Implied Comovement

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Abstract

This paper employs forward-looking information from the options market to shed light on the comovement implications of 302 S&P 500 index addition events over the 1997-2009 period. We find that a stock's addition leads to a significant increase in the implied correlation with the S&P 500 index. The results also reveal increased comovement between the implied variance and skewness of the added stock and the implied variance and skewness of the S&P 500. The empirical results suggest that the index inclusion effect is not as straightforward as hitherto believed and that options market trading activity is essential for understanding important aspects of higher moment comovement changes after index additions.

Key words: index inclusion effect, comovement, implied risk-neutral moments

JEL classification: G12, G13, G14

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1. Introduction

Empirical studies have shown that, when a stock is added to a broad stock market index, the included stock tends to commove more with that index than prior to inclusion. This phenomenon is known as the "index inclusion effect". In the US equity market, Vijh (1994) and Barberis, Shleifer and Wurgler (2005) (BSW, hereafter) find that, when a stock is added to the S&P 500 index, its beta with the index increases significantly. Similar results are also reported by Greenwood and Sosner (2007) for stocks added to the Nikkei 225 in Japan and by Coakley and Kougoulis (2004) for stocks added to the FTSE 100 in UK. Claessens and Yafeh (2011) confirm the index inclusion effect using data on a sample of some forty developed and emerging markets.

Despite the potentially important economic consequences of the index inclusion effect (see Wurgler, 2011), there is a debate about the mechanisms underlying the increase in stock price comovement. One issue is whether index inclusions reveal any information about the included stocks' fundamentals. BSW support the idea that the increase in the beta coefficients reflects excess return comovement which is unrelated to news about fundamentals.[1] The category view of comovement involves investors first grouping assets into categories (e.g., small-cap stocks vs. large-cap stocks, growth stocks vs. value stocks) in order to simplify portfolio decisions, and some of these investors may also be noise traders. In the habitat view of comovement, investors for a variety of reasons trade only a subset of assets such as domestic stocks or tracker funds tied to the performance of the S&P 500 index. Greenwood (2008) argues that both the category and habitat explanations of excess comovement are demand-driven because they predict that, when a stock is added to the index, correlated noise trader demand tends to induce excess comovement with other S&P stocks. However, the

[1]Companies that construct equity indices argue that the decision to add a company to an index is an "information free" event that does not signal or imply changes in the fundamentals of the added company. Standard & Poor's claim that a stock is included in the S&P 500 only to make the index more representative of the overall US equity market and additions "do not in any way reflect an opinion on the investment merits of the company".

BSW view of excess comovement being independent of fundamentals has been challenged.[2] Studies such as Denis, McConnell, Ovtchinnikov, and Yu (2003), Cai (2007) or Kasch and Sarkar (2011) argue that index changes happen exactly when fundamentals also change and hence index reclassifications are economically informative events.

This paper addresses this issue from a novel angle. The S&P 500 inclusion effect is investigated and couched basically in terms of changes in historical, backward-looking beta coefficients with respect to the market index. The first contribution of this paper is that it tackles the index inclusion effect using forward-looking first moments garnered from options market data in addition to historical data. Implied betas can be backed out from options data using the recently proposed method by Chang, Christofersen, Jacobs, and Vainberg (2012). Our approach enjoys several advantages over previous studies that use historical beta estimates for studying changes in return comovement. One very important one is that risk-neutral moments are based on "forward looking" information extracted from the options market and may reflect more accurately changes in market conditions or changes in the structure of the underlying company. For this reason implied excess comovement imposes a higher burden of proof.

The use of option implied information can help differentiate between fundamental and sentiment or friction based theories of the index addition effect. If added firms experience changes to fundamentals or investors expect future changes to fundamental before index addition one would expect this information to be first reflected in the options market. If this is the case, one would expect no permanent changes in option implied measure of comovements after index inclusion. In the context of option markets, the category-or habitat-based view of

[2] BSW (2005) also adduce a third more rational explanation of the comovement change based on the information diffusion view in the presence of market frictions. This approach suggests that the betas of stocks added to a market index increase because, following inclusion, they become more liquid with lower trading costs and incorporate market-wide news simultaneously with other index stocks. They find that information diffusion can explain some of the excess comovement.

index inclusion can be rationalised on the following grounds. When a stock is added to the S&P 500, its options become more closely linked to S&P 500 index options.[3] The option prices of the added stock comove more with the S&P 500 index option prices because of index tracking and arbitrage trading strategies. The latter include dispersion trades, where arbitrageurs sell (buy) index options and buy (sell) the individual options of the index constituent stocks.[4] Such an approach can also be reconciled with the increase in historical betas since as BSW point out "even if category- or habitat-based investors trade S&P futures and options rather than the underlying stocks, any influence they have on the prices of these futures and options is quickly transmitted to the cash market by index arbitrageurs".

Our empirical analysis is based on time series data of risk-neutral variance and skewness. We calculate the risk-neutral moments using the model-free method of Bakshi, Kapadia and Madan (2003). This method takes into account the full cross section of option prices and, for any given maturity, the risk-neutral skewness and volatility are equivalent to portfolios of call and put option prices. An additional advantage from using option implied information is that the estimation of implied risk-neutral moments and implied betas is not affected by the choice of sampling frequency. BSW find a significant increase in the betas of stocks added to S&P 500 at both daily and weekly frequencies. However, changes in betas are not significant at monthly frequencies for the three-year post event estimation window. BSW suggest that comovement disappears in the long run because of reversion in noise trader sentiment. Since option prices are based on the distribution of future stock prices, implied moments should not be significantly affected by temporary stock price movements.

[3]In a recent study, Agyei-Ampomah and Mazouz (2011) examine changes in return comovement around the listing and delisting of stock option contracts and find evidence consistent with the category-or habitat-based view. They show that after option listing the return of the underlying stock comoves more with a portfolio of option listed stocks and comoves less with a portfolio of stocks that do not have listed options. They also show that commonalities in option trading can induce some of the comovement in the option listed stocks.

