Comovement

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Abstract

A number of studies have identified patterns of positive correlation of returns, or comovement, among different traded securities. We distinguish three views of such comovement. The traditional “fundamentals” view explains the comovement of securities through positive correlations in the rational determinants of their values, such as cash flows or discount rates. “Category-based” comovement occurs when investors classify different securities into the same asset class and shift resources in and out of this class in correlated ways. A related phenomenon of “habitat-based” comovement arises when a group of investors restricts its trading to a given set of securities, and moves in and out of that set in tandem.

We present models of each of the three types of comovement, and then assess them empirically using data on stock inclusions into and deletions from the S&P 500 index. Index changes are noteworthy because they change a stock’s category and investor clientele (habitat), but do not change its fundamentals. We find that when a stock is added to the index, its beta and R-squared with respect to the index increase, while its beta with respect to stocks outside the index falls. The converse happens when a stock is deleted. These results are broadly supportive of the category and habitat views of comovement, but not of the fundamentals view. More generally, we argue that these non-traditional views may help explain other instances of comovement in the data.

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1 Introduction

Researchers studying the structure of asset returns have uncovered numerous patterns of comovement. There is a strong common factor in the returns of small-cap stocks, for example, and also in the returns of value stocks, closed-end funds, stocks in the same industry, and bonds of the same rating and maturity. There is common movement within national markets and across international markets.

Common factors such as these have attracted considerable attention because of the possible role they play in explaining average rates of return. However, there has been much less work on understanding why the common factors arise in the first place. Why do certain groups of assets comove while others do not? What determines loadings, or betas, on these common factors? In this paper, we consider three theories of comovement – one traditional, two more novel – and present new evidence in support of the non-traditional theories.

The traditional view is that comovement in prices reflects comovement in fundamental values. This follows as a direct corollary of the efficient markets hypothesis. Since, under that hypothesis, prices equals fundamental value – in other words, the sum of an asset’s rationally forecasted cash flows, discounted at a rate appropriate for their risk – any comovement in prices must be due to comovement in fundamentals.

An asset’s fundamental value can change either because of news about cash flows or because of news about discount rates. Under the traditional view, then, correlation in returns is either due to correlation in cash flow news or to correlation in news about discount rates. Correlation in discount rate news can in turn arise because of news about interest rates or risk aversion, which affects all discount rates simultaneously, or because of correlated news about asset riskiness.

There is little doubt that this “fundamentals” view of comovement explains many instances of common factors in returns: stocks in the oil industry move together primarily because there is a common component in news about their future earnings, while the market factor in returns is at least in part due to changes in interest rates.1

1Shiller (1989) neatly demonstrates the importance of accounting for changes in discount rates when examining patterns of comovement. He shows that the U.S. and U.K. stock markets comove more than can
Recently, a number of papers have presented evidence suggesting that the traditional view of comovement is incomplete. Froot and Dabora (1999) study Siamese-twin stocks, which are claims to the same cash flow stream, but are traded in different locations. Royal Dutch, traded in the U.S., and Shell, traded in the U.K., are perhaps the best known example. If return comovement is purely a reflection of comovement in news about fundamentals, these two stocks should be perfectly correlated. In fact, as Froot and Dabora show, Royal Dutch comoves more with the S&P 500 index of U.S. stocks than Shell does, while Shell comoves more with the FTSE index of U.K. stocks.

Hardouvelis, La Porta, and Wizman (1994) and Bodurtha, Kim, and Lee (1995) uncover related evidence in a study of closed-end country funds, whose assets trade in a different location from the funds themselves. Since funds and their underlying assets represent claims to similar cash flow streams, the fundamentals view of comovement predicts that fund returns and returns on their net assets values should be highly correlated. In fact, closed-end country funds comove much more with the national stock market in the country where they are traded than with the national stock market in the country where their assets are traded. For example, a closed-end fund invested in German equities but traded in the U.S. typically comoves more with the U.S. stock market than with the German stock market.

Fama and French (1995) investigate whether the strong common factors detected in the returns of value stocks and small stocks by Fama and French (1993) can be traced to common factors in the earnings of these stocks. While they do uncover a common factor in the earnings of small stocks, as well as in the earnings of value stocks, these cash flow factors are weaker than the factors in returns and there is little evidence that the return factors are driven by the cash flow factors. Once again, there appears to be comovement in returns that has little to do with comovement in news about fundamentals.

Finally, Pindyck and Rotemberg (1990) find strong comovement in the prices of seven commodities – wheat, cotton, copper, gold, crude oil, lumber, and cocoa – that are chosen to be as independent of one another as possible. They are neither complements nor substitutes, are grown in different climates and are used for different purposes. Under the traditional be explained by correlation in news about dividends alone; however, he also shows that allowing for plausible changes in discount rates can potentially explain the residual comovement.
view of comovement, the only plausible source of price correlation is news about aggregate
demand. However, even after experimenting with a variety of forecasting models, Pindyck
and Rotemberg (1990) are unable to find sufficient volatility in news about aggregate demand
to fully explain the comovement.2

These examples suggest that investor trading patterns, and not just fundamentals, may
be important determinants of return comovement. In this paper, we consider two specific
versions of such trading-induced comovement. The first version, which we label the “cat-
egory” view of comovement, was recently analyzed by Barberis and Shleifer (2000). They
argue that when making portfolio decisions, many investors first group assets into categories
such as small-cap stocks, oil industry stocks, or junk bonds, and then allocate funds across
these various categories. If some of the investors who use categories are noise traders with
correlated sentiment, and if their trading affects prices, then as they move funds from one
category to another, their coordinated demand will induce common factors in the returns of
assets that happen to be classified into the same category, even if these assets’ cash flows
are largely uncorrelated.

Another type of trading-induced comovement, which we refer to as the “habitat” view of
comovement, starts from the observation that many investors choose to trade only a subset
of all available securities. Such preferred habitats may arise because of transaction costs,
international trading restrictions, or lack of information (Merton, 1987). As these investors’
risk aversion or sentiment changes, they alter their exposure to the securities in their habitat,
thereby inducing a common factor in the returns of these securities. Put differently, this view
of comovement predicts that there will be a common factor in the returns of securities that
are the primary holdings of a specific subset of investors, such as individual investors.

Trading-induced comovement is a simple way of understanding the empirical evidence
described above. If small-cap stocks and value stocks form natural categories in investors’
minds – and the large number of money managers and mutual funds focused on such stocks

2Pindyck and Rotemberg (1993) uncover similar evidence in an analogous study of stock returns. They
construct groups of stocks that are in completely different lines of business and find that even though the
stocks within each group are in different industries, their returns still comove strongly. This “excess” comove-
ment remains even after controlling for any cash flow or discount rate correlation induced by macroeconomic
variables.
suggests that they do – then the category view of comovement predicts that there will be common factors in the returns of such stocks even if their cash flows are only weakly correlated. Moreover, if many individual investors in the U.S. confine themselves to holding domestically traded securities, then the habitat view of comovement predicts that closed-end country funds traded in the U.S. will comove substantially with U.S. stocks even if their holdings consist of foreign equities.

The idea that trading unrelated to news about fundamental value might generate comovement builds on earlier evidence that such trading affects prices. Some of the best-known evidence of this type comes from stock index redefinitions. When an index is redefined, investors who follow it must reduce their holdings of securities that have been downweighted in the index and buy those whose weighting has increased. Under the efficient markets view, these demand shifts should not affect prices, as they carry no information about fundamental value. However, Harris and Gurel (1986), Shleifer (1986), and Lynch and Mendenhall (1997) find strong price effects for S&P 500 inclusions, while Kaul, Mehrotra, and Morck (1999) and Greenwood (2001) find similar effects in other indices.

In this paper, we return to S&P 500 inclusion and deletion data. The same data that has proved useful in showing that uninformed demand can affect prices may also be helpful in providing evidence of trading-induced comovement. Since addition to the S&P 500 carries no information about fundamental value, a stock’s inclusion does not change the correlation of its cash flows with the cash flows of other stocks already in the index. Under the fundamentals view of comovement, then, nor should it change the correlation of the stock’s return with the return of the S&P 500. In particular, a univariate regression of a stock’s return on the S&P 500 return both before and after the stock’s inclusion should produce similar slope coefficients, or S&P 500 betas, and similar $R^2$s.

