Volume in Redundant Assets

by

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Introduction

Financial markets are often characterized by multiple contingent claims on the same underlying asset. While, as financial economists, we have made tremendous progress on how these claims should be priced relative to each other, what is less well understood is the nature of the trading activity in these claims. Why do theoretically redundant securities attract volume? How correlated is trading activity across these contingent claims? In which of these markets does price discovery take place? While a full answer to these questions should take voluminous amounts of work, in this paper we hope to shed some light on these issues in the context of three contingent claims on the S&P 500 index: futures, options, and the exchange traded fund.

Volume plays a fairly limited role in theories of contingent claims pricing. For example, Black and Scholes (1973) treat options as securities that are redundant and can be replicated in continuous time by investments in stocks and bonds. In this paradigm, there is no role for options volume. But, options are not replicable with stocks and bonds when the process for the underlying stock involves stochastic discontinuities (see Naik and Lee, 1990, and Pan and Liu, 2003). In general, when markets are incomplete, options cannot be replicated by trading in simple equity or fixed income securities (see Ross, 1976, Hakansson, 1982, and Detemple and Selden, 1991). But, no model of options markets explicitly allow for trading activity related to market completion.

Options markets may also alter the incentives to trade on private information about the underlying asset. Cao (1999) argues that informed agents should be able to trade more effectively in options that span more contingencies. In addition, informed traders may prefer to trade options rather than stock, because of increased leverage (Back, 1992).[1] Cao and Wei (2010) find evidence that information asymmetry is greater for options than for the underlying stock, implying that informed agents prefer options. This finding is supported by Easley, O'Hara, and Srinivas (1998), Chakravarty, Gulen, and Mayhew (2004), and Pan and Poteshman (2006), who find that options orders contain information about future stock prices. Ni, Pan, and Poteshman (2008) show that options order flows forecast stock volatility. Cao, Chen, and Griffin (2005) show that options volume predicts returns around takeover announcements, suggesting the presence of informed traders in the options market prior to corporate events.

In sum, the literature suggests that options markets stimulate informed trading. It also is well-known that options are used for hedging positions in other options as well as the underlying stock.[2] Thus, the literature suggests that options volume could arise both for informational as well as risk-sharing reasons. In a recent study, Roll, Schwartz, and Subrahmanyam (2010) analyze whether the ratio of index options volume relative to spot index volume is related to hedging and informational proxies. However, no studies have analyzed options volume in relation to other contingent claims on the same asset such as futures and ETFs.

[1]Figlewski and Webb (1993), Danielsen and Sorescu (2001), and Ofek, Richardson, and Whitelaw (2004) explore the role of options in alleviating short-selling constraints.
[2]Lakonishok, Lee, Pearson, and Poteshman (2007) show that covered call writing, a form of hedging, is one of the most commonly used strategies in options markets.

Some research has also looked at the relation between futures and the cash market. In a frictionless world, these securities would also be redundant, but Gorton and Pennachi (1993) and Subrahmanyam (1991) indicate that index futures may provide a means for uninformed traders by removing sensitivity to firm-specific informational asymmetries. Along these lines, Daigler and Wiley (1999) find that futures volatility is primarily caused by (presumably uninformed) members of the general public not part of the trading floor. Allaying concerns that derivatives may attract too many uninformed agents and cause volatility spillovers to the stock market, Bessembinder and Seguin (1992) find that futures volume only has a limited impact on stock volatility. Roll, Schwartz, and Subrahmanyam (2007) find that the liquidity of the underlying index influences the pricing gap between the theoretical and observed basis, but they do not analyze volume.

With regard to exchange-traded funds (ETFs), the third type of contingent claim we analyze, there has been no analysis of volume in ETFs vis-à-vis the underlying index, nor in relation to other contingent claims such as futures and options. However, Hasbrouck (2003) analyzes price formation in ETFs and finds that they are an important source of price discovery about the underlying index.

There also have been previous time-series studies of equity volume, many of which have focused on the contemporaneous links between volume and other variables such as return volatility or short-term patterns in volume. For example, a number of empirical papers have documented a positive correlation between volume and absolute price changes (see Karpoff, 1987, Schwert, 1989, and Gallant, Rossi, and Tauchen, 1992). Other papers document calendar regularities in volume. Thus, Amihud and Mendelson (1987, 1991) find that volume is higher at the market's open, while Foster and Viswanathan (1993) demonstrate a U-shaped intraday volume pattern and also find that trading volume is lower on Mondays. In another stream of research, Campbell, Grossman, and Wang (1993) and Llorente, Michaely, Saar, and Wang (2002) analyze the dynamic relation between returns and volume levels. Chordia, Roll, and Subrahmanyam (2010) consider the causes of the recent trend in trading activity and conclude that it is mainly due to a rise institutional trading, but they do not consider trends in contingent claims volume.

In contrast to previous work on trading activity, which has mostly analyzed volume in equities or in the context of a single contingent claim, we conduct an empirical study of the joint time-series of volume in the underlying S&P 500 index, its ETF, and index futures and options. Our data span a long (twelve-year) period and thereby allow us to uncover reliable patterns in these time-series. We are not aware of any previous attempt to jointly analyze trading activity that spans multiple contingent claims on the equity market.

