Financial Integration:
A New Methodology and
An Illustration

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Two Objectives:

1. Derive new methodology to assess integration of assets across instruments/borders/markets, etc.

2. Use methodology to illustrate technique empirically
   - Find remarkably little evidence of asset integration between S&P and NASDAQ

Definition of Asset Integration

- Assets are *integrated* if satisfy asset-pricing condition:

$$p_t^j = E_t(d_{t+1} x_{t+1}^j) \qquad (1)$$

- Completely standard general framework

Paper Focus: $E_t(d_{t+1})$

- Marginal Rate of Substitution/Discount Factor ties together all intertemporal decisions
- Subject of much research (Hansen-Jagannathan, etc.)
- Prices all assets
- Unobservable, even *ex post* (but estimable)
- Should be identical for all assets *in an integrated market*

Empirical Strategy

Definition of Covariance:

$$p_t^j = E_t(d_{t+1} x_{t+1}^j) = COV_t(d_{t+1}, x_{t+1}^j) + E_t(d_{t+1}) E_t(x_{t+1}^j). \qquad (2)$$

Rearrange and substitute actual for expected (WLOG):

$$x_{t+1}^j = -[1/E_t(d_{t+1})] COV_t(d_{t+1}, x_{t+1}^j) + [1/E_t(d_{t+1})] p_t^j + e_{t+1}^j,$$

$$x_{t+1}^j = d_t (p_t^j - COV_t(d_{t+1}, x_{t+1}^j)) + e_{t+1}^j \qquad (3)$$

where $d_t = 1/E_t(d_{t+1})$

Impose Two (Reasonable?) Assumptions for Estimation:

1) *Rational Expectations*: e_{t+1}^{j} is assumed to be white noise, uncorrelated with information available at time t, and

2) *Factor Model*:

$COV_t(d_{t+1}, x_{t+1}^j) = b_j^0 + \Sigma^i b_j^i f_t^i$, for the relevant sample.

Now we have an estimable Panel Equation:

$$x_{t+1}^j = d_t(p_t^j - COV_t(d_{t+1}, x_{t+1}^j) + e_{t+1}^j \qquad (3)$$

- Use *Cross-sectional* variation to estimate the coefficients of interest $\{d\}$ – the shadow discount rates
- Use *Time-series* variation to estimate nuisance coefficients {ß}
- Can estimate $\{d\}$ for two sets of assets and compare them
    - o Should be equal if assets are integrated – priced with same shadow discount rate

Why this Strategy?

- Natural to look at first moment (of MRS) first
- Easy to estimate
- Insensitive in practice
- Confirm priors, previous research, but discriminating

Are Assumptions Reasonable?

Easier

- Rational expectations in financial markets at relatively high frequencies

Harder

- Portfolio-specific covariances (payoffs with discount rates) are either constant or have constant relations with small number of factors, *for short samples*
  - Standard assumption to make in literature
  - Use standard factor model (Fama-French)
    - FF: 30 years; here for 2 months
  - Sensitivity Analysis for robustness

Strengths of Methodology

1. Tightly based on general theory
2. Do not need particular asset pricing model held with confidence *for long period of time*
3. Do not model discount rate directly
4. Relatively loose assumptions required
5. Requires accessible, reliable data

6. Can be used at many frequencies

7. Can be used for many asset classes (stocks, bonds, foreign)

8. Requires no special/obscure software (E-Views/RATS/TSP/STATA all work – just NLLS)

9. Focused on intrinsically interesting object

Differences with Literature

- We focus on first-moment of δ (estimated discount rate/MRS)
    - Standard: β (factor loadings), or second moment of δ
- Our set-up is intrinsically non-linear
- We don't fixate on asset-pricing model (though need it)

Most Importantly, don't impose bond market integration

- Consider risk-free gov't T-bill with price of $1, interest i_t:

  $1=E_t(d_{t+1}(1+i_t))$ => $1/(1+i_t)=E_t(d_{t+1})$

  - We do not use the T-bill rate *since the T-bill market may not be integrated with the stock market!*
  - Will test *(and reject!)* this assumption

- Do not violate replication/arbitrage since we are testing for integration across markets where replication is impossible

Implementation

Estimate:

$$x^j_{t+1}/p^j_{t-1} = d_t((p^j_t/p^j_{t-1}) + b^0_j + b^1_j f^1_t + b^2_j f^2_t + b^3_j f^3_t) + e^j_{t+1} \quad (4)$$