On the other hand, the vast popularity of S&P 500-linked investment products suggests that the index is a preferred habitat for some investors, and is viewed as a natural category by many more. The trading-based theories may therefore differ from the fundamentals view in their predictions about patterns of comovement before and after inclusion. By writing down simple models of the category and habitat views, we show that they predict that in the univariate regression described above, S&P 500 beta and $R^2$ should increase after inclusion
and fall after deletion; that in a *bivariate* regression of a stock’s return on both the S&P 500 and the non-S&P 500 returns, the S&P 500 beta should rise sharply after inclusion while the non-S&P 500 beta should fall, and vice-versa for deletions; and finally, that there should be a decrease in the correlation between the S&P 500 returns and the non-S&P 500 returns over time.

Our evidence strongly supports the trading-based theories. Over a range of data frequencies, stocks added to the S&P 500 sharply increase their beta and $R^2$ with the S&P 500, while in bivariate regressions that control for the return of S&P 500 stock returns, increases in S&P 500 beta are even more pronounced. Significant results in the opposite direction are observed when stocks are deleted from the index. We also confirm a significant decrease in the correlation of S&P 500 and non-S&P 500 returns over time.

Our univariate regression results fit well with the evidence of Vijh (1994), who investigates whether the rise of S&P 500-linked products affects stocks’ beta with respect to the *overall* market. He finds a significant increase in market beta after inclusion, which is consistent with the increase in S&P 500 beta that we detect, given the dominant contribution of S&P 500 stocks to the value-weighted market return.

In Section 2, we present some simple models to illustrate the various views of comovement, as well as their distinct predictions. In Section 3, we test a number of these predictions using data on S&P 500 inclusions and deletions. Section 4 concludes.

## 2 Three Models of Comovement

In this section, we lay out three theories of return comovement. Our models are simple, but they nevertheless allow us to illustrate the predictions of each theory. These predictions motivate the empirical work in Section 3.

In all three models, the economy contains a riskless asset in perfectly elastic supply and with a zero rate of return, and also $2n$ risky assets in fixed supply. Risky asset $i$ is a claim to a single liquidating dividend $D_{i,T}$ to be paid at some later time $T$. The eventual dividend
equals
\[ D_{i,T} = D_{i,0} + \varepsilon_{i,1} + \cdots + \varepsilon_{i,T}, \] (1)
where \( \varepsilon_{i,t} \) becomes known at time \( t \), and where
\[ \varepsilon_t = (\varepsilon_{1,t}, \ldots, \varepsilon_{2n,t})' \sim N(0, \Sigma_D), \text{ i.i.d over time.} \]
For simplicity, we impose a one-factor structure on the cash flow shocks:
\[ \varepsilon_{i,t} = \psi_M f_{M,t+1} + \sqrt{1 - \psi_M^2} f_{i,t+1}, \forall i. \] (2)
Here \( f_{M,t+1} \) is a market-wide factor and \( \{f_{i,t+1}\}_{i=1,\ldots,2n} \) are idiosyncratic factors. The factors are all distributed \( N(0, 1), \text{ i.i.d. over time, and are orthogonal to one another.} \) This immediately implies
\[ (\Sigma_D)_{ij} = \text{cov}(\varepsilon_{i,t+1}, \varepsilon_{j,t+1}) = \begin{cases} 1, & i = j \\ \psi_M^2, & i \neq j \end{cases}. \] (3)
We use \( P_{l,t} \) to denote the price of a share of risky asset \( l \) at time \( t \). The return on the asset between time \( t-1 \) and time \( t \) is\(^3\)
\[ \Delta P_{l,t} \equiv P_{l,t} - P_{l,t-1}. \] (4)

### 2.1 Fundamentals-based Comovement

Under the fundamentals view, comovement in returns is due to comovement in news about fundamental value. This prediction emerges from a wide range of models. We present a simple example below.

The economy contains a large number of identical agents known as “fundamental traders.” These traders are given an amount \( W^F \) to allocate at the start of each period. They have CARA utility defined over the value of their invested wealth one period later, and take price changes to be normally distributed.\(^4\) They therefore solve
\[ \max_{N_t} E^F_t \left( -\exp\left[ -\gamma(W^F_t + N_t'(P_{t+1} - P_t)) \right] \right), \] (5)

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\(^3\)For simplicity, we refer to the asset’s change in price as its return.

\(^4\)This assumption is confirmed in equilibrium.
where
\[ P_t = (P_{1,t}, \ldots, P_{2n,t})' \]
\[ N_t = (N_{1,t}, \ldots, N_{2n,t})'. \]

\( N_{i,t} \) is the number of shares allocated to risky asset \( i \), \( \gamma \) governs the degree of risk aversion and \( E_t^F \) denotes fundamental trader expectations at time \( t \).

Optimal holdings \( N_t^F \) are given by
\[ N_t^F = \frac{(V_t^F)^{-1}}{\gamma} (E_t^F (P_{t+1}) - P_t), \tag{6} \]
where
\[ V_t^F = \text{var}_t^F (P_{t+1} - P_t), \]
with the \( F \) superscript in \( \text{var}_t^F \) again denoting a forecast made by fundamental traders.

If the total supply of the \( 2n \) assets is given by the vector \( Q \), then given fundamental trader expectations about future prices, current prices satisfy
\[ P_t = E_t^F (P_{t+1}) - \gamma V_t^F Q. \tag{7} \]

Rolling this equation forward and setting
\[ E_t^{F_{T-1}}(P_T) = E_t^{F_{T-1}}(D_T) = D_{T-1}, \]
where
\[ D_t = (D_{1,t}, \ldots, D_{2n,t})', \]
leads to
\[ P_t = D_t - \gamma V_t^F Q - E_t^F \sum_{k=1}^{T-t-1} \gamma V_{t+k}^F Q. \tag{8} \]

If fundamental traders set
\[ V_t^F = \Sigma_D, \forall t, \tag{9} \]
equation (8) reduces to
\[ P_t = D_t - (T-t)\gamma \Sigma_D Q. \tag{10} \]

This means that up to a constant
\[ \Delta P_{t+1} = \Delta D_{t+1}, \tag{11} \]
confirming fundamental traders’ conjecture about the conditional covariance matrix of returns.

Equation (11) shows that in this economy, return comovement simply reflects comovement in news about fundamental value. More specifically, since discount rates are constant, it is a reflection of comovement in news about future cash flows.\textsuperscript{5} This is surely a useful model for understanding many instances of common factors in returns. The strong market and industry factors in returns, for example, are at least in part due to market-level and industry-level factors in cash flow news.

\subsection*{2.2 Category-based Comovement}

Barberis and Shleifer (2000) argue that when making their portfolio decisions, many investors first group assets into categories based on some characteristic, and then allocate funds at the level of these categories rather than at the level of individual securities. Thinking about investments in terms of categories is particularly attractive to institutional investors who, as fiduciaries, must follow systematic rules in their portfolio allocation. Investing by category simplifies the investment process, and also provides a consistent way of evaluating the performance of money managers.

One way of identifying categories in practice is to look at the labels mutual and pension fund managers use to describe their products to clients. If money managers are responsive to client needs, they will choose labels that correspond to the categories people like to use when thinking about investments. For example, since many money managers offer funds that invest in value stocks, “value stocks” may be a category in the minds of many investors. This way of thinking suggests that Treasury bonds, junk bonds, large stocks, small stocks, growth stocks, or stocks within a particular industry, country, or index are also all examples of categories.

The category view of comovement argues that some of the investors who use categories are noise traders with correlated sentiment. As their sentiment changes, they channel funds

\textsuperscript{5}Discount rates are constant because the riskless rate is constant, as are investors’ risk aversion and their perception of risk.
in and out of the various categories. If these fund flows affect prices, they will generate common factors in the returns of assets that happen to be classified into the same category, even if these assets’ fundamental values are uncorrelated. For example, if “value stocks” is a popular style, then as noise traders move funds in and out of value stocks in line with their changing sentiment about value stocks, they will create a common factor in value stock returns even if value stock earnings are completely uncorrelated.

To see this in a formal model, suppose that there are just two such categories, $X$ and $Y$, and that risky assets 1 through $n$ are in category $X$ while assets $n+1$ through $2n$ are in $Y$. It may be helpful to think of $X$ and $Y$ as “old economy” and “new economy” stocks, respectively. We write noise trader demand $N_{i,t}^C$ for shares of asset $i$ as\(^6\)

$$N_{i,t}^C = \frac{1}{n} [A_X + u_{1,t}] , \ i \in X$$

$$N_{j,t}^C = \frac{1}{n} [A_Y + u_{2,t}] , \ j \in Y,$$

where $A_X$ and $A_Y$ are constants, and where the time $t$ sentiment shocks $u_{1,t}$ and $u_{2,t}$ are distributed

$$\begin{pmatrix} u_{1,t} \\ u_{2,t} \end{pmatrix} \sim N \left( \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \sigma_u^2 \begin{pmatrix} 1 & \rho_u \\ \rho_u & 1 \end{pmatrix} \right), \ i.i.d. \ \text{over time.}$$

The fact that the demand for all assets within a category is the same underscores the fact that these investors allocate funds at the category level and do not distinguish among assets in the same category.