Our main results can be summarized as follows: While volume in options, spot, and the ETF has trended upwards, that in futures has trended downward, indicating that other markets have acted as substitutes for the futures contract. All time-series fluctuate significantly from day to day. While daily changes in futures, spot, and ETF volumes are strongly and positively correlated, changes in options volume exhibit only weak correlations with the other series, suggesting that non-linear option payoffs attract a different clientele than the other markets.

We also find that calendar regularities are not common to all series. For example, there is a reliable January seasonal in spot volume, but not in the other series, providing support for the notion that year-end cash inflows stimulate equity investments (Ogden, 1990). Impulse response functions reveal that the series are jointly determined, though volume innovations in futures and ETF lead spot volume; this suggests that informed traders may trade first in contingent claims markets due to low transaction costs and additional leverage. We uncover evidence that contingent claims volume predicts shifts in the term structure and the credit spread, as well as returns and volatility around major macroeconomic announcements, thus underscoring the role of derivatives in price discovery.

The remainder of this paper is organized as follows. Section I describes the data. Section II presents the regressions intended to address calendar regularities and trends. Section III describes vector autoregressions. Section IV describes the role of the volume series in price formation around macroeconomic announcements. Section V concludes.

I. Data

The data are obtained from several sources. First, price-data.com provided data on index futures. Second, index options data were obtained from OptionMetrics (we simply use the sum of volume in calls and puts on the S&P 500 during a trading day[3]). Third, the CRSP database was used to obtain data on S&P 500 volume as well as volume on the S&P 500 ETF (SPDR). The sample spans the years 1996 to 2007, i.e., more than 3000 trading days.

The S&P500 index (or spot) volume is created by value-weighting individual stock volume for all stocks in the index every day, using value weights as of the end of the previous day. In creating this volume series, an important issue is the treatment of Nasdaq volume. Atkins and Dyl (1997) indicate that Nasdaq volume is overstated because of double counting of interdealer trading. However, Dyl and Anderson (2005) argue that in recent times, due to the rise of public limit orders and ECN trades reported on Nasdaq, the double-counting issue has been mitigated. They examine the trading of firms that switched from the NASDAQ to the NYSE in the 1997-2002 time period and find that median volume drops by about 37% which is less than the 50% number found by Atkins and Dyl (1997). We therefore scale Nasdaq volume by the implied adjustment factor of 1.59 (=100/63) prior to its usage in compute aggregate S&P500 volume.

[3] In part of the analysis we also use separately the volume in calls and puts.

The index futures volume series is constructed by starting with a contract having three months to maturity and rolling over every third Friday of March, June, September, and December into a successive contract with the same original time to maturity.[4]

Volume numbers are those reported by the data source; SPDRs trade in units of one-tenth of the index, options trade in units of $100 times the index, and futures trade in units of $500 times the index. These scale factors need to be borne in mind comparing the levels of volume.

Table 1 provides summary statistics on the data. The means are fairly close to the medians indicating little skewness, except for the ETF series. Panel B of Table 1 provides summary statistics for absolute proportional changes in volume. Options volume fluctuate the most from day to day while spot volume fluctuates the least. The percentage daily changes in volume are quite large, ranging from 13.2% per day for the spot market to 39.4% for the options market. Note that the median absolute change is lower than the mean for each of the volume series, suggesting some days with very large positive changes; this notion is confirmed by the consistently positive skewness statistic for each of the four series.

Figure 1 presents the time-series plots of the four series. As can be seen, the futures series exhibits a slight downward trend, whereas the other three series exhibit marginal to strong up-trends, with the Spider (ETF) volume growing the most. It appears

[4]Our exploratory investigation revealed that longer-maturity contracts are not very active, indicating that futures volume series with a longer time to maturity would not add much additional insight to our study.

that other contingent claims as well as the spot index have been crowding out futures markets as alternative avenues for trading equities. All series appear to be highly volatile, thus confirming the patterns in Panel B of Table 1.

In Table 2, we present the correlation matrix for levels as well as percentage changes. The futures volume levels (Panel A) are negatively correlated with other volume series, presumably because futures volume has trended downwards whereas the other series have trended upwards. The negative futures pattern disappears in Panel B, which reports correlations in percentage daily changes. Percentage changes in volume are strongly positively correlated among spot, futures, and the ETF, while volume changes exhibit only weak correlations the other three series. Perhaps the non-linear nature of option payoffs and the leverage afforded by options attracts a clientele with unique information, whose trades are, by definition, uncorrelated with those in the spot market and in other contingent claims.

II. Trends and Calendar Regularities

One of our primary goals is to perform vector autoregressions (VARs) to ascertain properties of the joint time-series of volume in contingent claims. For these VARs, it is desirable to first remove common regularities and trends from the time-series in order to mitigate the possibility of spurious conclusions. Prior research (Chordia, Roll, and

Subrahmanyam, 2001) finds that spreads exhibit time-trends and calendar regularities. It seems plausible that the volume series could also exhibit such phenomena. Thus, the raw time-series are first expunged of deterministic variation; (see Gallant, Rossi, and Tauchen, 1992 for a similar approach to adjusting the series of equity volume). Since little is known about seasonalities or regularities in contingent claims volume, this analysis is of independent interest. Subsequently in Section III, innovations (residuals) from the adjustment regressions are related in a vector autoregression (VAR).