[4] See Driessen, Maenhout and Vilkov (2009) for a description of dispersion trading strategies.

We calculate implied betas using the method proposed by Chang, Christofersen, Jacobs, and Vainberg (2012) and the method proposed by French, Groth, and Kolari (1983). We find that option implied betas increase after index inclusions, albeit the results are statistically less significant for the case of Chang, Christofersen, Jacobs, and Vainberg (2012) impied betas. We decompose changes in implied betas and we find a significant positive change in the implied correlation between the added stock and S&P 500. Besides looking at changes in implied betas, the paper's second contribution is that it investigates the index inclusion effect by testing for changes in comovement between higher-order moments. Specifically, we examine whether the implied variance and skewness of a stock comoves more with the implied variance and skewness of the S&P 500 after index addition. Examining changes in variance comovement between added stocks and the market is an alternative indirect way to examine changes in return comovement.[5] We find a permanent increase in the comovement between the implied variance and skewness of the added stock and the implied variance and skewness of the S&P 500. Overall, our empirical results support the category-or habitat-based explanation of the index addition affect and provide evidence that the index inclusion effect is not as straightforward as hitherto believed and that trading activity in the options market may explain important aspects of comovement changes after index additions.

The remainder of the paper is structured as follows. The next section describes the methodology for calculating the implied variance and skewness and the implied beta. Section 3 presents and discusses the empirical results. The final Section concludes and presents the implications of the study. It also suggests directions for future research.

[5] Supposed that stock returns are well described by a one-factor market model, $R_i = a + \beta_i R_M + \varepsilon_i$. If we calculate the variance of both sides, the variance of the stock is, $VAR(R_i) = \beta_i^2 VAR(R_M) + VAR(\varepsilon_i)$. Therefore, an increase in beta implies an increase in the sensitivity of stock variance to market variance.

2. Implied betas

We construct implied betas from options data using the method proposed by Chang, Christofersen, Jacobs, and Vainberg (2012; CCJV hereafter). We assume that the log return of stock *i* is well described by a one-factor market model of the form:

$$R_i = a + \beta_i R_M + \varepsilon_i \tag{1}$$

The skeweness of R_i can be written as:

$$\begin{aligned}
SKEW_i &= \frac{E[a_i + \beta_i R_m + \varepsilon_i - E[a_i + \beta_i R_m + \varepsilon_i]]^3}{VAR_i^{3/2}} \\
&= \frac{\beta_i^3 E[R_m - \mu_m]^3 + E[\varepsilon_i]^3}{VAR_i^{3/2}} \\
&= \frac{\beta_i^3 SKEW_m VAR_m^{3/2} + SKEW_{\varepsilon,i} VAR_{\varepsilon,i}^{3/2}}{VAR_i^{3/2}}
\end{aligned} \tag{2}$$

Solving for β_i we obtain:

$$\beta_i^{CCJV} = \left[\left(\frac{SKEW_i}{SKEW_m} \right) \left(\frac{VAR_i}{VAR_m} \right)^{3/2} - \left(\frac{SKEW_{\varepsilon,i}}{SKEW_m} \right) \left(\frac{VAR_{\varepsilon,i}}{VAR_m} \right)^{3/2} \right]^{1/3} \tag{3}$$

To obtain a solution for β_i^{CCJV} that depends only on moments of R_i and R_m, Chang, Christofersen, Jacobs, and Vainberg (2012) make the additional assumption that $SKEW_{\varepsilon,i} = 0$. Under this assumption, the solution for β_i^{CCJV} is:

$$\beta_i^{CCJV} = \left(\frac{SKEW_i}{SKEW_M} \right)^{1/3} \left(\frac{VAR_i}{VAR_M} \right)^{1/2} \tag{4}$$

where $SKEW_i$ and VAR_i are the skewness and variance of stock *i*, respectively, and $SKEW_M$ and VAR_M are the skewness and variance of the market. Comparing expression (4) with the historical OLS estimate of beta, $\beta_i^{hist} = \rho_{i,M} (\sigma_i / \sigma_M)$, it is evident that the skewness ratio can be used as a proxy for correlation.

Instead of using historical data as in extant studies, we calculate the moments of the return distribution using options data. We follow the method of Bakshi, Kapadia and Madan (2003) who show that the risk-neutral skewness and variance can be extracted in a model-free manner using out-of-the-money call and put option prices. For a given horizon τ, τhe risk-neutral skewness is expressed as a portfolio of three contracts: the quadratic contract, the cubic contract and the quartic contract, which are given by:

$$V(t,\tau) \equiv E^q\{e^{-r\tau} R_{t,\tau}^2\}$$

$$W(t,\tau) \equiv E^q\{e^{-r\tau} R_{t,\tau}^3\}$$

$$X(t,\tau) \equiv E^q\{e^{-r\tau} R_{t,\tau}^4\} .$$

At date *t*, the three contracts have the following form,

$$\begin{aligned} V(t,\tau) = & \int_{S_t}^{\infty} \frac{2(1-\ln[K/S_t])}{K^2} C(t,\tau;K)dK \\ & + \int_0^{S_t} \frac{2(1+\ln[S_t/K])}{K^2} P(t,\tau;K)dK, \end{aligned}$$

$$\begin{aligned} W(t,\tau) = & \int_{S_t}^{\infty} \frac{6\ln[K/S_t]-3(\ln[K/S_t])^2}{K^2} C(t,\tau;K)dK \\ & - \int_0^{S_t} \frac{6\ln[S_t/K]+3(\ln[S_t/K])^2}{K^2} P(t,\tau;K)dK \end{aligned}$$