This economy also contains fundamental traders whose objective function is the one in (5). In this case, they double up as market makers, treating the noise trader demand as a supply shock. Given their expectations about future prices, current prices are given by

$$P_t = E_t^F(P_{t+1}) - \gamma V_t^F(Q - N_t^C),$$

where

$$N_t^C = (N_{1,t}^C, \ldots, N_{2n,t}^C)' .$$

Rolling this equation forward, and setting $E_{T-1}^F(P_T) = D_{T-1}$, leads to

$$P_t = D_t - \gamma V_t^F(Q - N_t^C) - E_t^F \sum_{k=1}^{T-t-1} \gamma V_{t+k}^F(Q - N_{t+k}^C).$$

\(^6\)The “C” superscript stands for Category.
Suppose that fundamental traders conjecture that the conditional covariance matrix of returns has the form

\[ V_t^F = V = \sigma^2 \begin{pmatrix} A & B \\ B & A \end{pmatrix}, \forall t, \]  

(15)

where

\[ A = \begin{pmatrix} 1 & \rho_1 & \cdots & \rho_1 \\ \rho_1 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \rho_1 \\ \rho_1 & \cdots & \rho_1 & 1 \end{pmatrix}, \quad B = \begin{pmatrix} \rho_2 & \cdots & \cdots & \rho_2 \\ \vdots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \vdots \\ \rho_2 & \cdots & \cdots & \rho_2 \end{pmatrix}, \]

for some \( \sigma^2, \rho_1, \) and \( \rho_2. \)

Given this conjecture,

\[ P_t = D_t - \gamma V (Q - N_t^C) - (T - t - 1)\gamma V (Q - A), \]  

(16)

where

\[ A = \left( \frac{A_X}{n}, \frac{A_Y}{n}, \ldots, \frac{A_Y}{n} \right)' , \]

which means that up to a constant,

\[ \Delta P_{t+1} = \varepsilon_{t+1} + \gamma V \Delta N_t^C. \]  

(17)

This reduces to

\[ \Delta P_{i,t+1} = \varepsilon_{i,t+1} + \frac{\Delta u_{1,t+1}}{\phi_1} + \frac{\Delta u_{2,t+1}}{\phi_2}, \quad i \epsilon X, \]  

(18)

\[ \Delta P_{j,t+1} = \varepsilon_{j,t+1} + \frac{\Delta u_{1,t+1}}{\phi_2} + \frac{\Delta u_{2,t+1}}{\phi_1}, \quad j \epsilon Y, \]

where

\[ \phi_1 = \frac{1}{\gamma \sigma^2 (\rho_1 + (1 - \rho_1)/n)}, \]  

(19)

\[ \phi_2 = \frac{1}{\gamma \sigma^2 \rho_2}. \]

Equation (18) confirms fundamental traders’ conjecture about the structure of the conditional covariance matrix of returns: \( \text{cov}(\Delta P_{i,t+1}, \Delta P_{j,t+1}) \) is constant for all distinct assets \( i \) and \( j \) in the same category, and it is also constant for all assets \( i \) and \( j \) in different categories.
We study equilibria in which the specific values of $\sigma^2$, $\rho_1$, and $\rho_2$ conjectured by fundamental traders are also confirmed by (18).\footnote{It is straightforward to show that such equilibria exist for a wide range of values of the exogeneous parameters $\gamma$, $\psi_M$, $\sigma_u^2$, and $\rho_u$.}

Equation (18) shows that in this economy, there can be a common factor in the returns of a group of stocks simply because those stocks happen to belong to the same category. When noise traders experience a positive sentiment shock $\Delta u_{1,t+1}$ about category $X$, they invest more in all securities in $X$, pushing the prices of these assets up together.

The intuition for why $\Delta u_{1,t+1}$ affects the return on stock 1 is clear enough: when noise traders become bullish about old economy stocks, they channel funds into $X$, pushing the prices of all securities in that category up. Why $\Delta u_{2,t+1}$ also affects the return on stock 1 is less obvious. Suppose that noise traders become bullish about new economy stocks, pushing up the prices of securities in $Y$. Fundamental traders, seeing an overvaluation, will short stocks in $Y$, and hedge themselves against adverse fundamental news by buying stocks in $X$. In this way, the sentiment shock about category $Y$, $\Delta u_{2,t+1}$ is also transmitted to stocks in $X$.

The fact that in our model, noise traders can affect prices – and hence also, patterns of comovement – relies on the assumption that fundamental traders have horizons which end before cash flow uncertainty is resolved at time $T$. If fundamental traders only cared about wealth at time $T$, they would be much more aggressive in countering the effect of noise traders. In particular, since in the limit as $n \to \infty$, categories $X$ and $Y$ are claims to the same final cash flow, any difference in the prices of $X$ and $Y$ would be quickly exploited by fundamental traders. Since these traders have a one-period horizon, they are forced to worry about future noise trader demand, which makes them invest less aggressively. Equations (18) and (19) show that a high risk aversion $\gamma$ or perceived stock volatility $\sigma^2$ make them particularly reluctant to bet against the noise traders, increasing the impact of the sentiment shocks on returns.

The idea that fundamental traders may have short horizons has been emphasized by earlier work on limits to arbitrage (De Long et al. 1990, Shleifer and Vishny 1997). That such constraints might limit arbitrage capacity is supported by empirical evidence indicating

In order to uncover evidence of category-induced comovement, we look for testable predictions that are unique to this economy. One set of predictions describes what happens when a stock enters a category that it was not previously a member of. Such reclassification can occur in many ways. For example, if the market capitalization of a large-cap stock declines sufficiently, it will enter the small-cap stock category. More simply, stocks are regularly added to indices like the S&P 500 and Russell 2000 to replace stocks that have been removed due to bankruptcy or merger.

**Proposition 1:** Suppose that risky asset \( j \), previously a member of \( Y \), is reclassified into \( X \). Then, assuming a fixed cash flow covariance matrix \( \Sigma_D \), the OLS estimate of \( \beta_j \) in the univariate regression

\[
\Delta P_{j,t} = \alpha_j + \beta_j \Delta P_{X,t} + v_{j,t},
\]

where

\[
\Delta P_{X,t} = \frac{1}{n} \sum_{i \in X} \Delta P_{i,t},
\]

as well as the \( R^2 \) of this regression, increase after reclassification. In particular, before reclassification, \( \beta_j < 1 \), while after reclassification, \( \beta_j = 1 \).\(^8\)

The intuition is straightforward: when asset \( j \) enters category \( X \), it starts being buffeted by noise traders' flow of funds in and out of that category. This increases its covariance with the return on category \( X \), \( \Delta P_{X,t} \), and hence also its beta loading on that return. The same intuition lies behind the following prediction:

**Proposition 2:** Suppose that risky asset \( j \), previously a member of \( Y \), is reclassified as belonging to \( X \). Then assuming a fixed cash flow covariance matrix \( \Sigma_D \), the OLS estimate of \( \beta_{j,X} \) in the bivariate regression

\[
\Delta P_{j,t} = \alpha_j + \beta_{j,X} \Delta P_{X,t} + \beta_{j,Y} \Delta P_{Y,t} + v_{j,t},
\]

\(^8\)Proofs of all propositions are in the Appendix.
rises after reclassification, while the OLS estimate of $\beta_{j,Y}$ falls. In particular, before reclassification

$$\beta_{j,X} = 0, \beta_{j,Y} = 1,$$

while after reclassification,

$$\beta_{j,X} = 1, \beta_{j,Y} = 0.$$

Proposition 2 identifies a test that is potentially more powerful than the test in Proposition 1. The essential prediction of the category view of comovement is that when a stock enters category $X$, it is much more sensitive to the category $X$ sentiment shock $\Delta u_{1,t+1}$. Of course, $\Delta P_{X,t}$ is not a clean measure of this sentiment shock; its variation is primarily due to news about market-level cash flows, $f_{M,t+1}$. In regression (22), $\Delta P_{Y,t+1}$ can be thought of as a control for these cash flow news, making the coefficient on $\Delta P_{X,t+1}$ a cleaner measure of sensitivity to $\Delta u_{1,t+1}$.