The following variables are used to account for calendar regularities: (i) Four weekday dummies for Tuesday through Friday, (ii) 11 calendar month dummies for February through December, (iii) for the options and futures series, a dummy for the four days prior to expiration (the third Fridays in March, June, September, and December) to control for any maturity-related effects. We also use a time variable to remove any long-term trends.

Trading based on private information (Kyle, 1985, Glosten and Milgrom, 1985) suggests another group of volume determinants, namely, the announcement of material macroeconomic data. We thus include dummy variables for macroeconomic announcements about GDP, the unemployment rate, and the Consumer Price Index. For GDP we include advance, preliminary, and final release dates, whereas for unemployment announcements we include the day of as well as the four days following the announcement dates, on the grounds that trading activity and liquidity respond most strongly prior to this announcement (Fleming and Remolona, 1999, Chordia, Roll, and Subrahmanyam, 2001).

In Table 3 we report the results of these adjustment regressions. In the following discussion of the results, we focus on the coefficients significant at the 5% level or less. Confirming the results observed in Figure 1, the trend in volume is positive for the spot, the options and the ETF, but negative for the futures.

We find also that the stock market has a strong January seasonal in volume, which is largely attenuated in its contingent claims. This indicates that the January volume increase is driven by an increase in individual stock trading activity, rather than being a systematic phenomenon across financial markets. The is consistent with stock investment surges at the beginning of the calendar year from cash inflows to some retail investors in the form of year-end bonuses (Ogden, 1990). It is also consistent with re-investments following tax loss motivated selling just prior to the end of the previous year (Roll, 1983). Since these activities have no fundamental information content, the other volume series do not respond as much.[5]

Option volume increases in the last four months of the year.[6] Volume in all series is statistically lower on Mondays relative to other days of the week. This is a result with no obvious explanation, and deserves analysis in future research. We also find evidence that spot and futures volume tend to be higher on days of macroeconomic announcements

[5] The monthly coefficients for futures are entirely negative for February through December, though only a few are significant when considered alone. As a group, they also indicate a larger volume in January but the effect is much smaller than in the cash (spot) market.
[6] The monthly options volume coefficients are all positive, thereby revealing that January volume is unusually low.

(for GDP, around the second release). Volume is also higher in the ETF on the day of the unemployment announcement. This is consistent with information-endowed traders adjusting their holdings in response to the new macroeconomic information (Kim and Verrecchia, 1991).

Interestingly, the options exhibit decreased volume around the CPI and unemployment announcements. This may indicate that sophisticated uninformed agents stay away from these markets prior to macroeconomic announcements as they are apprehensive about trading against truly informed traders or against better-informed dealers or market makers. We shed more light on this phenomenon in Section IV by examining whether the volume series predict returns and volatility around macroeconomic announcements.

III. Vector Autoregression

The regressions of the previous section yield four residual series that we now analyze with a vector autoregression. This seems desirable because the four volumesmight exhibit heterogeneous time-series behavior. For example, some informed agents might prefer that venue with lower transactions costs while others may trade on the same information sequentially (Hirshleifer, Subrahmanyam, and Titman, 1994, Chakravarty, Gulen, and Mayhew, 2004) in one or more contingent claims. Alternatively, asset allocation trades between equities and bonds as a reaction to new public information may be conducted in spot markets as well as with contingent claims. This could result in the four volume series being jointly determined or to innovations in some series leading others.

To address these possibilities, a VAR is the natural tool.. In applying the VAR, we determine the number of lags by the Akaike and Schwarz information criteria. When these criteria indicate different lag lengths, the lesser lag length is chosen for the sake of parsimony. Typically, the slopes of the information criteria as a function of lag length are quite flat for longer lags, so the choice of shorter lag lengths is further justified. The criteria indicate a lag length of six for the VAR.

Correlations in VAR innovations and Granger causality tests are reported in Table 4. The correlation patterns generally confirm those in Table 1; specifically, all series except the options volume are positively correlated, and the options series exhibits very weak correlation with the other series. This again indicates that the series are jointly determined and that the clientele attracted by options (with non-linear payoffs) is different from that which prefers to trade in the other three markets.

As regards the Granger causality tests in Panel B of Table 4, it can be seen that innovations to the options and ETF volume series are Granger-caused by the other series. In addition, the futures and ETF series Granger-cause the index while the options series Granger-causes the futures series. It can be seen that the innovations in futures volume Granger-cause those in spot volume but the reverse is not true, suggesting that futures volume innovations lead those in the spot market. Overall, the evidence, supports the joint determination of the four volume series, as suggested by Panel A of Table 4. Thus, volume innovations in the three contingent claims and the spot market do not occur independently but in a coordinated fashion, suggesting that agents who trade in these markets are not random noise traders but arbitrageurs or hedgers whose trades naturally lend themselves to joint determination across the four markets.