$$\begin{aligned} X(t,\tau) = & \int_{S_t}^{\infty} \frac{12(\ln[K/S_t])^2-4(\ln[K/S_t])^3}{K^2} C(t,\tau;K)dK \\ & + \int_0^{S_t} \frac{12(\ln[S_t/K])^2+4(\ln[S_t/K])^3}{K^2} P(t,\tau;K)dK, \end{aligned}$$

where S_t is the price of the underlying asset and $C(t,\tau,K)$ and $P(t,\tau,K)$ are OTM call and put option prices, respectively, with strike price K and τ time to maturity. The risk-neutral variance and skewness can be expressed as follows,

$$VAR_{t,T}^{Q} \equiv E^{q}\{(R_{t,\tau} - E^{q}[R_{t,\tau}])^{2}\} = e^{r\tau}V(t,\tau) - \mu(t,\tau)^{2} \tag{5}$$

$$SKEW_{t,T}^{Q} \equiv= \frac{E^{q}\{(R_{t,\tau} - E^{q}[R_{t,\tau}])^{3}\}}{E^{q}\{(R_{t,\tau} - E^{q}[R_{t,\tau}])^{2}\}^{3/2}} = \frac{e^{r\tau}W(t,\tau) - 3e^{r\tau}\mu(t,\tau)V(t,\tau) + 2\mu(t,\tau)^{3}}{[e^{r\tau}V(t,\tau) - \mu(t,\tau)^{2}]^{3/2}} \tag{6}$$

where. $\mu(t,\tau) = e^{r\tau} - 1 - \frac{e^{r\tau}}{2}V(t,\tau) - \frac{e^{r\tau}}{6}W(t,\tau) - \frac{e^{r\tau}}{24}X(t,\tau)$.

Using the option implied moments the CCJV beta estimator is:

$$\beta_{i,t}^{CCJV} = \left(\frac{SKEW_{i,t}^{Q}}{SKEW_{M,t}^{Q}}\right)^{1/3}\left(\frac{VAR_{i,t}^{Q}}{VAR_{M,t}^{Q}}\right)^{1/2} \tag{7}$$

In the empirical analysis we also use the beta estimator proposed by French, Groth, and Kolari (1983; hereafter FGK):

$$\beta_{i,t}^{FGK} = \rho_{i,M}\left(\frac{VAR_{i,t}^{Q}}{VAR_{M,t}^{Q}}\right)^{1/2} \tag{8}$$

where $\rho_{i,M}$ is the correlation between stock *i* and the market which is computed using historical data. The FGK beta estimator is a hybrid approach that uses both historical and option implied information. Buss and Vilkov (2012) propose an alternative implied beta estimator which is also based solely on option implied data. They show that their proposed estimator is a better predictor of realized beta compared to the CCVJ and FGK estimators. Unfortunately, the Buss and Vilkov (2012) estimator requires the use of index weights and therefore cannot be applied to obtain implied betas before addition to the S&P 500.

Note that implied betas and historical betas need not be the same. Implied betas are calculated from option implied moments and these moments may reflect risk premiums. For example, numerous studies have documented a significant difference between risk-neutral volatility and historical volatility, which is usually attributed to the presence of a volatility risk premium. In addition, Driessen, Maenhout, and Vilkov (2005) show that implied correlation also embeds a risk premium. We discuss further this issue in section 3.2.

We use the volatility surface file from OptionMetrics to calculate the risk neutral skewness and volatility. OptionMetrics provides historical prices of all US listed equity and index options based on the closing quotes at the Chicago Board of Option Exchange (CBOE). The volatility surface file contains the interpolated volatility surface for each security using a methodology based on a kernel smoothing algorithm. From the volatility surface we use volatilities with 30, 60, 91, and 182 calendar days to expiration and calculate equations (5) and (6) using the methodology outlined in DeMiguel, Plyakha, Uppal, and Vilkov (2012).

3. Empirical results

The S&P 500 Index addition events are downloaded from Professor Jeffrey Wurgler's website for the 1997-2000 period and they are extracted from Standard & Poor's annual reviews for the 2001-2009 period. Similar to BSW (2005), inclusion events are excluded if the new firm is a spin-off or a restructured version of a firm already in the index or if the firm is engaged in a merger or takeover around the inclusion event. We collect the corresponding options data from the Ivy Database of OptionMetrics for each stock included in the addition list. We require at least one year of option prices data before and after the addition event for a stock to be included in the analysis. We employ addition events because the majority of stocks that are deleted from the S&P 500 do not satisfy the latter criterion. Overall, our sample period yields a total of some 302 inclusion events.

3.1 Characteristics of added stocks

Figure 1 shows the number of stock additions each year from 1997 to 2009.

[Figure 1 around here]

It indicates that addition events display a cyclical pattern with booms during the dot.com years and in the run up prior to the recent financial crisis. The maximum number of additions was in 2000 (42 additions) at the peak of the dot.com boom and the minimum number was in 2003 (5 additions).

Figure 2 plots the non-overlapping 30-day risk neutral moments of the S&P 500 and the 30-day risk neutral moments of the stocks employed in the empirical analysis for the 1997-2009 period.

[Figure 2 around here]

Panel A plots the implied variance of the S&P 500 and the average stock implied variance. At each point in time, the average stock implied variance is the equally weighted cross sectional average of the implied variance of stocks added to the S&P 500 during the 1996-2009 period. Panel B plots the implied skewness of the S&P 500 and the average stock implied skewness for the same time period. As expected, the average stock implied variance is higher than the S&P's implied variance. However, the S&P is consistently more negatively skewed. The S&P is more negatively skewed because out-of-the-money index put options are consistently more expensive than the corresponding out-of-the money index call options. Rubinstein (1994) refers to this phenomenon as "crash-o-phobia" and attributes it to the strong demand for out-of-the-money put options to hedge against market crashes. Bakshi, Kapadia and Madan, (2003) also find that the risk-neutral distribution of individual stocks is less negatively skewed and substantially more volatile than the risk-neutral distribution of the market index. The time series average implied variance of the stocks added to the S&P 500 is 0.18 (43% volatility) and the time series average implied variance of the S&P 500 is 0.05 (22% volatility). The time series average of stocks implied skewness is -0.18 and the time series average of the market's implied skewness is -0.71, and the substantial difference is statistically significant at the 1% level.