- Normalize to make Cov() more plausibly time-invariant (with factors)
- Use Fama-French (1996) 3 factors
- Estimate with NLLS, Newey-West covariances
  - o Degree of non-linearity low

Notes

- Similar in nature to Roll and Ross (1980)
- Subsumes static CAPM through $\{\beta^0\}$
- Add three time-varying factors from Fama-French (their data!)
    - Market return less T-bill return
    - Small minus large return
    - High minus low book/market returns

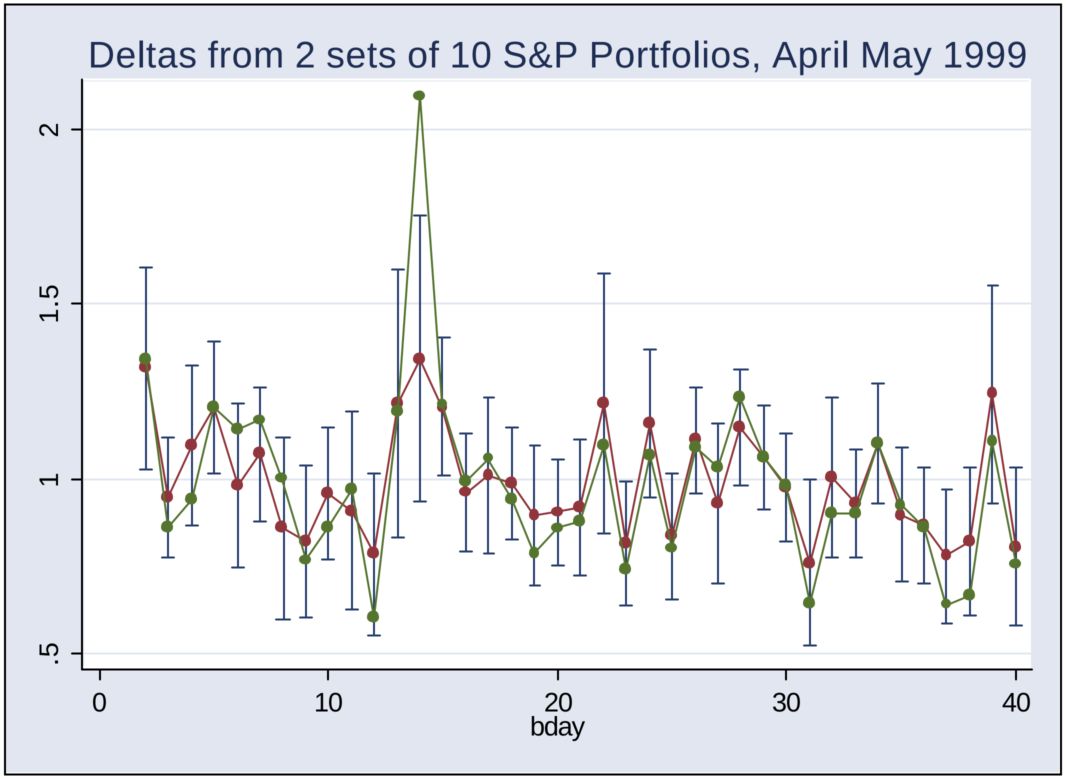
- Use moderately high-frequency approach
    - Daily data for 2-month spans

First Example

- April-May 1999
- Use first 100 S&P 500 firms (by ticker symbol) that did not go ex-dividend (no obvious bias)
- Group randomly into 20 portfolios of 5 firms each (by ticker)
- Closing rates from “US Pricing” of Thomson Analytics
- 41 days, lose one each for lead/lag

Shadow Discount Rates

- Can easily estimate from sets of 10 S&P portfolios (along with confidence intervals):



- Two delta estimates look reasonably close, day by day
- Lots of time-series variation (Hansen-Jagannathan)
- Can reject hypothesis that δ = Treasury bill return (sluggish at 4.4% annual

Likelihood-Ratio (Joint) Test for Asset Integration

- 2(2309-(1160+1166)) = 36
  - sits virtually at the median of $c^{2}(39)$
  - Can’t reject null Ho of asset integration
  - Bootstrapping (leptokurtosis!) implies p-value of .9

Broadening the Sample

- Five other samples (2 different sets of 2-month periods in 1999; same months in 2002) confirm integration