However, Granger causality is based on a bivariate comparisions. A clearer picture can potentially be provided by impulse response functions (IRFs), which account for the full dynamics of the VAR system. An IRF traces the impact of a one-time, unit standard deviation, positive shock to one variable (henceforth termed simply a ”shock” or “innovation” for expositional convenience) on the current and future values of the endogenous variables. Since the innovations are correlated, they need to be orthogonalized, so we use the inverse of the Cholesky decomposition of the residual covariance matrix to orthogonalize the impulses.

Figures 2 depict responses of a volume variable to a unit standard deviation shock in another variable traced forward over a period of ten days. Monte Carlo two-standard-error bands (based on 1000 replications) are provided to gauge the statistical significance of the responses. Period 1 in the IRFs represents the contemporaneous response, whereas subsequent periods represent lagged responses. The vertical axes are scaled to the measurement units of the responding variable.

The impulse responses reveal that innovations to futures volume are useful in forecasting volume in the ETF as well as the spot index. Volume innovations in the ETF forecast those in the spot index. There also is a curious delayed (fifth lag) response of options to innovations in the other volume series, which suggests a weekly seasonal that deserves analysis in future research. Overall, the picture is again that of the time-series of volume being jointly determined.

Figure 2 also indicates that over shorter lags, innovations in spot volume are not useful in forecasting other volume series (though ETF and futures innovations forecast spot volume), suggesting that volume in contingent claims leads that in the spot index at daily horizons. It can also be seen that that the forecasting ability of futures and ETF innovations on the spot market is persistent and the statistical significance lasts for at least ten days. Overall, our findings suggest that contingent claims, by offering lower transactions and higher leverage, are the preferred by informed agents, and trading activity in the spot market therefore follows innovations in contingent claims volume.

IV. Volume and Price Formation

Analysis of the volume series is worthwhile in its own right, but does not shed any light on the role played by these series on price formation. If obtaining data on volume in a timely fashion is costly, then volume does not fall in the domain of public information. As such, volume may predict the evolution of the price process to the extent that it represents trading on costly information (Grossman and Stiglitz, 1980).

By its very nature, volume does not reveal whether the trade is initiated by a buyer or a seller, which presumabley limits the ability of volume to predict signed returns. Nonetheless, volume should predict absolute returns, especially around informational announcements. Furthermore, if futures and options series can be used to get around cumbersome short-sales constraints in the spot market and thus enable more effective trading on negative information, high volume in contingent claims prior to informational announcements may signal negative information and thus predict signed returns. In other words, high volume in contingent claims might be negatively associated with future returns.

To check these observations, we take an empirical look at relation betwee volume and common macroeconomic indicators and then also explore volume around major macroeconomic announcements.

A. Volume and the Macroeconomy

We consider four macroeconomic variables; the term spread, the default spread the short-term interest rate, and the return on a broad stock market index. Our proxy for the short-term interest rate is the yield on three-month Treasury Bills. The term spread is the yield differential between Treasury bonds with more than ten years to maturity and T-bills that mature in three months. The default spread is the yield differential between bonds rated BAA and AAA by Moody's. The S&P 500 is our broad stock market index.

Panel A of Table 5 presents a daily contemporaneous correlation matrix between the volume series (calls and puts are included separately) and the absolute values of the first differences in the macroeconomic variables, and the absolute value of the S&P 500 return. The correlations of all of the volume series with shifts in macro variables are positive. The highest correlations are observed between the short-term interest rate and options as well as spot volume, and between options volume and the credit spread.

Table 5 presents predictive regressions where the dependent variables are the absolute values of the first differences in the macroeconomic variables, and the absolute value of the S&P 500 return. The right-hand volume variables represent the sum of volumes on the three lags of each of the five volume series (calls and puts are included separately). In addition, we control for the average three-day lag of the dependent variable (labeled "LagDepVar").

The results indicate that option (put) volume predicts shifts in three of the four macroeconomic variables. Futures volume predicts shifts in the credit spread as well as the stock market. Interestingly, ETF volume is negatively related to the absolute movement in the short-term interest rate and the term spread, indicating perhaps that some uninformed agents stay away from this market because they are apprehensive about trading against informed agents when a large move is predicted in the next few days. However, just as in the futures market, large ETF volume predicts a large shift in the credit spread. Overall, there is reliable evidence that four volume series contain information about shifts in the macroeconomic variables considered in Table 5.

B. Predictive Role of Volume Around Macroeconomic Announcements

Fleming and Remolona (1999) as well as Chordia, Roll, and Subrahmanyam (2001) suggest that GDP, CPI and unemployment announcements influence equity market liquidity; one would expect them to affect price formation as well. We thus consider whether trading activity in the contingent claims predicts returns around these announcements.

Table 6 presents two predictive return regressions, where the dependent variable is the signed index return on the day of the macroeconomic announcement in the first regression, and the absolute value of the return in the second regression. These variables are regressed on the sum of volumes on the three days preceding the announcement for each of the volume series. In addition, we control for the compound index return and the average absolute return over the past three days in the first and second regressions, respectively.