3.2 Historical and implied beta changes

Following DeFusco, Johnson, and Zorn (1990), market-adjusted implied variance is defined as the ratio of the implied variance of the stock to the implied variance of the market ($VAR_{i,t} / VAR_{M,t}$) and market-adjusted implied skewness is defined as the ratio of the implied skewness of the stock to the implied skewness of the market ($SKEW_{i,t} / SKEW_{M,t}$).We examine changes in market adjusted variance and skewness using very short time windows. Figure 3 plots the daily cross sectional average of market adjusted variance and skewness.

[Figure 3 around here]

The time window is 60 days before and 60 days after index addition announcement or implementation where these are different. On the announcement day, the market-adjusted variance of stocks added to the S&P 500 spikes and then reverts to normal levels within a 10-day period. It is consistent with the findings of Dash and Liu (2008) who show that option trading volume surges after the announcement and option prices increase. However, they also show that it is not possible to profit from options trading since changes in option prices happen very shortly after the announcement. This is one justification for excluding the announcement month. The time evolution of market-adjusted implied skewness does not display any systematic change during the announcement day.

In the main empirical analysis two different pre-and post-event estimation windows are considered:

(a) One year before and one year after the addition of the stock excluding the month of the announcement and inclusion implementation. This yields a total of 302 events.
(b) Three years before and three years after the addition of the stock excluding the month of the announcement and inclusion implementation. The total number of events now reduces to 190 due to data unavailability for the longer window span.

For each sample stock we obtain daily CCVJ and FGK implied implied betas and OLS historical betas using daily data. For the computation of the FGK implied betas we use the pre- and post-event historical data to estimate the correlation coefficient and the average pre- and post-event stock and market implied volatility. For the computation of the CCVJ betas we use daily implied variance and skewness data. All implied betas are computed for different horizons using using options with maturities of 30, 60, 91 and 182 calendar days – for the estimation windows (a) or (b) before and after a stock's addition to the S&P 500. Then we average across all stocks to obtain the pre- and post-event estimates and then test if the difference is significant.

Table 1 reports the results.

[Table 1 around here]

Using historical returns, the index inclusion effect results are broadly in line with those of BSW (2005). The pre-addition beta is 1.0741 and the post-addition beta is 1.256 and both are significant at the 1% level. The difference of some 18 percentage points is statistically significant at the 1% significance level (*t*-stat = 6.3569). This compares with the difference of some 21 percentage points found by BSW (2005) at the daily frequency for the 1988-2000 period.

The main hypothesis is that index inclusion involves no excess comovement in returns once one allows for forward looking information from the options market. This would imply no difference in the pre- and post-addition implied beta estimates. The results show that the post addition FGK implied betas are be 20-30 percentage points higher than their corresponding pre-addition estimates. The difference is significant regardless of option maturity or estimation window. In the case of CCVJ estimates, the post-addition implied beta estimates are approximately 6 percentage points higher than their corresponding pre-addition estimates at the 30 and 60 day maturities. These changes are statistically significant at the 10% significance level but insignificant at the longer two maturities and provide some weak evidence of temporary excess comovement that dissipates within one year. For the three-year window, only the difference at the 91-day maturity is significant at the 10% level.

In Table 2 we examine separately each component of the CCVJ and OLS beta estimates. [6] The first component is the correlation coefficient and the second component is the stock volatility to market volatility ratio. These two components are computed either from option data or from historical data. The change in the correlation coefficient computed from option prices, $(SKEW^{Q}_{i,t} \big/ SKEW^{Q}_{M,t})^{1/3}$, is always positive and statistically significant. The only exemption being the one-year estimation window with options maturity 182 days. For example, for the one-year estimation window the 30-day pre-event average implied correlation is 55% and the corresponding post-event estimate is 60%. The difference is significant with a *t*-statistic of 3.77. The pre-event historical correlation for the same estimation window is 40% and the post-event estimate is 50% and this difference is highly

[6] In discrete form, the total derivative of the beta estimate is given by: $\Delta\beta_i = (\sigma_i / \sigma_M)\Delta\rho_{i,M} + (\rho_{i,M} / \sigma_M)\Delta\sigma_i - (\rho_{i,M}\sigma_i \big/ \sigma_M^2)\Delta\sigma_M$. The beta can change because of a change in correlation, a change in firm's volatility or a change in market's volatility.

significant with a *t*-statistic of 10. Looking at the three-year estimation window, the 30-day pre-event average implied correlation is 55% and the corresponding post-event estimate is 62%. The difference is again significant with a *t*-statistic of 3.83. The pre-event historical correlation for the same estimation window is 34% and the post-event estimate is 50% and this difference is highly significant with a *t*-statistic of 13. The change in the stock volatility to market volatility ratio computed from option data is negative and always significant for the three-year estimation window. For the one-year estimation window the change is negative and significant only for options with 30-day maturity. The change in the stock volatility to market volatility ratio computed from historical data is negative and significant for both estimation windows.

Given the results in Table 2, we can conclude that the weak statistical results regarding the CCVJ estimates are driven by the interaction between changes in implied correlation and changes in the implied volatility ratio. The results in Table 2 can also help to understand the systematic divergence between historical betas, CCVJ betas and FGK betas. The CCVJ implied beta is higher than the OLS beta which in turn is higher than the FGK implied beta. The FGK is biased downwards compared to the OLS estimate because the stock volatility to market volatility ratio is smaller when computed from option data. This is because the implied market volatility tends to be higher than the historical market volatility. The CCVJ betas are higher than the OLS betas because the proxy for expected correlation (the skewness ratio) tends to be higher than the historical correlation, which also cancels out the impact of the lower volatility ratio.