Note that if, as in Section 2.1., there are no noise traders with demand function (12) in the economy, or if fundamental traders are able to counteract their effect, Propositions 1 and 2 will not hold. In these cases, return correlation is completely determined by cash flow correlation. Therefore if, as assumed in the propositions, the cash flow covariance matrix $\Sigma_D$ stays constant, the correlation structure of returns will also stay constant. In other words, $\beta_j$ and $R^2$ in Proposition 1 and $\beta_{j,X}$ and $\beta_{j,Y}$ in Proposition 2 will remain unchanged after reclassification.

One final prediction of the category view of comovement is the following:

**Proposition 3:** In the presence of noise traders with demand function (12), and in the limit as the number of risky assets $n \rightarrow \infty$, the correlation of the return on $X$ with the return on $Y$,

$$\text{corr}(\Delta P_{X,t}, \Delta P_{Y,t}),$$

is lower than it would be in an economy that contains only fundamental traders.

When the economy contains only fundamental traders, the correlation of the returns of categories $X$ and $Y$ is completely determined by the correlation of the fundamentals of those two categories. As soon as noise traders are added to the mix, they generate flows of funds
in and out of the two categories, driving the prices of securities in the two categories in different directions, and lowering the correlation between them.

Proposition 3 becomes testable in the time series if the number of noise traders with demand functions in (12) grows over time; in that case, assuming a fixed cash flow covariance matrix, the correlation of the two categories' returns should fall over time.

2.3 Habitat-based Comovement

The habitat view of comovement starts from the observation that many investors trade only a subset of all available securities. Such preferred habitats may arise because of transaction costs, international trading restrictions, or lack of information (Merton, 1987). For example, suppose that one group of investors – “habitat X” investors – trades only securities 1 through \( n \), a set we again refer to as \( X \), while another group – habitat \( Y \) investors – trades only \( n + 1 \) through \( 2n \), set \( Y \). We can think of assets 1 through \( n \) as U.S. stocks, and assets \( n + 1 \) through \( 2n \) as U.K. stocks; there are many investors in both countries who restrict themselves to trading only domestic securities. We emphasize that \( X \) and \( Y \) play different roles here than in Section 2.2. There, they represented groups of assets that some investors did not distinguish between when allocating their demand. Here, they represent groups of assets that are the sole holdings of some investors.

Now suppose that habitat \( X \) investors experience an increase in risk aversion, say. They will then reduce their positions in all the stocks they hold, generating a common factor in the returns of securities in \( X \), even if those stocks’ fundamental values are uncorrelated. More generally, the habitat view of comovement predicts a common factor in the returns of any group of stocks that happens to be the primary holdings of a particular subset of investors.\(^9\)

In order to compare this view with the category-based view, suppose that habitat \( X \)

\(^9\)Other models which consider investor habitats are motivated by similar information and transaction cost considerations as our own, but focus on different issues. Merton (1987) analyses the cross-sectional implications when investors apply standard mean-variance analysis, but only over a subset of all available assets. Our focus is on the effects of habitat-level demand shifts that affect all stocks in the habitat equally.
investors have demand $N_{i,t}^{HX}$ for risky asset $i$, where
\begin{align}
N_{i,t}^{HX} &= \frac{1}{n} [A_X + u_{1,t}] , \ i \in X \\
N_{j,t}^{HX} &= 0, \ j \in Y.
\end{align}
(23)

We think of $u_{1,t}$ as tracking their level of risk aversion, changes in which lead them to alter their exposure to all assets in $X$. Of course, $u_{1,t}$ can also be interpreted as an indicator of sentiment about the future returns of assets in $X$, although the model does not require such an interpretation. By definition, habitat $X$ investors’ demand for assets in $Y$ is zero.

Similarly, habitat $Y$ investors’ demand is
\begin{align}
N_{i,t}^{HY} &= 0, \ i \in X \\
N_{j,t}^{HY} &= \frac{1}{n} [A_Y + u_{2,t}] , \ j \in Y.
\end{align}
(24)

We assume
\[
\begin{pmatrix}
  u_{1,t} \\
  u_{2,t}
\end{pmatrix}
\sim N
\left( \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \sigma_u^2 \begin{pmatrix} 1 & \rho_u \\ \rho_u & 1 \end{pmatrix} \right), \ \text{i.i.d. over time.}
\]

As before, we close the economy with fundamental traders who behave as in (5). Given their expectations about future prices, current prices are given by
\begin{align}
P_t &= E_t^F (P_{t+1}) - \gamma V_t^F (Q - (N_{t}^{H1} + N_{t}^{H2})) \\
&= E_t^F (P_{t+1}) - \gamma V_t^F (Q - N_{t}^{C}),
\end{align}
(25)

exactly as in (13). In other words, even though investors’ demand functions are motivated differently here than in the case of category-based comovement, prices are the same. Once again, there will be a common factor in the returns of assets in $X$ and $Y$ even if there is no common factor in their fundamentals.

The equivalence in equation (25) means that Propositions 1 through 3 also hold in this economy, with $X$ and $Y$ signifying investor habitats, not categories. For example, Proposition 1 should now be interpreted as predicting that if a stock becomes part of the habitat of a specific group of investors, it will comove more with the other assets in that habitat than it did before.
It is important to note that the habitat-based view of comovement depends on arbitrage being limited, just as the category-based view does. The fact that some investors trade only in certain securities means that habitats \( X \) and \( Y \) can trade at different prices, even though in the limit as \( n \to \infty \), their final cash flows are identical. If fundamental traders were able to wipe the discrepancy out completely, there would be no habitat-induced comovement.

3 Empirical Tests

Propositions 1 through 3 lay out predictions that hold in an economy where return comovement is in part due to category-based or habitat-based trading flows, but which do not hold in an economy where return comovement is entirely a function of comovement in news about fundamentals. We now test these predictions to see if we can uncover any evidence of trading-induced comovement.

In order to test the propositions, we need to identify a group of securities with three characteristics. First, the group must be viewed as a natural category, or must be a preferred habitat for many investors, or both. Second, there must be clear and identifiable changes in group membership over time. Finally, a security’s inclusion or removal from the group should not carry any information about the correlation of the security’s cash flows with the cash flows of other securities in the group.

One set of securities that satisfies these requirements is the S&P 500 index. In Section 2.2., we suggested identifying categories by looking at the products money managers offer their clients. The immense popularity of S&P 500-linked products suggests that this index may be a natural category in many investors’ minds: S&P 500 index funds and depositary receipts are important investment vehicles for both institutions and individuals, while S&P 500 futures are heavily traded by index arbitrageurs. The S&P 500 may also be a preferred habitat for U.S. investors who are reluctant to invest in foreign stocks and who doubt that active fund managers can outperform passive indices.

The S&P 500 also has the second characteristic we require: there is clear and identifiable turnover in its membership. In a typical year there are about 30 changes; our full sample,
which we describe in Section 3.1, includes 375 additions and 51 deletions.

Finally, inclusion in the S&P 500 does not change a stock’s cash flow characteristics, nor does it directly reflect such a change, a point emphasized by Harris and Gurel (1986) and Shleifer (1986). First, the stated goal of S&P is to make the index representative of the U.S. economy, not to provide signals about future cash flows. Recent evidence that confirms this comes from Kaul, Mehrotra, and Morck (2000) and Greenwood (2001). They show that when a stock already in the index has its weight in the index increased, the price impact is similar to the impact observed when an entirely new stock is brought into the index. If the act of inclusion carried information, the price impact in the two cases would be different.

Deletions from the index, however, are another matter. Stocks are usually removed from the index because a firm is merging, being taken over, or nearing bankruptcy. In these situations cash flow characteristics may well be changing, so deletion events must be selected with care.

We therefore test Propositions 1 through 3 for the case where X is the S&P 500, and Y is stocks outside that index. In Section 3.2., in line with Proposition 1, we test whether a stock’s beta with the S&P 500 and the fraction of its variance explained by the index increase (decrease) after the stock’s inclusion in (removal from) the index. In Section 3.3., in line with Proposition 2, we test whether a stock’s beta with the S&P 500, controlling for the return of non-S&P stocks, goes up (falls) after inclusion (deletion). Finally, in Section 3.4., motivated by Proposition 3, we test whether the correlation of S&P stocks and non-S&P stocks has fallen in line with the growing importance of the S&P 500 as a category.

Our null hypothesis, laid out in Section 2.1., is that return comovement is primarily a function of comovement in news about fundamentals, so that the betas and $R^2$ just described, as well as the correlation of S&P and non-S&P stocks, do not change. The alternative hypothesis is that trading flows do induce comovement, and that the betas, $R^2$, and cross-category correlation change as predicted in the propositions.
3.1 Data

We use S&P 500 index inclusions between September 22, 1976 and December 31, 1999 and deletions between January 1, 1979 and December 31, 1999. Standard & Poor’s did not record announcement dates of index changes before September 1976 and we were unable to obtain data on deletions before 1979.

