+1$ to $t+k$, and $R_{f,t}$ is the gross risk-free rate over the same period.

Martin (2017) runs predictive regressions of excess market returns on lagged values of SVIX and finds indeed that the implied volatility measure holds predictive power over horizons up to twelve months. His results imply that the lower bound (1) is relatively tight. In this note, I replicate this main result by Martin (2017) and investigate its robustness. I start with predictive regressions of S&P 500 returns on the lagged SVIX index and find, similar to Martin (2017), that the SVIX index indeed predicts future returns. In further support of the theory, restrictions on the parameter space implied by the theoretical lower bound (1) can not be rejected at conventional significance levels.

The SVIX index measures the expected volatility of changes in prices, as implied by option contracts. The return in Eq. (1) thus refers strictly speaking to the excess market return *excluding* dividends. Martin assumes explicitly that dividends paid between time t and $t+k$ are known before time t, such that they have no impact on the uncertainty of returns. To test this assumption, I run the predictive regressions using both returns obtained from the S&P 500 price index, as well as the S&P 500 total return index. I find that the prediction results show strong similarity, suggesting that expected dividend variation does not contribute much to expected return variation. In addition, I find similar results when the S&P 500 returns are replaced by value-weighted market returns from the Center for Research in Security Prices (CRSP), both for returns including and excluding dividends.

The use of an option-implied volatility measure such as SVIX is conceptually appealing, since option prices presumably contain forward-looking information that is not reflected in past market returns. A clear disadvantage of SVIX is the stringent data requirement: prices of put and call options at multiple strike prices and various maturities are required. Moreover, for the estimates to be reliable, these option markets need to be sufficiently liquid. Even if options on the S&P 500 index are among the most traded equity options, Martin (2017) points out that the limited liquidity of one-year options cast doubt on the reliability of predictions over twelve-month horizons relative to one-month horizons. I therefore test whether the same predictive results could be obtained using a simple measure of realized volatility: the exponentially weighted moving average (EWMA) variance of daily returns. I find that the positive predictability of the equity premium disappears when SVIX is replaced by the realized volatility measure. These results thus imply, consistent with prior literature (e.g. Christensen and Prabhala, 1998), that option-implied volatility measures such as SVIX contain forward-looking information that is not captured by the variance estimated from historical returns.[1]

Martin's (2017) result that the equity premium is proportional to volatility provides evidence of a positive risk-return trade-off, one of the central principles in financial economics. A positive relation between market volatility (as a measure of market risk) and returns has been documented before, including by seminal studies such as Merton (1980) and French et al. (1987). This note contributes to this literature, by showing that the measurement of volatility matters. In particular, implied volatility positively predicts future returns, while realized volatility does not. Since a trade-off is expected between *future* returns and *future* volatility, returns should be predictable by expectations of future volatility. My results indeed show that option-implied volatility (SVIX) is a leading indicator of realized volatility, explaining its positive relation with the expected future equity premium.

[1]The Internet Appendix reports additional regression results for which the EWMA realized volatility measure is replaced by the realized monthly variance of daily returns, and the implied volatility measure SVIX is replaced by the closely related VIX index (See Martin, 2017, Section VII, for a discussion of the relation between SVIX and VIX). These results are qualitatively similar and do not lead to different conclusions than the results reported in this paper.

2 Empirical results

2.1 Data

Daily market returns are calculated from the S&P 500 price index over the sample 1950-2016, as well as from the S&P 500 total return index (sample 1988-2016).[2] In addition, I use the daily value-weighted returns and the value-weighted market returns excluding dividends from the Center for Research in Security Prices (CRSP, sample 1926-2016). All measures of daily market returns are compounded into monthly observations of forward looking cumulative 1, 2, 3, 6, and 12-month returns in excess over the risk-free rate. The risk-free rate is obtained from Kenneth French's data library.

For each of the four measures of market return, I compute the exponentially weighted moving average (EWMA) variance using daily returns:

$$\sigma^2_{EWMA,t} = \lambda \sigma^2_{EWMA,t-1} + (1-\lambda) r_t^2 \times 240, \tag{2}$$

where the decay rate λ is set at 0.94, following the convention in the literature (J.P. Morgan, 1996), and r_t is the daily net market return. All regression results reported below are highly similar when the returns in Eq. (2) are measured in deviation of the risk-free rate or in deviation of an exponentially weighted moving average. The daily return variance estimator is multiplied by 240 to obtain an annualized variance estimator. Since the regressions are estimated with monthly data, I use the variance estimator at the last day of each month.