3.3 Changes in implied variance and skewness comovement

Tables 3 and Table 4 report comovement in higher moments. More specifically, they show the changes in betas and R^2s before and after addition to the S&P 500 using the following regressions:

$$VAR_{i,t} = a + \beta_{i,VAR} VAR_{M,t} + \varepsilon_{i,t} \quad (8)$$

$$SKEW_{i,t} = a + \beta_{i,SKEW} SKEW_{M,t} + \varepsilon_{i,t} \quad (9)$$

where $SKEW_{i,t}$ and $VAR_{i,t}$ are the implied skewness and variance of stock *i*, respectively, and $SKEW_M$ and VAR_M are the implied skewness and variance of the S&P 500. For each stock in our sample, we estimate the slopes and R^2s of the two regressions using daily data one year (or three years) before the addition and then we restimate using data one year (or three years) after the addition of the stock to the S&P 500. In the estimation periods we exclude the month of the announcement/ implementation. We average across all stocks to obtain the pre- and post- event slope and R^2 estimates.

Table 3 presents the results for the implied variance regressions.

[Table 3 around here]

Regression (8) is an alternative indirect way to test for changes in return comovement. Since we assume that stock returns are well described by a one-factor market model, an increase in beta implies an increase in variance comovement, $VAR(R_i) = \beta_i^2 VAR(R_M) + VAR(\varepsilon_i)$, between the added stock and the market. The empirical results show that the implied variance of added stocks commoves more with the implied variance of the S&P index after stock inclusion. Moreover the results hold at all four option maturities.

The change is statistically significant at all conventional levels and regardless of the estimation window. The R^2 of the regression also increases significantly. For example, the β_{VAR} coefficient increases from 1.9391 to 2.8754 and the R^2 increases from 31.46% to

42.41% in the one-year estimation window for the 60-day maturity. For the same options maturity, the β_{VAR} coefficient increases from 1.6192 to 2.8223 and the R^2 increases form 28.21% to 54.55% in the three-year estimation window. The conclusion is that there is unequivocal evidence of excess comovement in implied volatility after stock inclusions in the S&P 500.

Table 4 presents the results for the implied skewness regressions.

[Table 4 around here]

They indicates that the comovement between the risk neutral skewness of a stock and the risk neutral skewness of the market does not change significantly when we use the one-year pre-and-post estimation window. The changes in R^2 are positive and significant for the one-year window but the levels of the R^2 range are low. For example, the R^2 *f*or the 30-day implied skewness increases from 3.2% to 5%. The small R^2 is consistent with Dennis and Mayhew (2002) who find that firm specific factors are more important than systematic factors in explaining the variation in the risk-neutral skewness of individual equity options. By contrast, comovement given by the change in the β_{SKEW} coefficient increases significantly for the three-year window and the increases of the coefficients are in the 0.12 - 0.23 range. The pre-event R^2 is in the range of 3.19% - 6.45% and the post-event R^2 is in the range of 10.50% to 26.74% for the various option maturities.

4. Conclusions

In this paper we examine the S&P 500 index addition effect using information from the options market. Our sample covers the 1997 to 2009 period, a total of 302 addition events. We test if implied betas and market-adjusted implied variance and skewness change significantly after index addition. We also test for changes in comovement between higher-moments. Specifically, we examine whether the implied variance and skewness of a stock comoves more with the implied variance and skewness of the S&P 500 after index addition. The empirical analysis shows that a stock's addition to the S&P 500 leads to: (a) significant positive change in implied correlation (b) weakly significant positive change in implied betas and (c) increased comovement between the implied variance and skewness of the added stock and the implied variance and skewness of the S&P 500. Overall, our empirical results support the category-or habitat-based explanation of the index addition and suggest trading activity in the options market may explain important aspects of comovement changes after index additions.

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Figure 1: S&P 500 Stock Additions for the Time Period 1997-2009

The S&P 500 Index addition events are collected from Professor Jeffrey Wurgler's website for the 1997-2000 period and are collected from Standard & Poor's annual reviews for 2001-2009. Similar to BSW (2005), inclusion events are excluded if the new firm is a spin-off or a restructured version of a firm already in the index or if the firm is engaged in a merger or takeover around the inclusion event.