Consider the coefficients for the signed return regressions in Panel A of Table 6. Again, it is worth observing that without information about trade initiation, , the signs of the coefficients do not lend themselves to an obviously intuitive explanation. Specifically, volume could be influenced by information, and hedging of large spot or derivative positions, as well as circumvention of short-sale constraints using contingent claims. With this caveat in mind, and focusing on the significant coefficients, we find that spot and ETF volumes predict returns prior to the CPI announcement, and options and futures volume predict the return on the day of the GDP announcement.

Regarding the coefficient signs, note that the hypothesis that contingent claims are used to circumvent short-selling constraints is supported for calls and futures prior to GDP announcements, because these coefficients are negative. This hypothesis is not supported for puts because the coefficient on put volume is positive. Further, volume falls in spot markets prior to CPI announcements. This may suggest retail investors' reluctance to trade large amounts of equities prior to a major macroeconomic announcement and thereby prevent exposure to the risk of a major price move. The positive coefficient on ETF volume prior to CPI announcements suggests either a volume surge prior to positive releases or a volume decrease prior to adverse releases. We will shed more light on these possibilities when we discuss regression with the absolute return as the dependent variable.

Many of the preceding patterns on predictability of signed returns are lost when aggregating across all announcements, in which case only the spot volume predicts returns. Importantly, the lagged index return itself is never significant in predicting the return on the day of the announcement, which underscores the role of trading activity in price formation around macroeconomic announcements.

Turning now to the absolute return regressions in Panel B of Table 6, and focusing again on the significant coefficients, we find that high ETF volume prior to CPI announcements predicts lower absolute returns on the day of the announcement, indicating again, as in Table 5, that some uninformed agents back away from ETF trading prior to announcement with a large anticipated price move. The result in Panel A indicates that this phenomenon occurs primarily prior to adverse CPI releases. Panel B also suggests that high put and futures volume indicate high absolute returns on the day of the GDP announcements, and this result is consistent with the results for signed returns in Panel A. These patterns are all reflected in the regression that combines the macroeconomic announcements. Overall, all of these results confirm the role of the contingent claims in price discovery around informational announcements.

IV. Conclusion

When agents trade, they incur both opportunity costs and direct transfers to intermediaries. It therefore becomes interesting to ascertain why assets that would be redundant in a frictionless world attract trading activity. Finance textbooks are filled with knowledge about how these claims should be priced relative to each other,[7] but there is comparatively little known about the relative extent of trading activity in these claims.

To the best of our knowledge, this paper contains the first analysis of the joint time-series of trading activity on multiple and mutually "redundant" derivative assets.. We study trading volume in three contingent claimss, index options, index futures, and the ETF, as well as volume in the underlying cash index, the S&P 500. This provides

[7] See, for example, Bodie, Kane, and Marcus (2009), Chapters 21 to 23.

some empirical information about the degree to which trading activity in contingent claims is jointly determined and the extent to which it plays a role in price formation. The data used here span a long time-period of twelve years (more than 3000 trading days), thereby providing some assurance of reliability. We are not aware of another study that has analyzed the joint time-series of trading activity in multiple contingent claims and on the underlying asset over such a long time-period.

The volumes on S&P index options, the ETF, and on the cash index itself have trended upward over recent years but futures volume has trended downward; This suggests that other markets have acted as substitutes for the futures market. Trading activity innovations in all series except options are strongly and positively autocorrelated. The options series exhibits only weak correlation with the other series, suggesting that non-linear options payoffs attract a different clientele.. Calendar regularities also differ across contracts; for example, there is a January volume seasonal in the cash index but none in its contingent claims, which reveals trading in individual stocks at the turn of the year.

Vector autoregressions and Granger causality tests indicate that the time-series are jointly determined. However, at daily horizons, impulse responses indicate that while ETF and futures volume innovations forecast cash index volume, innovations in the underlying cash index volume are not useful in forecasting volume in any of the contingent claims; this suggests that contingent claims volume leads..

Further, we find that trading activity predicts shifts in the term structure of interest rates as well as returns and volatility around major macroeconomic announcements. Specifically, option and futures volumes predict signed returns on the day of the GDP announcement, suggesting that agents trade on private information in derivative markets, possibly to circumvent short-selling constraints in spot markets. Options and ETF volumes also predict volatility on the days of these announcements. Overall, the analysis supports the notion that contingent claims (futures, options, and ETFs), with likely lower trading costs and enhanced leverage relative to the cash market, play a material role in price formation.

More needs to be done to relate how these series contribute to price formation around other announcements such as shifts in the stance of the Federal Reserve, as well their relation as other macroeconomic variables such as credit and term spreads. Further, an investigation into what types of clientele (individuals versus institutions) these markets attract would also be of considerable interest.

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Table 1: Summary statistics

This table presents summary statistics for daily volume data on the S&P 500 index (Spot), and options, futures, and the ETF on the index. In Panel A, all numbers are in millions of contracts or shares except the number of observations, skewness, and kurtosis. SPDRs trade in units of one-tenth of the index, options trade in units of $100 times the index, and futures trade in units of $500 times the index. The time-period is 1996 to 2007.