There are 532 inclusion events in the inclusion sample period and 507 deletions in the deletion sample period. Inclusion events are excluded if the new firm is a spin-off or a restructured version of a firm already in the index, if the firm is engaged in a merger or takeover around the inclusion event, or if required return data is not available.\footnote{This last possibility may arise if the inclusion occurs so close to the end of the sample that it prevents us from estimating post-event betas.} Deletion events are excluded if the firm is involved in a merger, takeover, or bankruptcy proceeding. These circumstances, determined by searching the NEXIS database, exclude the vast majority of deletions. The final sample includes 375 inclusions and 51 deletions.\footnote{The S&P 500 inclusion and deletion data are available upon request.}

3.2 Univariate Regressions

If category-induced or habitat-induced trading flows cause return comovement, Proposition 1 predicts that stocks which are added to (deleted from) the S&P 500 will comove more (less) with the other members of the index after the addition or deletion event.

For each inclusion and deletion – in other words, for each event – we run the univariate regression

\[
R_{j,t} = \alpha_j + \beta_j R_{S&P,t} + \nu_{j,t}
\]

separately for the period before the event and for the period after the event. \(R_{j,t}\) is the return of the stock involved in the change between time \(t - 1\) and \(t\), while \(R_{S&P,t}\) is the contemporaneous return on the S&P 500 index, obtained from CRSP.\footnote{In order to avoid spurious effects, we remove the contribution of the stock in question from the right-hand side variable. For addition events, this means that there are 500 stocks in the right-hand side variable before the addition, and 499 afterward. The reverse applies for deletion events.} We run the regression...
using daily, weekly, and monthly data. With daily and weekly data, the pre-event regression is run over the 12 month period ending a month before the announcement of the inclusion or deletion, while the post-event regression is run over a 12 month period starting a month after the inclusion or deletion is implemented. In the case of monthly data, we use a five period ending a month before the announcement date and a five year period starting a month after the implementation date for the pre-event and post-event regressions, respectively.\footnote{Up until October 1989, inclusions and deletions were made effective on the day of their announcement. Since then, the changes have been announced a few weeks in advance of their actual implementation. It is not clear whether to view the to-be-added stock as being in the index, or not in the index during the time between announcement and implementation; significant price effects have been documented on both days. To avoid these issues entirely, we do not use data from the month of the announcement or the implementation; these are almost always the same month.}

Table 1 presents the results of this analysis for all three data frequencies, for both the full sample as well as for two subperiods. It reports the difference between the pre-event and post-event regression slopes, averaged across all events in the sample, $\bar{\Delta \beta}$, as well as the average change in $R^2$, $\Delta R^2$.

Table 1 also reports a quantity we call the average relative change in $R^2$, $\bar{\Delta \Delta R^2}$. The motivation for including this additional statistic is the work of Campbell, Lettau, Malkiel, and Yu (2001), who report that the fraction of an individual stock’s variance that can be explained by movements in a diversified portfolio has steadily declined over the past three decades. In other words, the $R^2$ in regressions like (26) has on average gone down for the full universe of stocks. This can confound a test of trading-based comovement: when a stock is added to the S&P 500 category, trading pressure may work to raise the $R^2$ in (26), but this may be more than offset by the overall downward trend in $R^2$ over time.

Our “relative change in $R^2$” measure controls for the trend identified by Campbell et al. (2001). For each stock that is included or removed from the index, we compute the change in $R^2$ after the event minus the average change in $R^2$ over the same time period experienced by stocks already in the S&P 500. Finally, we compute the average of this relative change in $R^2$ across all events in the sample and report it in Table 1.

Panel A confirms that stocks added to the S&P 500 experience a significant increase in daily beta, while those removed experience a significant decrease.
additions, the median increase in daily beta is 0.132. For deletions, the median decrease in beta is -0.163. The middle and right-hand columns report that there are also significant changes in both $R^2$ and relative $R^2$ in the direction predicted by Proposition 1. The results in the second half of the addition sample tend to be stronger than those in the first half.

Panel B shows that the results are similar in weekly data. There is a significant jump in beta and $R^2$ for additions, and a significant drop in beta for deletions, although no significant decrease in $R^2$ for deletions. Panel C shows the results are weaker in monthly data. In the second half of the addition sample, there are statistically significant increases in beta and in relative $R^2$ but in the first half the results are significant in the opposite direction.

### 3.3 Bivariate Regressions

The univariate regressions provide some evidence of trading-based comovement at higher frequencies. Stronger evidence comes from tests of Proposition 2, which predicts that controlling for the return of non-S&P 500 stocks, a stock that is added to or removed from the S&P will experience a large change in its loading on the S&P 500 return. To test this, for each inclusion and deletion, we run the bivariate regression

$$R_{j,t} = \alpha_j + \beta_{j,S&P} R_{S&P,t} + \beta_{j,non-S&P} R_{non-S&P,t} + v_{j,t}$$

(27)

for the period before the event and the period after the event. $R_{non-S&P,t}$ is the return on non-S&P stocks in the NYSE, AMEX, and Nasdaq universe between time $t - 1$ and time $t$. This last variable is inferred from index return and capitalization data using the identity that the capitalization-weighted average return of S&P stocks and of non-S&P stocks equals the overall CRSP value-weighted return on NYSE, AMEX, and Nasdaq stocks. The S&P return and CRSP return are easily computed, allowing us to deduce the non-S&P return.

As before, we run the regressions using daily, weekly, and monthly data. Daily and weekly regressions are run over a 12 month period ending a month before the announcement date and over a 12 month period starting a month after the implementation date. The monthly regressions use five year periods before announcement and after implementation.

Table 2 reports the results of the bivariate regressions. They are stronger than the
univariate results. At all three data frequencies, S&P 500 inclusion is associated with a substantial and significant increase in beta with the S&P and a substantial and significant decrease in beta with the rest of the market. For example, daily beta with the S&P 500 goes up by a median of 0.380 and daily beta with other stocks drops by -0.397. Large and significant results obtain for most subsamples, even in monthly data, as well as for deletion events.

Figures 1 through 3 use rolling regressions to show the dynamics of these changes. Panel A shows how the daily betas change over event time. The solid line shows the median daily beta with the S&P and the dashed line shows the median daily beta with the non-S&P. These coefficients are re-estimated each month using the prior 12 months of daily data. Therefore coefficients plotted to the left of the left vertical line use only pre-event returns. Coefficients plotted to the right of the right vertical line use only post-event returns. Coefficients in between use both pre- and post-event data. In terms of these figures, the beta changes reported in Table 2 are the average beta as of event month +12, which uses data from months [+1, +12] minus the average beta as of event month -1, which uses data from months [-12, -1]. There are fewer data points in the figures than in the table, however, because the figures include only firms that survived for some period after the inclusion.

Our results on changes in S&P 500 and non-S&P 500 betas are consistent with the findings of Vijh (1994), who studies whether the rise of S&P 500-linked products have affected the standard measure of stock risk, namely beta with the overall market return. He finds that over the 1975-1989 period, a stock’s daily beta with the market on average goes up by a statistically significant 0.08 after inclusion. Since a large fraction of overall market value comes from S&P 500 stocks, this fits with our finding of an increase in S&P 500 beta over a similar time period. Given our result that non-S&P 500 beta falls significantly, it also makes sense that overall market beta does not display as striking an increase as the S&P 500 beta.

3.4 Comovement Across Categories

Proposition 3 predicts that the correlation of the returns of two groups of securities will be lower than the correlation of their fundamentals if these groups form natural categories or
habitats. This proposition is testable in the time series under the condition that the groups’ importance as categories or habitats has grown over time.

The S&P 500 satisfies this last condition: its use in various investment styles has grown dramatically in the last few decades. Consistent with this trend, Wurgler and Zhuravskaya (2001) find that the size of the inclusion price jump has grown with the size of funds devoted to S&P indexing, and our earlier results show increasing comovement effects in more recent years.

Table 3 reports the trends in comovement between the S&P and other stocks over the past thirty years. The left column shows that the relative size of the S&P and whole market has remained constant. The declining correlations in the right columns show that at all three data frequencies, the returns on the S&P 500 have grown increasingly divorced from the returns on the rest of the market. The correlation in returns remains high today, but it is not as high as it was prior to the advent of the S&P 500 as a category. Another interesting pattern is that the decline in the daily correlation seems to have halted in recent years, while the weekly and monthly correlations continue to decline.