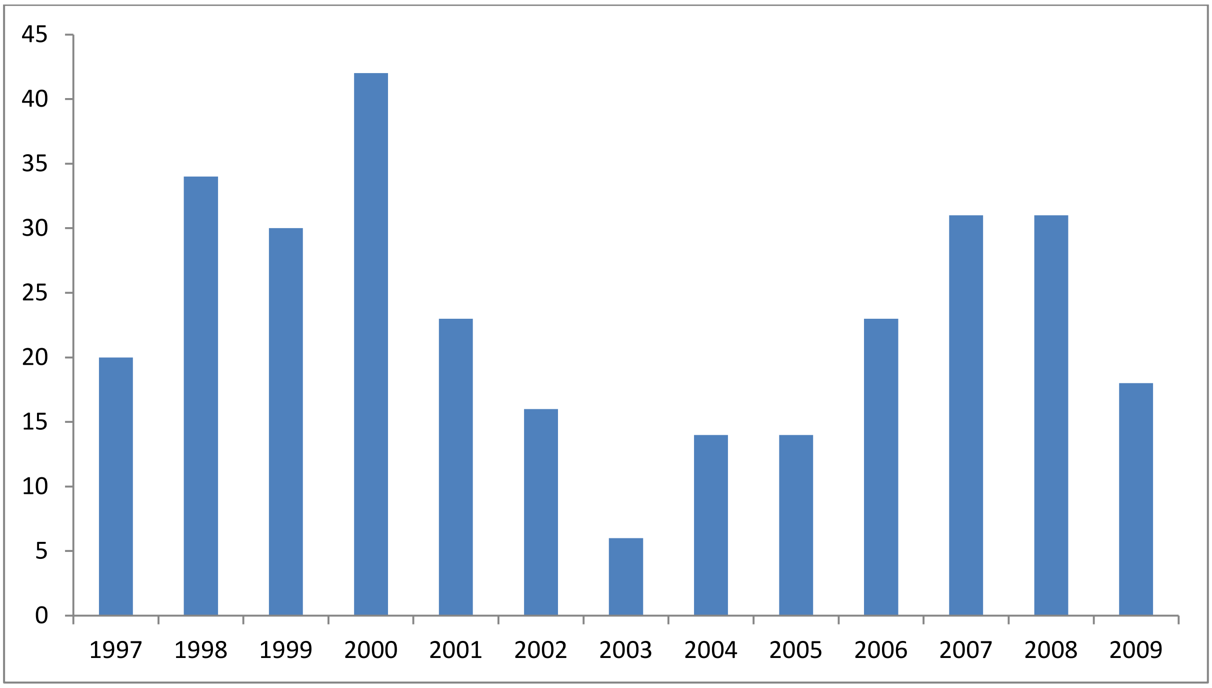


Figure 2: Implied Moments 1996-2010

The top panel plots the implied variance of the S&P 500 and the average stock implied variance. The average stock implied variance at each point in time is the cross sectional average of the implied variance of stocks added to the S&P 500.

The lower panel plots the implied skewness of the S&P 500 and the average stock implied skewness.

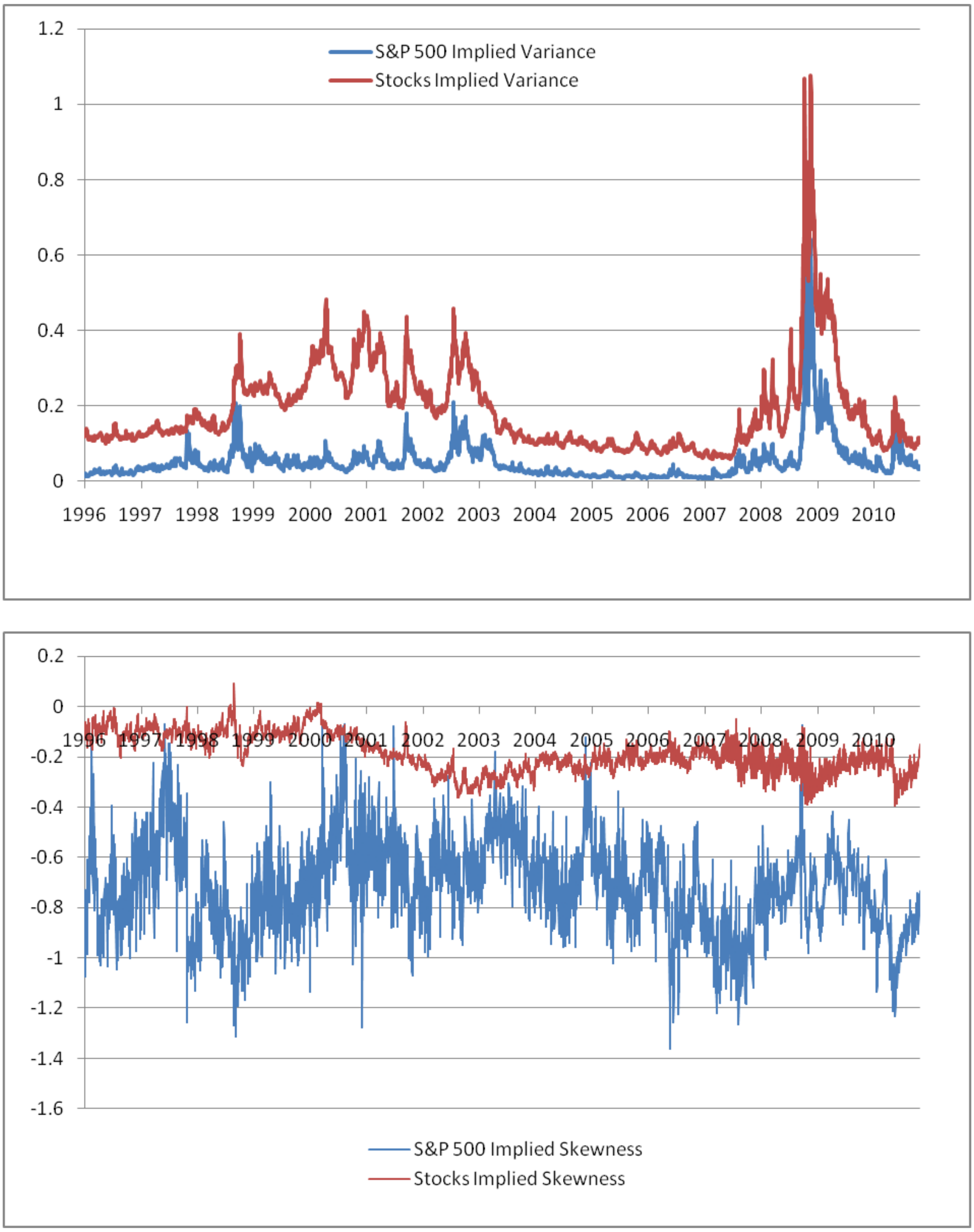
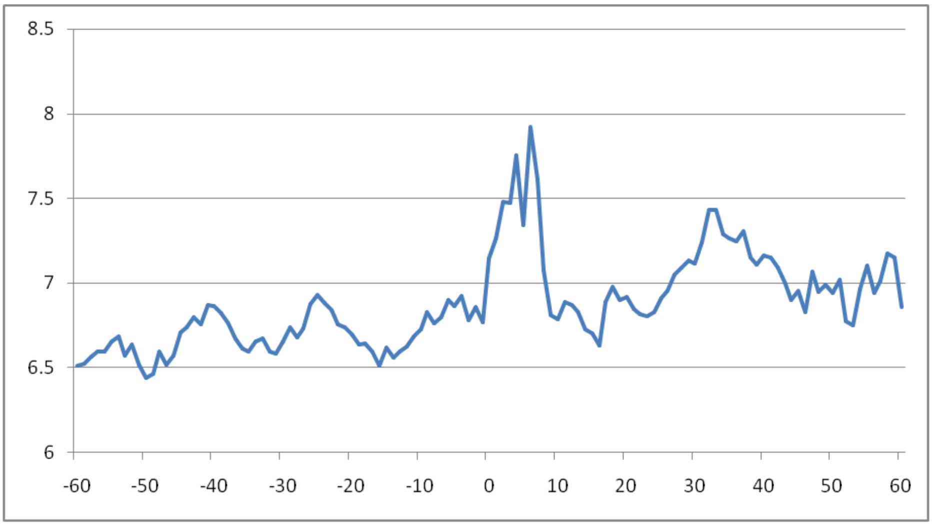