Panel A: Levels

Statistic	Spot	Options	Futures	ETF
No. of observations	3014	3012	3020	3020
Mean	48.845	3.380	0.063	37.176
Median	46.260	2.283	0.061	18.747
Standard deviation	24.533	4.203	0.030	51.254
Mean absolute deviation	17.878	2.231	0.024	33.061
Skewness	1.29	4.94	0.72	3.42
Kurtosis	3.09	34.75	0.83	17.27

Panel B: Daily absolute (proportional) changes

Statistic	Spot	Options	Futures	ETF
No. of observations	3013	3009	3018	3018
Mean	0.132	0.394	0.228	0.327
Median	0.096	0.306	0.168	0.255
Standard deviation	0.142	0.350	0.288	0.307
Mean absolute deviation	0.092	0.260	0.156	0.212
Skewness	3.31	1.82	10.38	4.12
Kurtosis	16.75	5.09	196.76	44.50

Table 2: Correlation matrix

This table presents the correlation matrix for daily volume data on the S&P 500 Index, and options, futures, and the ETF on the index. The time-period is 1996 to 2007. Volume is in number of contracts.

Panel A: Levels

Variable	Spot	Options	Futures
Options	0.609		
Futures	-0.228	-0.173	
ETF	0.817	0.704	-0.268

Panel B: Daily Percentage Changes

Variable	Spot	Options	Futures
Options	0.036		
Futures	0.567	-0.006	
ETF	0.532	0.018	0.437

Table 3: Time-Series Regressions

This table presents coefficients from the time-series regressions of volume on variables intended to remove calendar regularities and trends. The macroeconomic announcement dates are the day of the announcement except for the unemployment dummy that covers the announcement day and four days following the announcement. The GDP numbers cover the advance, preliminary, and corrected announcements. The Remtrm dummy for options and futures is unity for the four days prior to expiration of the contracts (the third Fridays in March, June, September, and December). The time-period is 1996 to 2007.

	Spot		Options		Futures		ETF	
Variable	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Unempl 0	0.0257	1.64	-0.1971	-4.46	0.1371	4.50	0.1804	4.80
Unempl+1	0.0450	2.36	-0.0965	-1.87	0.1099	3.07	0.0048	0.11
Unempl+2	0.0686	3.45	-0.1024	-1.93	0.1072	2.89	0.0483	1.05
Unempl+3	0.0748	4.02	-0.1129	-2.23	0.1009	2.87	0.0254	0.58
Unempl+4	0.0997	6.03	-0.0917	-1.95	0.1099	3.39	0.0747	1.88
CPI	0.0090	0.80	-0.0732	-2.27	0.0598	2.68	0.0067	0.25
GDP#1	-0.0053	-0.26	0.0904	1.63	0.0145	0.38	0.0074	0.16
GDP#2	0.0980	4.91	0.0334	0.60	0.1316	3.43	0.0811	1.71
GDP#3	0.0369	1.90	0.0920	1.69	-0.0280	-0.75	0.0437	0.94
Trend	1.4730	25.65	1.7130	21.07	-0.9375	-15.52	4.8830	57.64
Tuesday	0.0998	12.62	0.1378	5.91	0.1371	8.59	0.1414	7.27
Wednesday	0.1392	14.16	0.1732	6.07	0.1560	7.96	0.1674	6.99
Thursday	0.1153	11.51	0.1963	6.76	0.0887	4.45	0.1843	7.55
Friday	0.0752	8.51	0.0995	3.78	0.0347	1.92	0.1099	5.09
February	-0.1420	-3.33	0.0635	0.68	-0.0711	-1.07	-0.1020	-1.18
March	-0.1449	-2.91	0.1997	2.04	-0.0093	-0.13	-0.0293	-0.31
April	-0.1339	-2.55	0.1021	1.03	-0.1033	-1.44	-0.0089	-0.09
May	-0.2127	-3.98	0.1186	1.19	-0.1334	-1.85	-0.0784	-0.81
June	-0.1869	-3.47	0.0837	0.84	-0.0051	-0.07	-0.0182	-0.19
July	-0.3477	-6.45	0.0878	0.89	-0.1941	-2.71	-0.1483	-1.54
August	-0.3549	-6.59	0.1517	1.53	-0.1591	-2.22	-0.0396	-0.41
September	-0.2700	-5.02	0.2498	2.49	-0.0054	-0.07	0.0134	0.14
October	-0.2629	-5.03	0.2065	2.11	-0.1242	-1.75	0.0529	0.56
November	-0.3832	-7.61	0.2268	2.29	-0.2001	-2.79	-0.1428	-1.50
December	-0.2603	-6.05	0.2949	3.21	-0.1327	-2.01	-0.1386	-1.60
Remtrm			0.0804	1.48	-0.1092	-2.89		
Intercept	3.2230	348.20	4.955	161.30	3.873	185.90	4.2200	169.40
Adjusted R^2	0.264		0.161		0.126		0.536	

Table 4: Correlations Between VAR Innovations and Granger Causality Tests

This table presents correlations in the innovations from a vector autoregression and Granger causality tests for daily residuals obtained by regressing trading volume on the S&P 500 Index, and options, futures, and the ETF on the index against calendar regularities and macroeconomic announcements as reported in Table 3. The time-period is 1996 to 2007. Volume is in number of contracts.