Daily data on the annualized SVIX index at 1, 2, 3, 6, and 12-month horizons are directly obtained from Ian Martin's website[3], for the period January 1996 - January 2012. All results below are based on this restricted sample, although I do use the earlier history of returns to compute $\sigma^2_{EWMA,t}$ and the historical mean, to which the fit of the model is compared. Figure 1 plots the SVIX indices and $\sigma_{EWMA,t}$ over time.

[2]Source: `finance.yahoo.com`
[3]`personal.lse.ac.uk/martiniw/`

2.2 SVIX and the equity premium

Table 1 reports the results from the following regression model:

$$R^e_{t+1:t+k} \times \tau_k = \alpha + \beta \left(R_{f,t} \times SVIX^2_{t,k}\right) + \varepsilon_{t,k}, \tag{3}$$

where $R^e_{t+1:t+k}$ is the cumulative excess (i.e.: in deviation of the risk-free rate) market return realized over the months $t+1$ to $t+k$, τ_k is a scaling factor to obtain annualized returns ($\tau_k = \frac{12}{k}$), and $\left(R_{f,t} \times SVIX^2_{t,k}\right)$ is the square of the SVIX index at the last day of month t scaled by the risk-free rate. The model (3) is estimated with four different proxies for market returns: returns on the S&P 500 price index, the S&P 500 total return index, and the CRSP value-weighted market return excluding and including dividends. Table 1 reports the estimated coefficients $\widehat{\alpha}$ and $\widehat{\beta}$, and Hansen-Hodrick (1980) standard errors.[4] The estimated coefficients based on the S&P 500 price index (top-left panel of Table 1) are nearly identical to those reported by Martin (2017; Table II).

Table 1: SVIX and the equity premium

This table reports results of regressing monthly forward looking excess market returns, at different horizons k, on the squared SVIX index scaled by the risk free rate, as in (3). Standard errors are computed following Hansen and Hodrick (1980), with k lags. Sample: 1996:01-2012:01

	S&P 500 price index					S&P 500 total return index				
k (months)	1	2	3	6	12	1	2	3	6	12
$\widehat{\alpha}$	0.01	-0.02	-0.02	-0.08	-0.04	0.03	0.00	-0.01	-0.06	-0.03
S.E.(α)	0.07	0.09	0.08	0.06	0.08	0.07	0.09	0.08	0.06	0.09
$\widehat{\beta}$	0.42	1.09	1.16	2.28	1.70	0.46	1.13	1.20	2.33	1.75
S.E.(β)	1.52	2.02	1.97	0.81	1.12	1.52	2.02	1.96	0.82	1.16
p-val ($H_0 : \alpha = 0, \beta = 1$)	0.89	0.92	0.91	0.24	0.82	0.92	1.00	0.99	0.26	0.74
R^2	0.00	0.01	0.01	0.07	0.05	0.00	0.01	0.01	0.07	0.05
$1 - \sum \varepsilon^2_{restricted,t,k} / \sum v^2_{t,k}$	0.00	0.01	0.01	0.04	0.04	0.01	0.02	0.02	0.06	0.06
	CRSP excluding dividends					CRSP including dividends				
k (months)	1	2	3	6	12	1	2	3	6	12
$\widehat{\alpha}$	0.02	-0.02	-0.03	-0.09	-0.05	0.04	-0.01	-0.01	-0.07	-0.04
S.E.(α)	0.07	0.09	0.08	0.06	0.08	0.07	0.09	0.08	0.06	0.08
$\widehat{\beta}$	0.37	1.23	1.38	2.61	2.00	0.42	1.28	1.43	2.68	2.07
S.E.(β)	1.60	2.04	1.97	0.78	1.13	1.60	2.04	1.97	0.79	1.17
p-val ($H_0 : \alpha = 0, \beta = 1$)	0.92	0.95	0.93	0.11	0.67	0.88	0.98	0.97	0.11	0.56
R^2	0.00	0.01	0.02	0.08	0.06	0.00	0.01	0.02	0.08	0.07
$1 - \sum \varepsilon^2_{restricted,t,k} / \sum v^2_{t,k}$	0.00	0.01	0.02	0.05	0.05	0.00	0.01	0.02	0.06	0.06