Log Likelihoods	**April-May 1999**	**July-Aug. 1999**	**Oct.-Nov. 1999**
First 10 portfolios	1160.	1302.	1157.
Second 10 portfolios	1166.	1299.	1172.
All 20 portfolios	2309.	2574.	2303.
Test (bootstrap P-value)	36 (.90)	54 (.37)	51 (.43)
	April-May 2002	**July-Aug. 2002**	**Oct.-Nov. 2002**
First 10 portfolios	1438.	1255.	1247.
Second 10 portfolios	1405.	1302.	1227.
All 20 portfolios	2805.	2525.	2456.
Test (bootstrap P-value)	75 (.06)	62 (.24)	37 (.90)

Table 1: Integration inside the S&P 500, Fama-French-Factor Model

Add Different Asset Classes

- NASDAQ firms
- Same timing, samples

NASDAQ is usually (not always) integrated

Log Likelihoods	**April-May 1999**	**July-Aug. 1999**	**Oct.-Nov. 1999**
First 10 portfolios	881.	1066.	757.
Second 10 portfolios	816.	990.	945.
All 20 portfolios	1677.	2023.	1625.
Test (bootstrap P-value)	42 (.83)	65 (.20)	153** (.00)
	April-May 2002	**July-Aug. 2002**	**Oct.-Nov. 2002**
First 10 portfolios	1052.	1061.	991.
Second 10 portfolios	1174.	1003.	962.
All 20 portfolios	2185.	2035.	1919.
Test (bootstrap P-value)	82* (.03)	58 (.45)	69 (.08)

Table 2: Integration inside the NASDAQ, Fama-French-Factor Model

NASDAQ is *never* integrated with the S&P

- Test statistics for across-market integration are an order of magnitude higher than those for within-market integration

Log Likelihoods	**April-May 1999**	**July-Aug. 1999**	**Oct.-Nov. 1999**
20 S&P Portfolios	2309.	2574.	2303.
20 NASDAQ Portfolios	1677.	2023.	1625.
Combined	3706.	4396.	3633.
Test (bootstrap P-value)	559** (.00)	403** (.00)	590** (.00)
	April-May 2002	**July-Aug. 2002**	**Oct.-Nov. 2002**
20 S&P Portfolios	2805.	2525.	2456.
20 NASDAQ Portfolios	2185.	2035.	1919.
Combined	4735.	4352.	4170.
Test (bootstrap P-value)	511** (.00)	416** (.00)	410** (.00)

Table 3: Integration between S&P 500 and NASDAQ, Fama-French Model

Sensitivity Analysis

- Does exact factor model matter?

- Can drop 2 “extra” Fama-French factors; similar results

Test Statistics (bootstrap P-value)	**April-May 1999**	**July-Aug. 1999**	**Oct.-Nov. 1999**
Within S&P	36 (.93)	48 (.75)	30 (.99)
Within NASDAQ	47 (.79)	65 (.27)	127** (.00)
S&P vs. NASDAQ	548** (.00)	388** (.00)	594** (.00)
	April-May 2002	**July-Aug. 2002**	**Oct.-Nov. 2002**
Within S&P	44 (.88)	55 (.61)	35 (.98)
Within NASDAQ	80 (.09)	58 (.61)	72 (.13)
S&P vs. NASDAQ	497** (.00)	432** (.00)	422** (.00)