Panel A: Correlation Matrix for VAR Innovations

Variable	Spot	Options	Futures
Options	0.001		
Futures	0.493	-0.040	
ETF	0.535	0.004	0.412

Panel B: Granger Causality Tests

Exclude	Chi-sq	df	*p*-value
Dependent variable: Spot			
Futures	15.23834	6	0.0185
Options	10.79789	6	0.0948
ETF	17.43188	6	0.0078
All	43.65616	18	0.0006
Dependent variable: Futures			
Spot	12.03045	6	0.0613
Options	5.189359	6	0.5198
ETF	19.64028	6	0.0032
All	62.6355	18	<0.0001
Dependent variable: Options			
Spot	241.1804	6	<0.0001
Futures	53.84673	6	<0.0001
ETF	46.49945	6	<0.0001
All	690.4252	18	<0.0001
Dependent variable: ETF			
Spot	13.64112	6	0.0339
Futures	13.18396	6	0.0402
Options	17.4517	6	0.0078
All	47.10534	18	0.0002

Table 5: Volume and the Macroeconomy

Panel A of this table presents contemporaneous correlations between volume and absolute values of the daily changes in macroeconomic variables and the absolute return on the S&P 500 index. Panel B presents regressions where the dependent variable is the absolute daily change in three macroeconomic variables and the absolute return on the S&P 500 index. The three macroeconomic variables are (i) the short-term interest rate (ii) the term spread, and (iii) the credit spread. The term spread is the yield differential between constant maturity ten-year Treasury bonds and Treasury bills that mature in three months. The credit spread is the yield differential between bonds rated Baa and Aaa by Moody's. The right-hand volume variables represent the sum of three lags of daily volume data on the S&P 500 Index (Spot), call and put options, index futures, and the ETF on the index. The variable LagDepVar is the average three-day lag of the dependent variable. The time-period is 1996 to 2007. Volume is in number of contracts, and all volume coefficients are multiplied by 1000.

Panel A: Contemporaneous Correlations

	Short-term interest rate	Term Spread	Credit Spread	Stock Market
Spot	0.1100	0.0963	0.0853	0.0807
Call	0.1503	0.0973	0.0344	0.0130
Put	0.1827	0.1370	0.0673	0.0778
Futures	0.0550	0.0731	0.0426	0.3116
ETF	0.0564	0.0855	0.0874	0.0593

Panel B: Predictive Regressions

	Short-term interest rate		Term Spread		Credit Spread		Stock Market	
Variable	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Spot	1.165	1.29	0.585	0.55	0.148	0.46	7.240	0.43
Call	1.013	1.87	-0.133	-0.21	-0.143	-0.74	-26.760	-2.66
Put	3.129	5.13	4.098	5.76	0.003	0.01	61.920	5.56
Futures	0.184	0.33	0.591	0.89	0.611	3.06	80.570	6.93
ETF	-1.662	-4.75	-1.270	-3.13	0.268	2.20	-9.435	-1.48
LagDepVar	0.196	26.73	0.1424	16.80	0.086	9.15	0.098	9.91
Intercept	-0.146	-3.64	-0.126	-2.70	-0.029	-2.05	-3.466	-4.54
Adjusted R^2	0.2770		0.1256		0.0384		0.1023	

Table 6: Predictive Return Regressions Around Macroeconomic Announcements

This table presents regressions where the dependent variable is in turn the signed and absolute S&P500 return on the date of the macroeconomic announcement. The right-hand volume variables represent the sum of three lags of daily volume data on the S&P 500 Index (Spot), call and put options, index futures, and the ETF on the index. "Spotret" represents the compounded three lags of returns on the index. The time-period is 1996 to 2007. Volume is in number of contracts.

Panel A: Signed Announcement-Day Return

	Unempl.		CPI		GDP		All	
Variable	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Spot	-0.0746	-0.52	-0.4670	-4.40	0.0290	0.24	-0.1742	-2.31
Call	0.1676	1.68	0.0656	1.10	-0.1465	-2.01	0.0040	0.09
Put	-0.0471	-0.52	-0.0692	-0.90	0.1986	2.40	0.0232	0.47
Futures	0.1384	1.61	-0.0587	-0.82	-0.2451	-2.93	-0.0104	-0.22
ETF	-0.0468	-0.91	0.1180	3.08	-0.0728	-1.47	0.0215	0.76
Spotret	-0.0185	-0.29	0.0522	1.05	-0.0696	-1.27	0.0110	0.33
Intercept	-3.12	-0.49	24.56	4.27	7.86	1.48	7.35	2.20
Adjusted R^2	0.0216		0.1178		0.0470		0.0032	