Table 1 also reports the p-value of an F-test on the hypothesis $H_0 : \alpha = 0, \beta = 1$ implied

[4]Highly similar results are obtained using Newey-West (1987) standard errors.

by Eq. (1). In support of Martin's (2017) theory, the restriction on the parameter space can not be rejected at conventional significance levels, for all horizons k. Finally, similar to Martin (2017), the table reports the regression R^2 and an additional out-of-sample measure comparing the fit of the restricted model to a historical rolling mean return model:

$$1 - \frac{\sum \varepsilon^2_{restricted,t,k}}{\sum v^2_{t,k},} \tag{4}$$

where

$$\begin{aligned} \varepsilon_{restricted,t,k} &= R^e_{t+1:t+k} \times \tau_k - \left(R_{f,t} \times SVIX^2_{t,k}\right) \\ v_t &= R^e_{t+1:t+k} \times \tau_k - \tfrac{1}{t-k} \textstyle\sum_{i=1}^{t-k} R^e_{i:i+k} \times \tau_k. \end{aligned} \tag{5}$$

The results suggest that the restricted model by Martin (2017) outperforms the realized mean model in terms of predicting the equity premium, in particular at longer horizons. Highly similar results are obtained when the realized rolling mean is replaced by a constant annualized mean return of 6%.

Interestingly, the results are very similar when the market returns are based on the S&P 500 total return index (top-right panel of Table 1). Even if the SVIX index measures volatility of the price, the results are hardly affected when the returns include dividends in addition to price changes. For robustness, the lower panel of Table 1 reports the regression results using CRSP value-weighted market returns, including and excluding dividends, instead of S&P 500 returns. Also with CRSP data, the results remain similar: the restriction $\alpha = 0, \beta = 1$ cannot be rejected at conventional levels. Overall, the results by Martin (2017) are robust to different measurements of the market return.

2.3 EWMA variance and the equity premium

Next, I re-estimate (3) while replacing $SVIX^2_{t,k}$ by σ^2_{EWMA} (Eq. 2) at the last day of month t.

$$R^e_{t+1:t+k} \times \tau_k = \alpha + \delta\left(R_{f,t} \times \sigma^2_{EWMA,t}\right) + \varepsilon_{t,k}. \tag{6}$$

The results, reported in Table 2, show that the estimates are highly sensitive to the choice of volatility measure, even if the correlation between $SVIX^2$ and σ^2_{EWMA} is close to 90%. In particular at shorter horizons, the estimates of δ are closer to -1 then to 1. Hence, at short

Table 2: EWMA variance and the equity premium

This table reports results of regressing monthly forward looking excess market returns, at different horizons k, on the EWMA variance scaled by the risk free rate, as in (6). Standard errors are computed following Hansen and Hodrick (1980), with k lags. Sample: 1996:01-2012:01

	S&P 500 price index					S&P 500 total return index				
k (months)	1	2	3	6	12	1	2	3	6	12
$\widehat{\alpha}$	0.08	0.06	0.06	0.03	0.02	0.09	0.08	0.08	0.05	0.04
S.E.(α)	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.05
$\widehat{\delta}$	-1.09	-0.71	-0.68	0.15	0.40	-1.06	-0.69	-0.66	0.17	0.43
S.E.(δ)	0.90	0.83	0.86	0.24	0.14	0.91	0.84	0.86	0.24	0.15
p-val ($H_0 : \alpha = 0, \delta = 1$)	0.06	0.09	0.11	0.00	0.00	0.04	0.06	0.08	0.00	0.00
R^2	0.01	0.01	0.01	0.00	0.02	0.01	0.01	0.01	0.00	0.02
$1 - \sum \varepsilon^2_{restricted,t,k} / \sum v^2_{t,k}$	-0.02	-0.03	-0.06	-0.03	-0.01	-0.02	-0.03	-0.06	-0.02	-0.01
	CRSP excluding dividends					CRSP including dividends				
k (months)	1	2	3	6	12	1	2	3	6	12
$\widehat{\alpha}$	0.10	0.08	0.08	0.04	0.04	0.08	0.07	0.06	0.03	0.02
S.E.(α)	0.05	0.04	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.05
$\widehat{\delta}$	-1.11	-0.61	-0.56	0.32	0.50	-1.14	-0.64	-0.58	0.29	0.47
S.E.(δ)	1.04	0.91	0.92	0.22	0.22	1.04	0.91	0.92	0.22	0.21
p-val ($H_0 : \alpha = 0, \delta = 1$)	0.07	0.10	0.10	0.00	0.07	0.09	0.14	0.16	0.00	0.04
R^2	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.00	0.02
$1 - \sum \varepsilon^2_{restricted,t,k} / \sum v^2_{t,k}$	-0.01	-0.02	-0.04	-0.01	0.01	-0.01	-0.02	-0.04	-0.01	0.01