In Table 4 we determine whether the decreasing correlation between S&P and non-S&P stocks is statistically significant, or whether the correlation between two random groups would on average display a similar decline. We construct value-weighted returns on a random group of 500 stocks and compute their correlation with the value-weighted returns on the rest of the market over consecutive five year periods. By repeating this procedure for many random groups of 500 stocks, we can construct sampling distributions for the change in correlation over various intervals. We can then determine whether the decline in the S&P correlation is unusually large.

The left columns of Table 4 report the sampling distribution of the changes in correlation between the random 500 and the rest of the market. The correlations between random groups of stocks have declined. Panel A shows that, from the early 1970s to the late 1990s, the daily return correlation between random groups has fallen by a median of -0.043. For comparison, the second column from the right reports the experience of the S&P 500. Over this same period, Table 3 indicates that the daily return correlation between the S&P and the rest of the market has fallen by -0.118. The last column indicates that this is a much
greater decline than expected by chance.

Our simulation controls for the possibility that the decline in the S&P and non-S&P return correlation is due to a general decline in the correlation of stock fundamentals. Indeed, the results of Campbell et al. (2001) suggest that such a decline in fundamental correlation may have occurred, making it important to control for. Our simulation does not, however, rule out the possibility that our results are due to an especially large decline in the correlation of S&P 500 stocks’ fundamentals with remaining stocks’ fundamentals, as compared to the decline in the correlation of a random 500 stocks’ fundamentals with remaining stocks’ fundamentals. However, we see no obvious reason why this would be the case, since the S&P has always been constructed to be representative of the overall economy.\textsuperscript{14}

4 Conclusion

In this paper, we have presented and examined empirically three models of comovement. The traditional model attributes comovement to correlation in news about fundamental values. The two alternative models we consider explain comovement by correlated investor demand shifts for securities in a given category, or by demand shifts by specific investor clienteles.

To assess these theories, we consider the well-studied phenomenon of stock inclusions into, and deletions from, the S&P 500 index. While previous studies have noted significant immediate price effects associated with inclusions and deletions, we focus on changes in the patterns of comovement of newly included (or deleted) stocks with stocks already in the index. We find that stocks included into the index begin to comove more with other stocks in the index, and less with stocks out of the index. The converse holds for deletions. Because inclusion into the S&P 500 index conveys no news about fundamentals, this evidence is inconsistent with the fundamental view of comovement, but broadly supports the theories

\textsuperscript{14}Panel A of Table 4 also shows that the abrupt halt in the decline of the daily S&P correlation after 1990 is not mirrored by the random-500 correlation, while the weekly and monthly S&P correlations continue to decline relative to the typical random-500 group. One explanation is that arbitrage has checked the decline in the daily correlation, but has yet to stop the decline in the weekly and monthly correlations. Shleifer and Vishny (1990) point out that long-horizon arbitrage is likely to be weaker than short-horizon arbitrage.
based on shifts in demand.

This evidence adds to the growing range of phenomena identified by financial economists that reveal the importance of asset classification, and of demand shifts among asset classes, for valuation. The evidence shows not only that comovement between assets can be understood from this perspective, but also that demand is a crucial determinant of a security’s price. From this perspective, a security’s value depends as much on which asset categories it belongs to, and which investor clienteles trade it, as it does on its fundamentals.
5 Appendix

Proof of Propositions 1, 2, and 3: Suppose that asset $n+1$ is reclassified from $Y$ into $X$, and that at the same moment, asset 1 is reclassified from $X$ into $Y$.

Before reclassification,

\[
\Delta P_{X,t+1} = \varepsilon_{X,t+1} + \frac{\Delta u_{1,t+1}}{\phi_1} + \frac{\Delta u_{2,t+1}}{\phi_2},
\]

(28)

\[
\Delta P_{Y,t+1} = \varepsilon_{Y,t+1} + \frac{\Delta u_{1,t+1}}{\phi_2} + \frac{\Delta u_{2,t+1}}{\phi_1},
\]

\[
\Delta P_{n+1,t+1} = \varepsilon_{n+1,t+1} + \frac{\Delta u_{1,t+1}}{\phi_2} + \frac{\Delta u_{2,t+1}}{\phi_1},
\]

where

\[
\varepsilon_{k,t} = \frac{1}{n} \sum_{k=1}^{n} \varepsilon_{t,t}, \ k = X, Y.
\]

This implies

\[
\text{cov}(\Delta P_{n+1,t+1}, \Delta P_{X,t+1}) = \psi_M^2 + \frac{4\sigma_u^2}{\phi_1 \phi_2} + 2\sigma_u^2 \rho_u \left(\frac{1}{\phi_1^2} + \frac{1}{\phi_2^2}\right),
\]

(29)

\[
\text{cov}(\Delta P_{n+1,t+1}, \Delta P_{Y,t+1}) = \psi_M^2 + \frac{4\sigma_u^2}{\phi_1 \phi_2} + 2\sigma_u^2 \rho_u \left(\frac{1}{\phi_1^2} + \frac{1}{\phi_2^2}\right) + \frac{4\sigma_u^2 \rho_u}{\phi_1 \phi_2},
\]

\[
\text{var}(\Delta P_{X,t+1}) = \text{var}(\Delta P_{Y,t+1}) = \psi_M^2 + \frac{4\sigma_u^2}{\phi_1 \phi_2} + 2\sigma_u^2 \rho_u \left(\frac{1}{\phi_1^2} + \frac{1}{\phi_2^2}\right).
\]

cov(\Delta P_{X,t+1}, \Delta P_{Y,t+1}) = \psi_M^2 + \frac{4\sigma_u^2}{\phi_1 \phi_2} + 2\sigma_u^2 \rho_u \left(\frac{1}{\phi_1^2} + \frac{1}{\phi_2^2}\right).

After reclassification, $\Delta P_{X,t+1}$ and $\Delta P_{Y,t+1}$ are still given by (28), but now

\[
\Delta P_{n+1,t+1} = \varepsilon_{n+1,t+1} + \frac{\Delta u_{1,t+1}}{\phi_1} + \frac{\Delta u_{2,t+1}}{\phi_2},
\]

(30)

This implies

\[
\text{cov} \left(\Delta P_{n+1,t+1}, \Delta P_{X,t+1}\right) = \psi_M^2 + \frac{4\sigma_u^2}{\phi_1 \phi_2} + 2\sigma_u^2 \rho_u \left(\frac{1}{\phi_1^2} + \frac{1}{\phi_2^2}\right),
\]

(31)

\[
\text{cov} \left(\Delta P_{n+1,t+1}, \Delta P_{Y,t+1}\right) = \psi_M^2 + \frac{4\sigma_u^2}{\phi_1 \phi_2} + 2\sigma_u^2 \rho_u \left(\frac{1}{\phi_1^2} + \frac{1}{\phi_2^2}\right),
\]

while var($\Delta P_{X,t}$), var($\Delta P_{Y,t}$), and cov($\Delta P_{X,t+1}, \Delta P_{Y,t+1}$) remain the same as before.

Since the OLS estimate of $\beta_{n+1}$ in the regression

\[
\Delta P_{n+1,t+1} = \alpha_{n+1} + \beta_{n+1} \Delta P_{X,t+1} + v_{n+1,t+1}
\]

(32)
is given by
\[
\beta_{n+1} = \frac{\text{cov}(\Delta P_{n+1,t+1}, \Delta P_{X,t+1})}{\text{var}(\Delta P_{X,t+1})},
\]
expressions (29) and (31) taken together with
\[
\frac{1}{\phi_1^2} + \frac{1}{\phi_2^2} - \frac{2}{\phi_1 \phi_2} = \left(\frac{1}{\phi_1} - \frac{1}{\phi_2}\right)^2 \geq 0,
\]
confirm that \(\beta_{n+1}\) increases after reclassification as claimed in Proposition 1. In particular, before reclassification, \(\beta_{n+1} < 1\), while after reclassification, \(\beta_{n+1} = 1\).