Panel B: Absolute Announcement-Day Return

	Unempl.		CPI		GDP		All	
Variable	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Spot	0.0266	0.31	0.1512	1.89	0.0130	0.17	0.0863	1.80
Call	-0.0130	-0.22	-0.0332	-0.73	-0.0379	-0.81	-0.0397	-1.41
Put	0.0537	1.00	0.0621	1.08	0.1118	2.09	0.0780	2.48
Futures	0.0672	1.17	0.0808	1.48	0.2308	3.71	0.1122	3.52
ETF	-0.0532	-1.77	-0.0698	-2.44	0.0015	0.05	-0.0472	-2.66
|Spotret|	0.1114	2.33	0.0777	1.67	-0.0410	-0.80	0.0508	1.84
Intercept	-1.98	-0.49	-8.77	-2.06	-10.51	-2.90	-6.75	-3.05
Adjusted R^2	0.1011		0.0859		0.1174		0.0936	

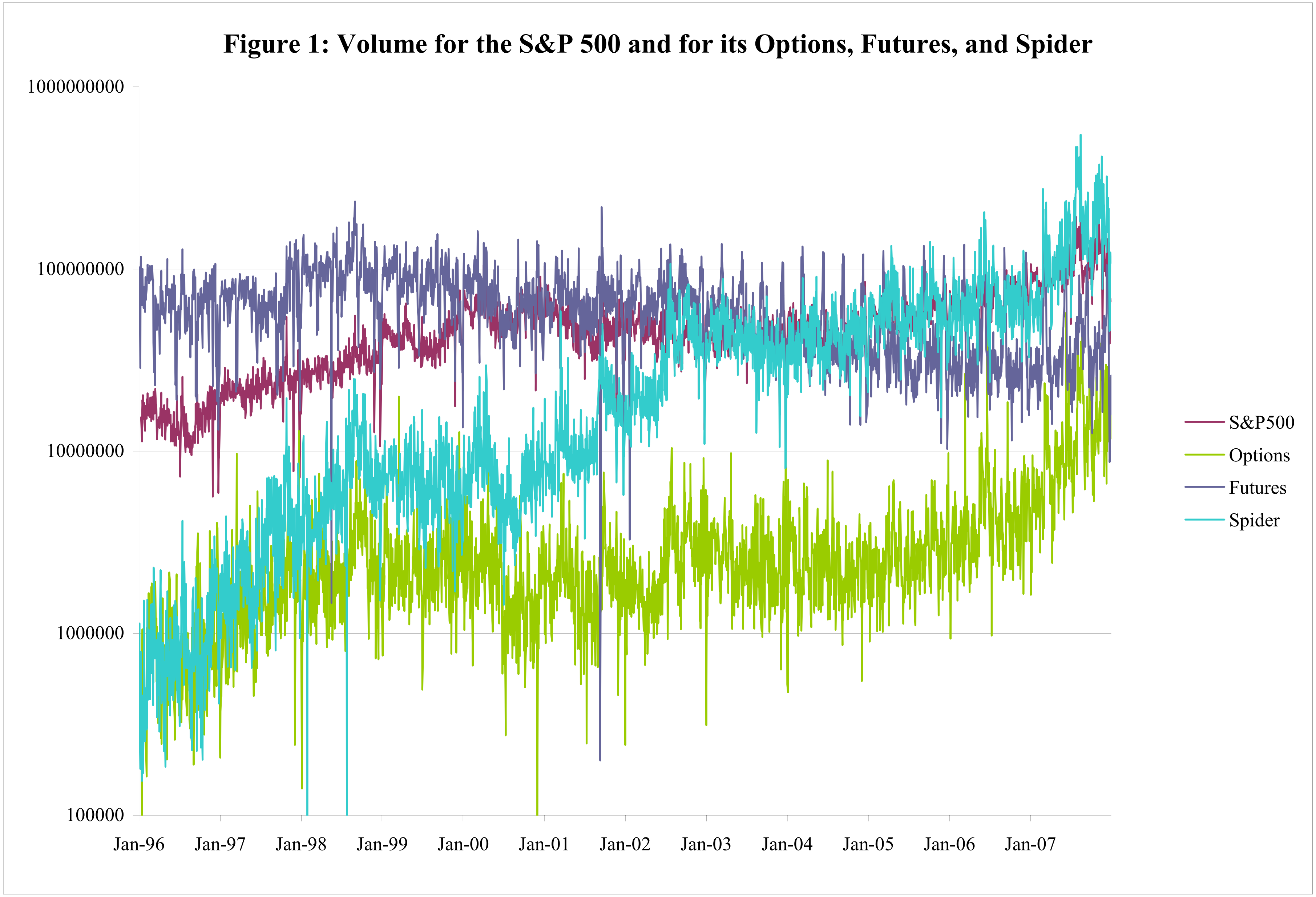

Figure 1: Volume for the S&P 500 and for its Options, Futures, and Spider
1000000000
100000000
10000000
1000000
100000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
S&P500
Options
Futures
Spider

Figure 2: Impulse Response Functions

This figure presents impulse response functions from a VAR daily volume data on the S&P 500 Index, and options, futures, and the ETF on the index. The time-period is 1996 to 2007. The data are the orthogonalized residual series from the regressions reported in Table 3.