horizons, realized volatility in fact predicts negative rather than positive excess returns. The p-values for the restriction $H_0 : \alpha = 0, \delta = 1$ are clearly lower than those reported in Table 1, and in most cases allow for rejection of the null hypothesis. The in-sample R^2s are mostly lower than reported in Table 1. Also the out-of-sample performance of the restricted model (4) is clearly weaker when $SVIX^2$ is replaced by σ^2_{EWMA}. It is worth noting that, as in Table 1, the results are highly similar regardless of the choice of market return.

I proceed by including both $SVIX^2$ and σ^2_{EWMA} as predictors in the regression:

$$R^e_{t+1:t+k} \times \tau_k = \alpha + \beta \left(R_{f,t} \times SVIX^2_{t,k} \right) + \delta \left(R_{f,t} \times \sigma^2_{EWMA,t} \right) + \varepsilon_{t,k}, \tag{7}$$

The results, reported in Table 3, show some interesting patterns. At short horizons, the estimates of $\widehat{\beta}$ and $\widehat{\delta}$ are pushed in opposite directions, due to the high correlation of the predictors. The result from regressions (3) and (6) that $SVIX^2$ (σ^2_{EWMA}) predicts the equity premium positively (negatively) at short horizons, holds in a multiple regression. This observation is in fact highly consistent with Bollerslev et al. (2009), who find that the equity premium is positively predictable by the *difference* between implied and realized volatility.

Table 3: SVIX, EWMA, and the equity premium

This table reports results of regressing monthly forward looking excess market returns, at different horizons k, on both the SVIX index and the EWMA variance scaled by the risk free rate, as in (7). Standard errors are computed following Hansen and Hodrick (1980), with k lags. Sample: 1996:01-2012:01

	S&P 500 price index					S&P 500 total return index				
k (months)	1	2	3	6	12	1	2	3	6	12
$\widehat{\alpha}$	-0.14	-0.18	-0.18	-0.17	-0.05	-0.13	-0.16	-0.17	-0.15	-0.03
S.E.(α)	0.06	0.07	0.07	0.09	0.10	0.06	0.07	0.07	0.09	0.10
$\widehat{\beta}$	8.61	8.69	8.16	5.89	2.11	8.61	8.69	8.18	5.91	2.12
S.E.(β)	2.27	1.52	1.63	1.76	1.78	2.27	1.53	1.66	1.81	1.85
$\widehat{\delta}$	-6.08	-5.24	-4.50	-2.07	-0.21	-6.05	-5.22	-4.49	-2.05	-0.19
S.E.(δ)	1.67	0.61	0.74	0.49	0.31	1.68	0.61	0.74	0.50	0.32
p-val ($H_0 : \alpha = \delta = 0, \beta = 1$)	0.00	1.00	0.00	0.00	0.99	0.00	1.00	0.00	0.00	0.99
R^2	0.10	0.15	0.19	0.15	0.05	0.09	0.15	0.19	0.15	0.05
	CRSP excluding dividends					CRSP including dividends				
k (months)	1	2	3	6	12	1	2	3	6	12
$\widehat{\alpha}$	-0.11	-0.16	-0.17	-0.16	-0.05	-0.12	-0.18	-0.19	-0.18	-0.07
S.E.(α)	0.06	0.07	0.08	0.10	0.10	0.06	0.07	0.08	0.10	0.10
$\widehat{\beta}$	8.18	8.58	8.39	6.34	2.69	8.17	8.56	8.36	6.30	2.67
S.E.(β)	2.24	1.72	1.88	1.85	1.73	2.24	1.70	1.85	1.81	1.68
$\widehat{\delta}$	-5.97	-5.20	-4.61	-2.15	-0.32	-6.00	-5.22	-4.61	-2.17	-0.34
S.E.(δ)	1.89	0.81	0.91	0.50	0.28	1.89	0.80	0.90	0.49	0.27
p-val ($H_0 : \alpha = \delta = 0, \beta = 1$)	0.01	0.00	0.00	0.00	0.61	0.01	0.00	0.00	0.00	0.61
R^2	0.08	0.13	0.17	0.16	0.07	0.08	0.13	0.17	0.16	0.07