Table 4: Integration between S&P 500 and NASDAQ, 1 factor (market) Model

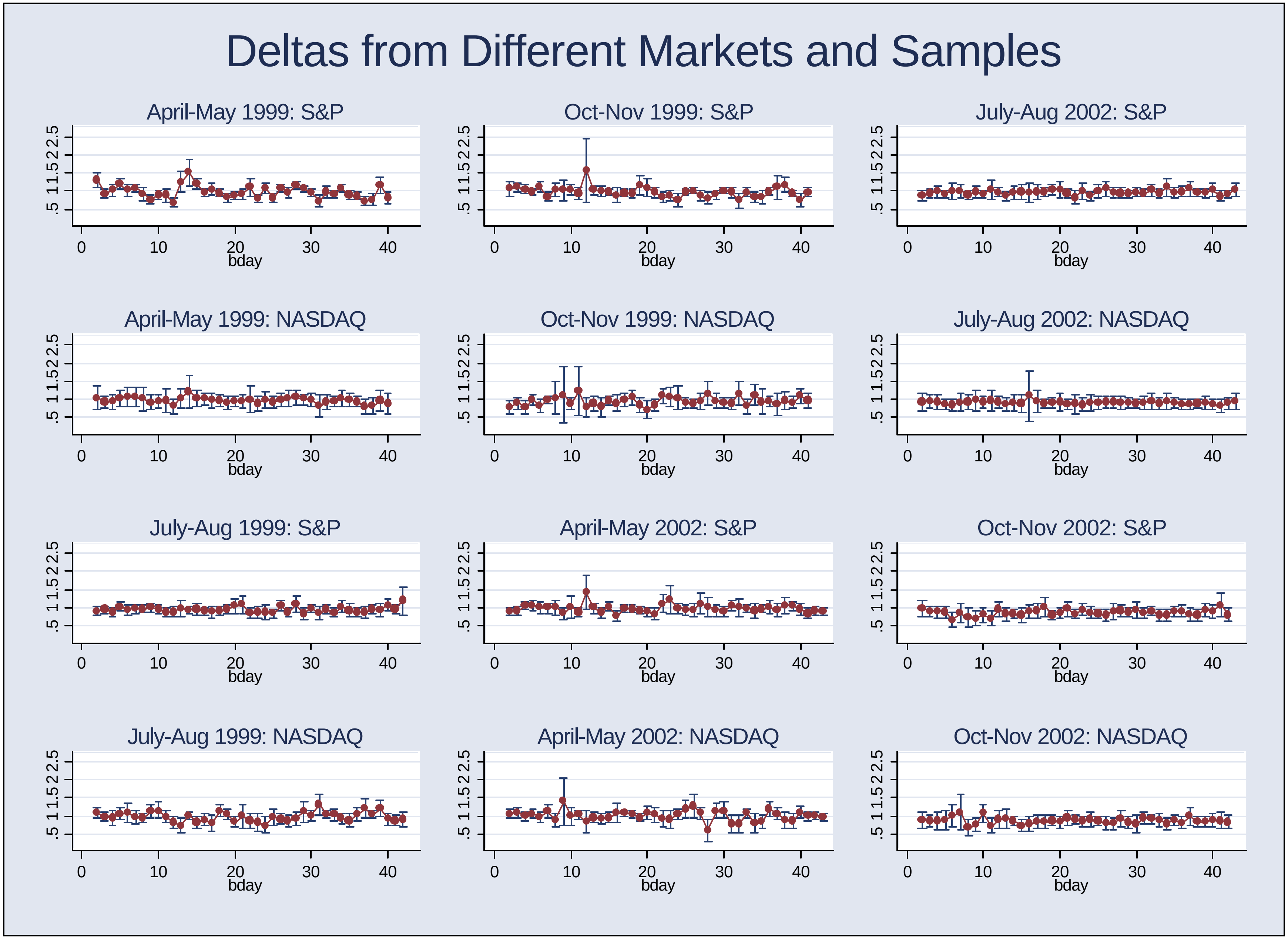
In fact, Time-Varying Factors Make Little Difference!