The OLS estimates of \(\beta_{n+1,X}\) and \(\beta_{n+1,Y}\) in the regression
\[
\Delta P_{n+1,t+1} = \alpha_{n+1} + \beta_{n+1,X} \Delta P_{X,t+1} + \beta_{n+1,Y} \Delta P_{Y,t+1} + v_{n+1,t+1}
\]
are given by
\[
\begin{pmatrix}
\beta_{n+1,X} \\
\beta_{n+1,Y}
\end{pmatrix} = \frac{1}{V_X V_Y - C_{XY}^2} \begin{pmatrix}
V_Y & -C_{XY} \\
-C_{XY} & V_X
\end{pmatrix} \begin{pmatrix}
C_{n+1,X} \\
C_{n+1,Y}
\end{pmatrix}
\]
where
\[
V_k = \text{var}(\Delta P_{k,t+1}), \quad k = X,Y
\]
\[
C_{XY} = \text{cov}(\Delta P_{X,t+1}, \Delta P_{Y,t+1})
\]
\[
C_{n+1,k} = \text{cov}(\Delta P_{n+1,t+1}, \Delta P_{k,t+1}), \quad k = X,Y.
\]

Before reclassification, \(C_{n+1,X} = C_{XY}\) and \(C_{n+1,Y} = V_Y\), which implies
\[
\beta_{n+1,X} = 0, \quad \beta_{n+1,Y} = 1,
\]
while after reclassification, \(C_{n+1,X} = V_X\) and \(C_{n+1,Y} = C_{XY}\), which implies
\[
\beta_{n+1,X} = 1, \quad \beta_{n+1,Y} = 0.
\]
Therefore \(\beta_{n+1,X}\) does indeed increase after reclassification, while \(\beta_{n+1,Y}\) falls. This proves Proposition 2.

Finally, given the expressions for \(\text{var}(\Delta P_{X,t+1})\), \(\text{var}(\Delta P_{Y,t+1})\), and \(\text{cov}(\Delta P_{X,t+1}, \Delta P_{Y,t+1})\) in equation (29), it is immediate that in the limit as \(n \to \infty\),
\[
\text{corr}(\Delta P_{X,t+1}, \Delta P_{Y,t+1}) < \frac{\psi_M^2}{\psi_M^2 + \frac{1 - \psi_M^2}{n}} = \text{corr}(\Delta D_{X,t+1}, \Delta D_{Y,t+1}).
\]
This proves Proposition 3.
6 References


Table I. Changes in comovement of stocks added to and deleted from the S&P 500 Index: Univariate results. Changes in the slope and the fit of univariate OLS regressions of returns on stocks added to and deleted from the S&P 500 Index on returns of the S&P 500 Index itself. The sample includes stocks added to and deleted from the S&P 500 between 1976 and 1998 with usable data. Returns from October 1987 are excluded. The univariate model

\[ R_{yt} = \alpha_t + \beta_{sp500,t}R_{sp500,t} + \epsilon_{yt} \]

is separately estimated for the pre-change and post-change period for each added stock \( i \). The difference between the pre-change slope and the post-change slope is denoted \( \Delta \beta_{sp500} \). The change in regression \( R^2 \) is denoted \( \Delta R^2_{sp500} \). The difference-in-difference \( R^2 \) is computed as the change between the pre-change and post-change value of the difference between the added stock’s \( R^2 \) and the average \( R^2 \) of the other stocks currently in the Index and is denoted \( \Delta \Delta R^2_{sp500} \). The pre-change and post-change estimation periods are \([-12, -1]\) and \([+1, +12]\) months for daily and weekly returns and \([-60, -1]\) and \([+1, +60]\) months for monthly returns. In the post-change estimation period, the mechanical influence of the added stock is removed from the S&P 500 Index return independent variable. Panels A, B, and C show results for daily, weekly, and monthly returns, respectively. Standard errors for the mean estimates are reported in parentheses. T-tests are conducted on the mean differences and sign tests are conducted on the median differences. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels in one-sided tests, respectively.

<table>
<thead>
<tr>
<th>Sample</th>
<th>N</th>
<th>( \Delta \beta_{sp500} ) Mean (s.e.)</th>
<th>Median</th>
<th>( \Delta R^2_{sp500} ) Mean (s.e.)</th>
<th>Median</th>
<th>( \Delta \Delta R^2_{sp500} ) Mean (s.e.)</th>
<th>Median</th>
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<tr>
<td>Panel A. Daily Returns</td>
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<tr>
<td>Additions</td>
<td>1976-1998</td>
<td>375</td>
<td>0.117*** (0.020)</td>
<td>0.132***</td>
<td>0.053*** (0.006)</td>
<td>0.044***</td>
<td>0.049*** (0.006)</td>
</tr>
<tr>
<td></td>
<td>1976-1987</td>
<td>176</td>
<td>0.060** (0.025)</td>
<td>0.046</td>
<td>0.026*** (0.008)</td>
<td>0.014**</td>
<td>0.006 (0.007)</td>
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<tr>
<td></td>
<td>1988-1998</td>
<td>199</td>
<td>0.168*** (0.031)</td>
<td>0.224***</td>
<td>0.078*** (0.008)</td>
<td>0.087***</td>
<td>0.087*** (0.010)</td>
</tr>
<tr>
<td>Deletions</td>
<td>1976-1998</td>
<td>51</td>
<td>-0.148*** (0.060)</td>
<td>-0.163***</td>
<td>-0.007</td>
<td>-0.013** (0.009)</td>
<td>-0.022***</td>
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### Panel B. Weekly Returns

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<tr>
<th></th>
<th>1976-1998</th>
<th>375</th>
<th>0.054**</th>
<th>0.057**</th>
<th>0.031***</th>
<th>0.041***</th>
<th>0.040***</th>
<th>0.044***</th>
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<tbody>
<tr>
<td></td>
<td>1976-1987</td>
<td>176</td>
<td>0.012</td>
<td>0.019</td>
<td>0.016</td>
<td>0.029</td>
<td>0.032**</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.040)</td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.016)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>1988-1998</td>
<td>199</td>
<td>0.092**</td>
<td>0.088**</td>
<td>0.045***</td>
<td>0.052***</td>
<td>0.046***</td>
<td>0.061***</td>
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<tr>
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<td></td>
<td>(0.038)</td>
<td>(0.011)</td>
<td>(0.011)</td>
<td>(0.012)</td>
<td></td>
<td></td>
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<tr>
<td>Deletions</td>
<td>1976-1998</td>
<td>51</td>
<td>-0.259**</td>
<td>-0.215**</td>
<td>-0.009</td>
<td>-0.010</td>
<td>0.023</td>
<td>0.036</td>
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<td></td>
<td></td>
<td></td>
<td>(0.135)</td>
<td>(0.111)</td>
<td>(0.011)</td>
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</tbody>
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### Panel C. Monthly Returns

<table>
<thead>
<tr>
<th></th>
<th>1976-1998</th>
<th>214</th>
<th>-0.027</th>
<th>-0.039</th>
<th>-0.019*</th>
<th>-0.023**</th>
<th>-0.014</th>
<th>0.004</th>
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<tbody>
<tr>
<td></td>
<td>1976-1987</td>
<td>133</td>
<td>-0.106***</td>
<td>-0.134**</td>
<td>-0.016</td>
<td>-0.024**</td>
<td>-0.070***</td>
<td>-0.055***</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>(0.040)</td>
<td>(0.047)</td>
<td>(0.015)</td>
<td>(0.016)</td>
<td>(0.016)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1988-1998</td>
<td>81</td>
<td>0.104**</td>
<td>0.115*</td>
<td>-0.023*</td>
<td>-0.021</td>
<td>0.079***</td>
<td>0.095***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.047)</td>
<td>(0.047)</td>
<td>(0.017)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deletions</td>
<td>1976-1998</td>
<td>21</td>
<td>-0.150*</td>
<td>-0.046</td>
<td>-0.017</td>
<td>-0.043</td>
<td>0.019</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.112)</td>
<td>(0.031)</td>
<td>(0.031)</td>
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</table>
Table II. Changes in comovement of stocks added to and deleted from the S&P 500 Index: Multivariate results. Changes in the slope and the fit of univariate OLS regressions of returns on stocks added to and deleted from the S&P 500 on returns of the S&P 500 Index and the non-S&P 500 rest of the market. The sample includes stocks added to and deleted from the S&P 500 between 1976 and 1998 with useable data. Returns from October 1987 are excluded. The model

\[ R_{it} = \alpha_i + \beta_{sp500,i} R_{sp500,t} + \beta_{non-sp500,i} R_{non-sp500,t} + \epsilon_{it} \]

is separately estimated for the pre-change and post-change period for each added stock \( i \). The differences between pre-change and post-change slopes are denoted \( \Delta \beta_{sp500} \) and \( \Delta \beta_{non-sp500} \). The pre-change and post-change estimation periods are \([-12,-1] \) and \([+1,+12] \) months for daily and weekly returns and \([-60,-1] \) and \([+1,+60] \) months for monthly returns. The mechanical influence of the added stock is removed, as appropriate, from both independent variables. Panels A, B, and C show results for daily, weekly, and monthly returns, respectively. Standard errors for the mean estimates are reported in parentheses. T-tests are conducted on the mean differences and sign tests are conducted on the median differences. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels in one-sided tests, respectively.