Figure 3: Market-adjusted variance and skewness before and after index addition announcements

The market-adjusted implied variance is defined as the ratio of the implied variance of the stock to the implied variance of the market ($VAR_{i,t}/VAR_{M,t}$) and market-adjusted skewness is defined as the ratio of the implied skewness of the stock to the implied skewness of the market ($SKEW_{i,t}/SKEW_{M,t}$). The Figure plots the daily stock cross sectional average of market-adjusted variance (top panel) and skewness (lower panel). The time window is 60 days before and 60 days after the index addition announcements.



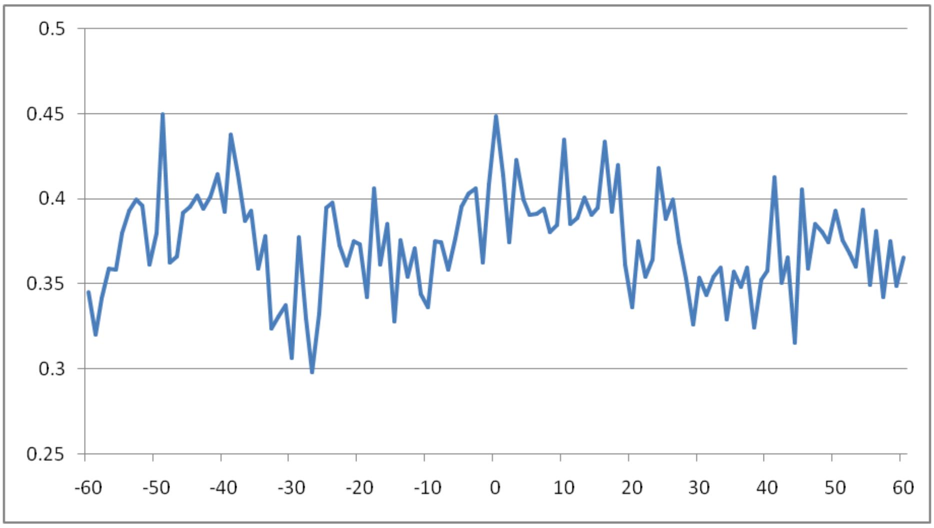


Table 1: Changes in implied and historical betas

The implied beta CCJV is calculated using equation (7) and the implied beta FGK is calculated using equation (8) . The historical beta is the OLS estimate from regression (1). For each stock in our sample we calculate the daily implied betas using daily data one year (or three years) before and one year (or three years) after the addition of the stock to the S&P 500 excluding the month of the announcement/implementation. Then for each stock we calculate the average implied beta before and after the inclusion event and we average across all stocks to obtain the pre- and post-event implied beta estimates. All implied betas are computed for different horizons using options with maturities of 30, 60, 91 and 182 calendar days.

Implied and historical betas									
One-year									
Maturity	30		60		91		182		
Method	CCVJ	FGK	CCVJ	FGK	CCVJ	FGK	CCVJ	FGK	Historical
Before	1.2715	0.9155	1.2560	0.8822	1.2277	0.8573	0.9544	0.8169	1.0741
After	1.3307	1.1147	1.3141	1.0766	1.2652	1.0513	0.8950	1.0140	1.2566
Difference	0.0592	0.1992	0.0581	0.1944	0.0306	0.1940	-0.059	0.1972	0.1825
t-stat	1.6560	7.8028	1.7980	7.6329	1.2265	7.7673	-1.523	8.0444	6.3569
Three-year									
Maturity	30		60		91		182		
Method	CCVJ	FGK	CCVJ	FGK	CCVJ	FGK	CCVJ	FGK	Historical
Before	1.3104	0.8242	1.2992	0.7851	1.2703	0.7584	1.0099	0.7180	1.0496
After	1.3566	1.0923	1.3687	1.0049	1.3458	0.9852	1.0733	0.9569	1.2840
Difference	0.0462	0.2680	0.0695	0.2198	0.0755	0.2268	0.0634	0.2389	0.2343
t-stat	0.9521	8.6813	1.4576	6.4828	1.6890	6.7527	1.3527	7.2207	6.5562

Table 2: Changes in implied correlation

The implied correlation (IC) is defined as the third root of the ratio of the implied skewness of the stock to the implied skewness of the market $(SKEW_i / SKEW_M)^{1/3}$. The implied volatility ratio (IVR) is the ratio of the implied volatility of the stock to the implied volatility of the market $(VAR_i / VAR_M)^{1/2}$. HC is the historical correlation and HVR is the ratio of stock volatility to market volatility using historical data. For each stock in our sample we calculate the daily ratios using daily data one year (or three years) before and one year (or three years) after the addition of the stock to the S&P 500 excluding the month of the announcement/ implementation. Then for each stock we calculate the average ratios before and after the inclusion event and we average across all stocks to obtain the pre- and post-event estimates. IC and IVR are computed for different horizons using options with maturities of 30, 60, 91 and 182 calendar days.