For the 12-month horizon, the estimate $\widehat{\beta}$ gets closer to one, while $\widehat{\delta}$ is close to zero. The restriction $\alpha = \delta = 0, \beta = 1$ can not be rejected when k=12, implying that the realized variance measure σ^2_{EWMA} has no incremental predictive power over $SVIX^2$. The restricted out-of-sample measure (4) is not reported in Table 3, as the measure is by construction identical to the measure reported in Table 1.

2.4 A comparison of SVIX and EWMA volatility

The results in the prior subsections provide evidence for a positive risk-return trade-off when risk is measured by implied volatility, but not when risk is measured by realized volatility. As emphasized by Martin (2018), the risk-return trade-off as described by e.g. Merton (1980) postulates a positive *instantaneous* relation between realized volatility and the equity premium, thus implying that future returns should be proportional to future volatility. In other words, returns should be predictable by predictors of future volatility, but not necessarily by historical realized volatility. To reconcile my results with this prior literature,

Table 4: SVIX and EWMA - correlation

This table reports the correlation between monthly observations of $SVIX^2_{t,k}$ at different horizons k, $\sigma^2_{EWMA_t}$, and the next month's equity premium R^e_{t+1}. $\sigma^2_{EWMA,t}$ and R^e_{t+1} are computed from the S&P 500 total return index. Panel A (B) reports correlations for all variables in levels (monthly changes). Sample: 1996:01-2012:01.

A: Correlation in levels

	$SVIX^2_{t,2}$	$SVIX^2_{t,3}$	$SVIX^2_{t,6}$	$SVIX^2_{t,12}$	$\sigma^2_{EWMA,t}$	R^e_{t+1}
$SVIX^2_{t,1}$	0.99	0.98	0.95	0.89	0.88	0.03
$SVIX^2_{t,2}$		0.99	0.97	0.93	0.87	0.04
$SVIX^2_{t,3}$			0.99	0.95	0.85	0.04
$SVIX^2_{t,6}$				0.98	0.81	0.06
$SVIX^2_{t,12}$					0.76	0.04
$\sigma^2_{EWMA,t}$						-0.12

B: Correlation in differences

	$\Delta SVIX^2_{t,2}$	$\Delta SVIX^2_{t,3}$	$\Delta SVIX^2_{t,6}$	$\Delta SVIX^2_{t,12}$	$\Delta\sigma^2_{EWMA,t}$	ΔR^e_{t+1}
$\Delta SVIX^2_{t,1}$	0.98	0.94	0.89	0.82	0.72	0.43
$\Delta SVIX^2_{t,2}$		0.98	0.95	0.88	0.71	0.44
$\Delta SVIX^2_{t,3}$			0.98	0.91	0.69	0.44
$\Delta SVIX^2_{t,6}$				0.94	0.66	0.45
$\Delta SVIX^2_{t,12}$					0.57	0.43
$\Delta\sigma^2_{EWMA,t}$						0.20

I have in this subsection a closer look at the relation between $SVIX^2$ and σ^2_{EWMA}. I show that the option-implied measure SVIX indeed contains information that is not captured by realized volatility, and is in fact predictive of future realized volatility. As a leading indicator of future market risk, SVIX therefore explains future market returns.

Table 4 reports the contemporaneous correlation between the $SVIX^2$ index at various horizons, and the realized variance measure σ^2_{EWMA}. The correlation between $SVIX^2$ and σ^2_{EWMA} is close to 90% at short horizons. Also in terms of monthly time-series differences (Table 4 Panel B), the correlation is strongly positive. Despite the evident similarity between the measures, the correlation with next month's excess return is positive for $SVIX^2$, while negative for σ^2_{EWMA}. Apparently, $SVIX^2$ (implied by option prices) contains information about future stock returns that is not reflected by σ^2_{EWMA} (calculated from observed returns).