<table>
<thead>
<tr>
<th>Sample</th>
<th>N</th>
<th>( \Delta \beta_{sp500} )</th>
<th>( \Delta \beta_{non-sp500} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (s.e.)</td>
<td>Median</td>
<td>Mean (s.e.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Panel A. Daily Returns</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additions 1976-1998</td>
<td>375</td>
<td>0.346*** (0.028)</td>
<td>0.380***</td>
</tr>
<tr>
<td>1976-1987</td>
<td>176</td>
<td>0.278*** (0.045)</td>
<td>0.275***</td>
</tr>
<tr>
<td>1988-1998</td>
<td>199</td>
<td>0.406*** (0.036)</td>
<td>0.436***</td>
</tr>
<tr>
<td>Deletions 1976-1998</td>
<td>51</td>
<td>-0.662*** (0.143)</td>
<td>-0.413***</td>
</tr>
</tbody>
</table>
## Panel B. Weekly Returns

<table>
<thead>
<tr>
<th></th>
<th>1976-1998</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>375</td>
<td>0.161*** (0.059)</td>
<td>0.259***</td>
<td>0.133*** (0.061)</td>
<td>-0.124**</td>
</tr>
<tr>
<td></td>
<td>176</td>
<td>0.119  (0.101)</td>
<td>0.264*</td>
<td>-0.135  (0.099)</td>
<td>-0.105</td>
</tr>
<tr>
<td></td>
<td>199</td>
<td>0.197*** (0.066)</td>
<td>0.259***</td>
<td>-0.131** (0.075)</td>
<td>-0.133*</td>
</tr>
<tr>
<td>Deletions</td>
<td>1976-1998</td>
<td>-0.540*** (0.167)</td>
<td>-0.380***</td>
<td>0.402*** (0.220)</td>
<td>0.449***</td>
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</tbody>
</table>

## Panel C. Monthly Returns

<table>
<thead>
<tr>
<th></th>
<th>1976-1998</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>214</td>
<td>0.281*** (0.072)</td>
<td>0.339***</td>
<td>-0.247*** (0.068)</td>
<td>-0.341***</td>
</tr>
<tr>
<td></td>
<td>133</td>
<td>0.202** (0.099)</td>
<td>0.341***</td>
<td>-0.184*** (0.090)</td>
<td>-0.300***</td>
</tr>
<tr>
<td></td>
<td>81</td>
<td>0.411*** (0.097)</td>
<td>0.336***</td>
<td>-0.390*** (0.102)</td>
<td>-0.398***</td>
</tr>
<tr>
<td>Deletions</td>
<td>1976-1998</td>
<td>-0.018 (0.318)</td>
<td>0.084</td>
<td>-0.070 (0.305)</td>
<td>-0.021</td>
</tr>
</tbody>
</table>
Table III. Trends in the correlation between returns on the S&P 500 and the rest of the market. Returns including distributions on the S&P 500 ($R_{sp500}$), and the total capitalization of stocks included in the S&P 500, are from the CRSP Index on the S&P 500 Universe file. Capitalization-weighted returns including distributions on the NYSE, AMEX, and Nasdaq, and the total capitalization of stocks in these markets, are from the CRSP Stock Index File. A capitalization-weighted return index of non-S&P 500 stocks ($R_{non-sp500}$) on the NYSE, AMEX, and Nasdaq is inferred from the identity:

$$R_{VWCRSP,t} = \left( \frac{MKTCAP_{CRSP,t} - MKTCAP_{sp500,t}}{MKTCAP_{CRSP,t}} \right) \cdot R_{non-sp500,t} + \left( \frac{MKTCAP_{sp500,t}}{MKTCAP_{CRSP,t}} \right) \cdot R_{sp500,t}.$$  

Weekly returns are constructed by compounding daily data in calendar weeks that include at least four trading days.

<table>
<thead>
<tr>
<th>Years</th>
<th>Mean of $\left( \frac{MKTCAP_{sp500,t}}{MKTCAP_{CRSP,t}} \right)$</th>
<th>Correlation between S&amp;P 500 and the rest of the market</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Daily Returns</td>
</tr>
<tr>
<td>1970 – 1974</td>
<td>0.689</td>
<td>0.941</td>
</tr>
<tr>
<td>1975 – 1979</td>
<td>0.685</td>
<td>0.898</td>
</tr>
<tr>
<td>1980 – 1984</td>
<td>0.670</td>
<td>0.871</td>
</tr>
<tr>
<td>1985 – 1989</td>
<td>0.683</td>
<td>0.818</td>
</tr>
<tr>
<td>1990 – 1994</td>
<td>0.690</td>
<td>0.817</td>
</tr>
<tr>
<td>1995 – 1999</td>
<td>0.701</td>
<td>0.823</td>
</tr>
</tbody>
</table>
Table IV. Test that the declining correlation between the S&P 500 and the rest of the market is unusual. The decline in correlation between returns on the S&P 500 ($R_{sp500}$) and the rest of the market ($R_{non-sp500}$) is evaluated relative to the null hypothesis that a similar decline applies to random sets of stocks. The distribution of changes in the correlation between the value-weighted return on 500 random stocks from NYSE, AMEX, and Nasdaq and the value-weighted return on the rest of the market is determined by simulation. The following procedure is repeated 500 times to determine sampling distributions. (1) A value-weighted return of 500 random stocks from the NYSE, AMEX, and Nasdaq is constructed from all stocks on CRSP as of 1970. A value-weighted return on the remainder of the market is also constructed as of 1970. (2) The daily, weekly, and monthly correlation between these two return series is computed and recorded annually from 1970 – 1999. When a stock drops out of the random 500 sample, it is replaced with another stock randomly taken from the rest of the market sample. (3) The time-series correlation between these two series constitutes one complete sample path. Panels A, B, and C show results for daily, weekly, and monthly returns, respectively.

<table>
<thead>
<tr>
<th>Years</th>
<th>Change in correlation between random 500 and the rest of the market</th>
<th>Change in correlation between S&amp;P 500 and the rest of the market</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5th percentile</td>
<td>10th percentile</td>
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<tr>
<td>1995 – 1999 vs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970 – 1974</td>
<td>-0.070</td>
<td>-0.064</td>
</tr>
<tr>
<td>1975 – 1979</td>
<td>-0.073</td>
<td>-0.066</td>
</tr>
<tr>
<td>1980 – 1984</td>
<td>-0.070</td>
<td>-0.065</td>
</tr>
<tr>
<td>1985 – 1989</td>
<td>-0.079</td>
<td>-0.073</td>
</tr>
<tr>
<td>1990 – 1994</td>
<td>-0.048</td>
<td>-0.042</td>
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</table>

Panel A. Daily Returns
### Panel B. Weekly Returns

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<td>-0.076</td>
<td>-0.076</td>
<td>-0.068</td>
<td>-0.075</td>
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<tr>
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<td>-0.032</td>
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<td>0.002</td>
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<td>0.002</td>
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### Panel C. Monthly Returns

<table>
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<tr>
<td></td>
<td>-0.115</td>
<td>-0.114</td>
<td>-0.102</td>
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<td>-0.059</td>
<td>-0.050</td>
<td>-0.066</td>
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<td>0.162</td>
<td>0.202</td>
<td>0.112</td>
<td>0.110</td>
<td>0.274</td>
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</table>
Figure I. Changes in comovement of stocks added to the S&P 500 Index: Bivariate results. Plots of the mean slope coefficients of univariate OLS regressions of returns on stocks added to the S&P 500 on returns of the S&P 500 Index and the non-S&P 500 rest of the market. The sample includes added stocks with complete returns data over the entire event horizon examined in each figure (-12 to +24 months in daily and weekly returns data and -60 to +120 months in monthly returns data) and which remain in the Index for the duration of the post-event horizon considered. The model

$$R_{i,t} = \alpha_i + \beta_{sp500,t} R_{sp500,t} + \beta_{non-sp500,t} R_{non-sp500,t} + \epsilon_{i,t}$$

is estimated in rolling regressions where the sample intervals are [-12,-1] months for daily and weekly returns and [-60,-1] months for monthly returns. The mechanical influence of the added stock is removed, as appropriate, from both independent variables. The event time median of each coefficient is plotted. The left vertical line indicates the addition date; coefficients to the left of this line are estimated using only pre-event data. Coefficients to the right of the right vertical line are estimated using only post-event data. In between the vertical lines, coefficients are estimated using both pre- and post-event data.

A. Daily returns coefficients for 1976-1998 additions (n=327)
B. Weekly returns coefficients for 1976-1998 additions (n=327)

C. Monthly returns coefficients for 1976-1998 additions (n=126)