				One-year						
Maturity	30		60		91		182			
	IC	IVR	IC	IVR	IC	IVR	IC	IVR	HC	HVR
Before	0.5502	2.2851	0.5721	2.1964	0.5844	2.1333	0.5131	2.0287	0.4002	2.8234
After	0.6001	2.2169	0.6202	2.1467	0.6261	2.0920	0.5304	2.0087	0.5052	2.6116
Difference	0.0499	-0.0682	0.0481	-0.0498	0.0416	-0.0413	0.0173	-0.0200	0.1050	-0.2117
t-stat	3.7764	-2.0340	4.3339	-1.4764	3.7920	-1.2590	1.1725	-0.6563	10.7928	-3.0166
				Three-year						
Maturity	30		60		91		182			
	IC	IVR	IC	IVR	IC	IVR	IC	IVR	HC	HVR
Before	0.5563	2.3505	0.5855	2.2356	0.5988	2.1571	0.5321	2.0401	0.3425	3.0523
After	0.6245	2.0533	0.6535	1.9985	0.6662	1.9568	0.5971	1.8968	0.5063	2.7151
Difference	0.0682	-0.2972	0.0680	-0.2371	0.0674	-0.2003	0.0651	-0.1433	0.1637	-0.3372
t-stat	3.8329	-5.1899	3.9193	-4.1700	3.8395	-3.6153	3.2148	-2.7522	13.2369	-2.5191

Table 3: Changes in Implied Variance Comovement

We examine changes in implied variance comovement given by changes in betas ($\beta_{i,VAR}$) and R^2s before and after S&P 500 addition using the regression, $VAR_{i,t} = a + \beta_{i,VAR} VAR_{M,t} + \varepsilon_{i,t}$ where VAR_i is the implied variance of the stock and VAR_M is the implied variance of the S&P 500. We estimate the slope and R^2 of the regression for each sample stock (a total of xx stocks) using daily data one year (or three years) before the addition and then we restimate using data one year (or three years) after the addition of the stock in the S&P 500. We exclude the inclusion/ implementation month from the estimation periods. We average across all stocks to obtain the pre- and post-event slope and R^2 estimates. Implied stock variance and implied market variance are computed for different horizons using options with maturities of 30, 60, 91 and 182 calendar days.

Slope									
	One-year				Three-years				
Maturity	30	60	91	182	Maturity	30	60	91	182
Before	2.2562	1.9391	1.7423	1.7490	Before	1.7991	1.6192	1.3717	1.4447
After	2.8848	2.8754	2.5529	2.5477	After	2.7307	2.8223	1.4495	3.1003
Difference	0.6286	0.9362	0.8106	0.7988	Difference	0.9316	1.2031	0.0778	1.6556
t-stat	2.7248	3.2114	2.7774	2.0321	t-stat	4.5781	5.1610	5.5367	5.5167

R^2									
	One-year				Three-years				
Maturity	30	60	91	182	Maturity	30	60	91	182
Before	0.2885	0.3146	0.3277	0.3443	Before	0.2531	0.2821	0.2979	0.3227
After	0.3935	0.4241	0.4483	0.4549	After	0.5163	0.5455	0.5653	0.5818
Difference	0.1050	0.1095	0.1206	0.1105	Difference	0.2633	0.2634	0.2674	0.2590
t-stat	5.2251	5.4360	5.8512	5.3507	t-stat	9.6567	9.2602	9.2971	9.1118

Table 4: Changes in Implied Skewness Comovement

We examine changes in implied skewness comovement given by changes in betas ($\beta_{i,SKEW}$) and R^2s (ΔR^2) before and after inclusion using the regression, $SKEW_{i,t} = a + \beta_{i,SKEW} SKEW_{M,t} + \varepsilon_{i,t}$ where $SKEW_i$ is the implied skewness of the stock and $SKEW_M$ is the implied skewness of the S&P 500. We estimate the slope and R^2 of the regression for each sample stock (a total of xx stocks) using daily data one year (or three years) before the addition and then we restimate using data one year (or three years) after the addition of the stock in the S&P 500. We exclude the inclusion/ implementation month from the estimation periods. We average across all stocks to obtain the pre- and post-event slope and R^2 estimates. Implied stock skewness and implied market skewness are computed for different horizons using options with maturities of 30, 60, 91 and 182 calendar days.

				Slope					
	One-year					Three-years			
Maturity	30	60	91	182	Maturity	30	60	91	182
Before	0.0591	0.0489	0.0397	0.0428	Before	-0.0237	-0.0608	-0.0783	-0.0777
After	0.0725	0.0703	0.0653	0.1021	After	0.0996	0.0767	0.0876	0.1517
Difference	0.0133	0.0214	0.0256	0.0592	Difference	0.1233	0.1375	0.1658	0.2295
t-stat	0.4092	0.6996	0.8257	1.3493	t-stat	4.6399	4.5140	4.8839	5.6627
				R^2					
	One-year					Three-years			
Maturity	30	60	91	182	Maturity	30	60	91	182
Before	0.0319	0.0492	0.0648	0.0804	Before	0.0186	0.0323	0.0504	0.0645
After	0.0505	0.0666	0.0823	0.0994	After	0.1116	0.1478	0.1753	0.2022
Difference	0.0186	0.0174	0.0174	0.0190	Difference	0.0931	0.1155	0.1249	0.1377
t-stat	3.7668	2.5716	2.1245	1.8432	t-stat	5.9421	5.9648	5.8156	6.0127