Table 5 reports the results from regressing monthly time-series differences in both $SVIX^2$ and σ^2_{EWMA} on lagged differences of both volatility measures. Consistent with the view that the implied volatility measure SVIX contains incremental forward looking information compared to realized volatility, I find that monthly changes of $SVIX^2$ predict next month's changes of σ^2_{EWMA}, while the reverse predictably of σ^2_{EWMA} to $SVIX^2$ is clearly much weaker.

Table 5: SVIX and EWMA - cross-predictability

This table reports the results from regressing monthly changes in $SVIX^2_{t,1}$ and $\sigma^2_{EWMA,t}$ on the prior month's (lagged) changes in both measures. $\sigma^2_{EWMA,t}$, is computed from the S&P 500 total return index. Newey-West standard errors are reported below the coefficients. Sample: 1996:01-2012:01.

	$\Delta SVIX^2_{t,1}$	$\Delta SVIX^2_{t,1}$	$\Delta SVIX^2_{t,1}$	$\Delta\sigma^2_{EWMA,t}$	$\Delta\sigma^2_{EWMA,t}$	$\Delta\sigma^2_{EWMA,t}$
intercept	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S.E.	0.0010	0.0010	0.0009	0.0021	0.0020	0.0020
$\Delta SVIX^2_{t-1,1}$	0.0277		-0.1397	0.3469		0.2727
S.E.	0.0863		0.0993	0.1199		0.1293
$\Delta\sigma^2_{EWMA,t-1}$		0.0931	0.1631		0.2092	0.0724
S.E.		0.0645	0.0963		0.1203	0.1657
R^2	0.0008	0.0177	0.0272	0.0587	0.0436	0.0612

3 Conclusions

Martin (2017) finds that the expected equity premium is proportional to the implied volatility measure SVIX. I investigate the robustness of this result by (*i*) considering US market returns including and excluding dividends and (*ii*) testing the predictive power of a simple measure of realized volatility.

I find that dividends have no notable impact on the predictive relation between SVIX and the equity premium: even if SVIX measures the volatility of price changes, the predictive results are nearly identical regardless of whether the market return is based on price changes alone or includes dividend yields.

The predictive relation does not hold, on the other hand, when the implied volatility measure SVIX is replaced by an EWMA measure of realized volatility. The results further indicate that SVIX predicts realized volatility, demonstrating that SVIX holds forward-looking information that is not captured by realized volatility. Overall, these results provide evidence for a positive risk-return trade-off, and for the hypothesis that option-implied volatility is a better predictor of future risk, and therefore of future market returns, than realized volatility.

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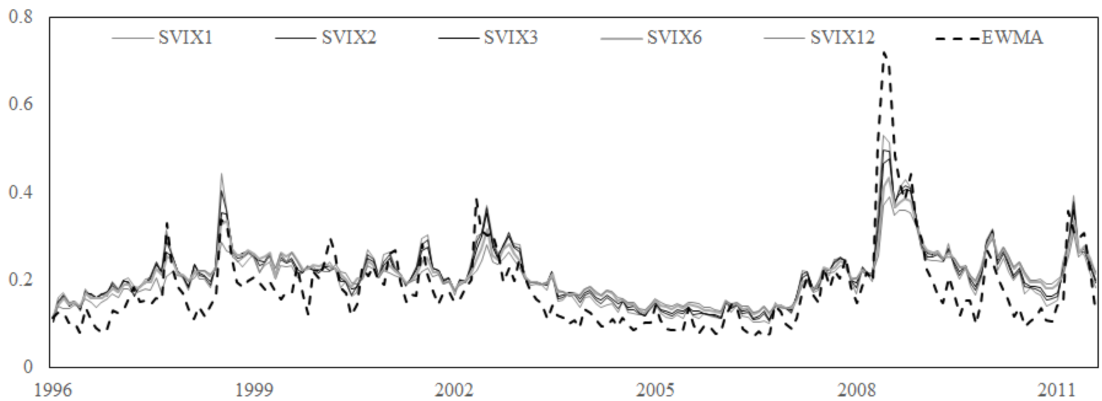

Figure 1: Time series of $\sigma_{EWMA,t}$ and $SVIX_{t,k}$, for 1, 2, 3, 6, and 12-month horizons k. Sample: 1996:01-2012:01