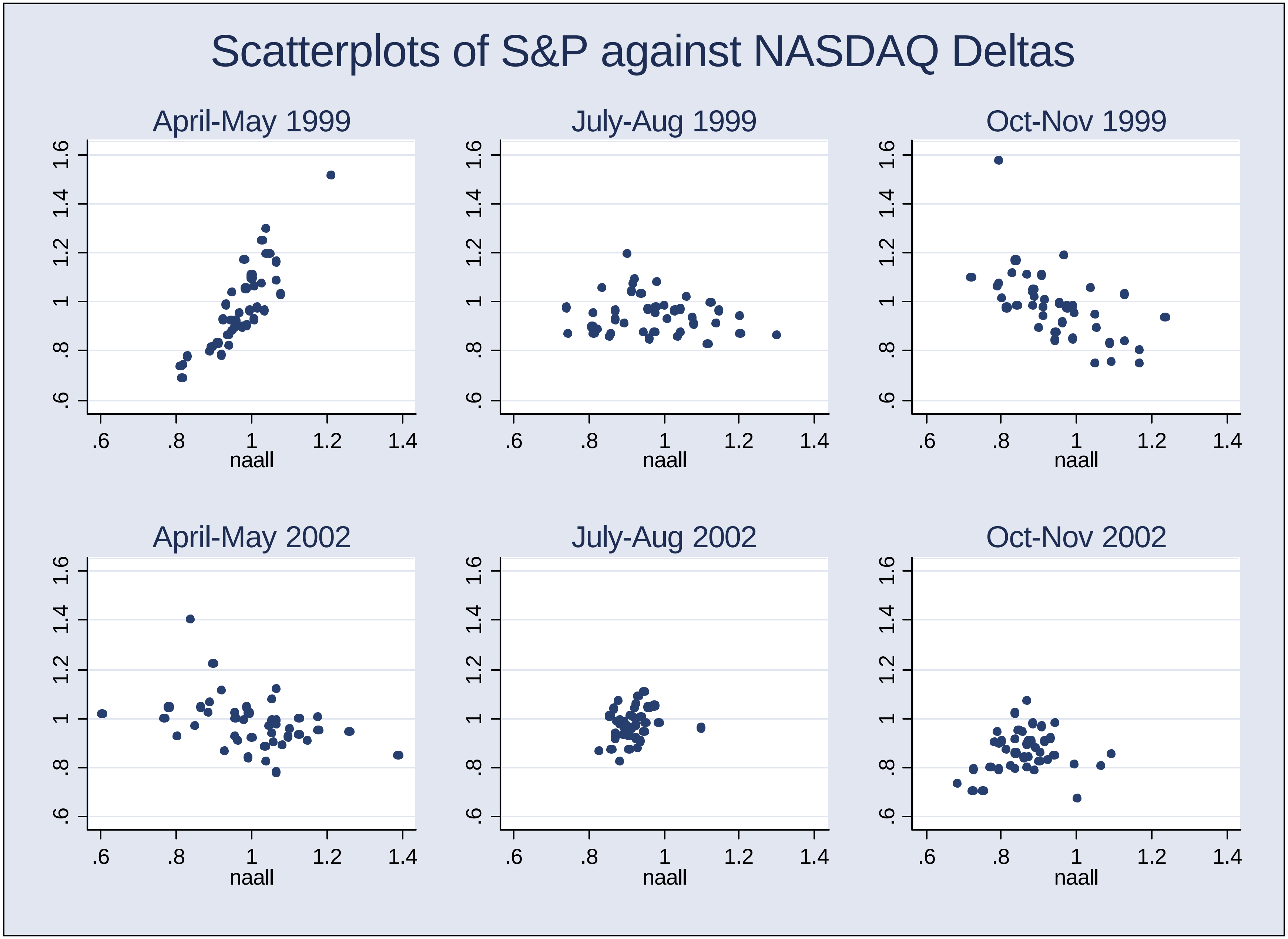
- Can estimate with only firm-specific intercepts

- Very similar results and conclusions

Test Statistics (bootstrap P-value)	**April-May 1999**	**July-Aug. 1999**	**Oct.-Nov. 1999**
Within S&P	33 (.97)	46 (.71)	34 (.94)
Within NASDAQ	42 (.80)	62 (.28)	114** (.00)
S&P vs. NASDAQ	534** (.00)	378** (.00)	591** (.00)
	April-May 2002	**July-Aug. 2002**	**Oct.-Nov. 2002**
Within S&P	46 (.76)	47 (.77)	36 (.95)
Within NASDAQ	86* (.03)	52 (.63)	68 (.12)
S&P vs. NASDAQ	506** (.00)	416** (.00)	419** (.00)

Table 5: Integration between S&P 500 and NASDAQ, Only Firm Intercepts


Deltas from Different Markets and Samples
April-May 1999: S&P
Oct-Nov 1999: S&P
July-Aug 2002: S&P
April-May 1999: NASDAQ
Oct-Nov 1999: NASDAQ
July-Aug 2002: NASDAQ
July-Aug 1999: S&P
April-May 2002: S&P
Oct-Nov 2002: S&P
July-Aug 1999: NASDAQ
April-May 2002: NASDAQ
Oct-Nov 2002: NASDAQ
bday


Scatterplots of S&P against NASDAQ Deltas
April-May 1999
July-Aug 1999
Oct-Nov 1999
April-May 2002
July-Aug 2002
Oct-Nov 2002
.6
.8
1
1.2
1.4
1.6
naall

Future Work

- Monte Carlo work for small samples
- Examine before/after crises
- Lower frequencies (housing? more factors? trends?)
- Higher frequencies
- Is the finding of little integration general?

Most Importantly

- Causes of low integration?