Financial Asset Integration

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All materials (data sets, programs, papers, slides) at:

http://faculty.haas.berkeley.edu/arose

Two Objectives:

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

Definition of Asset Integration

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

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

- Completely standard general framework

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

- Marginal Rate of Substitution/Stochastic Discount

  Factor/Pricing Kernel ties together all intertemporal decisions

- Subject of much research (Hansen-Jagannathan, etc.)

- Prices all assets (and intertemporal decisions!)

- Unobservable, even *ex post* (but estimable)

Key:

- 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^{j}_{t+1} is assumed to be white noise, uncorrelated with information available at time t, and

2) *Factor Model*:

$$COV_t(d_{t+1}, x^{j}_{t+1}) = b^{0}_{j} + \Sigma^{i} b^{i}_{j} f^{i}_{t}$$, for the relevant sample.

Now we have an estimable Panel Equation:

$$x_{t+1}^{j} = d_t (p_t^j + \sum_i b^{i,j} f_t^i) + e_{t+1}^{j} \qquad (3)$$

- 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
  - 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
    - Especially at relatively high frequencies

Harder

- Portfolio-specific covariances (payoffs with discount rates) are either constant or have constant relations with small number of factors
    - Again, easier *for short samples*
    - Standard assumption to make in literature

- Try to use standard factor models (e.g., Fama-French)
    - Fama-French: 30 years; here for 1/2 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 need to model discount rate/MRS directly
4. Only relatively loose assumptions required
5. Requires only 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
- The set-up is intrinsically non-linear
- Don’t fixate on asset-pricing model

Most Importantly, *don't impose bond market integration*

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

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

  - Do not use the T-bill rate for MRS *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 are testing for integration across markets where replication is impossible

Illustration #1: American Equity Data

Estimate:

$$x_{t+1}^{j} / p_{t-1}^{j} = d_t((p_t^j / p_{t-1}^j) + b_j^0 + b_j^1 f_t^1 + b_j^2 f_t^2 + b_j^3 f_t^3) + e_{t+1}^j \quad (4)$$

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

Notes

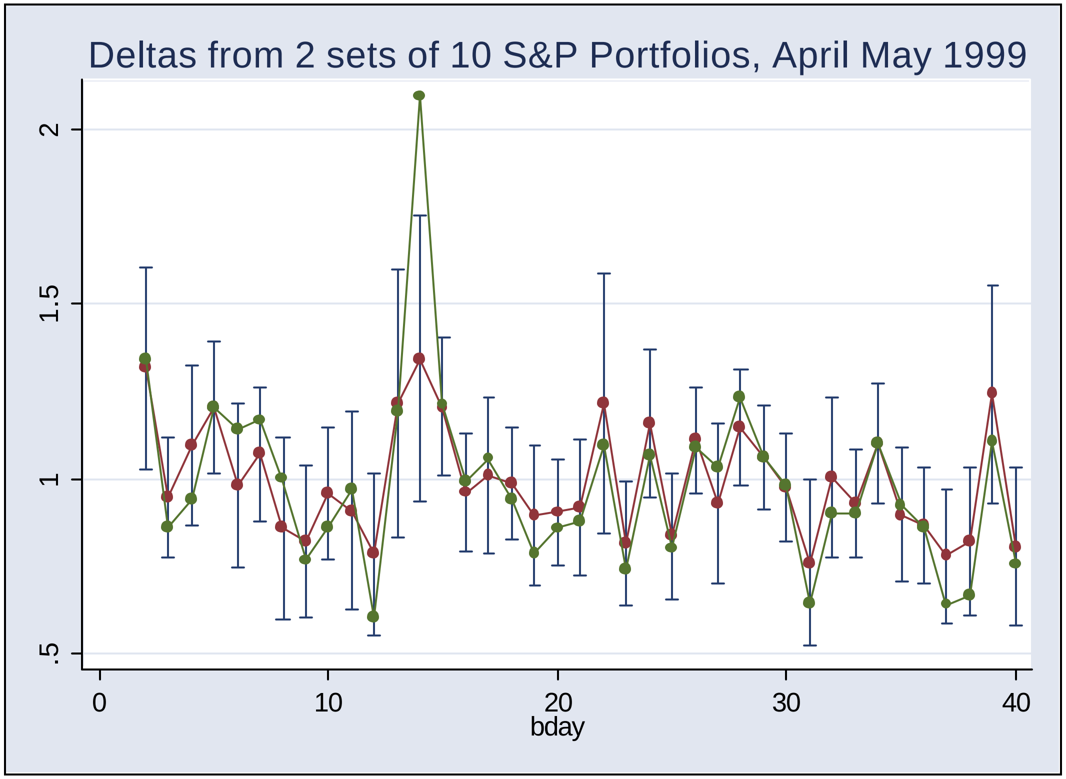
- Similar in nature to Roll and Ross (1980)
- Subsumes static CAPM through $\{ß^0\}$
- Add three time-varying factors from Fama-French (their data!)
    - Market return less T-bill return
    - Small minus large return
    - High minus low book/market returns

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)

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

Add Different Asset Classes

- NASDAQ firms
- Same timing, samples, factors

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)

Integration inside the NASDAQ, Fama-French-Factor Model

More Interesting: 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)

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)

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

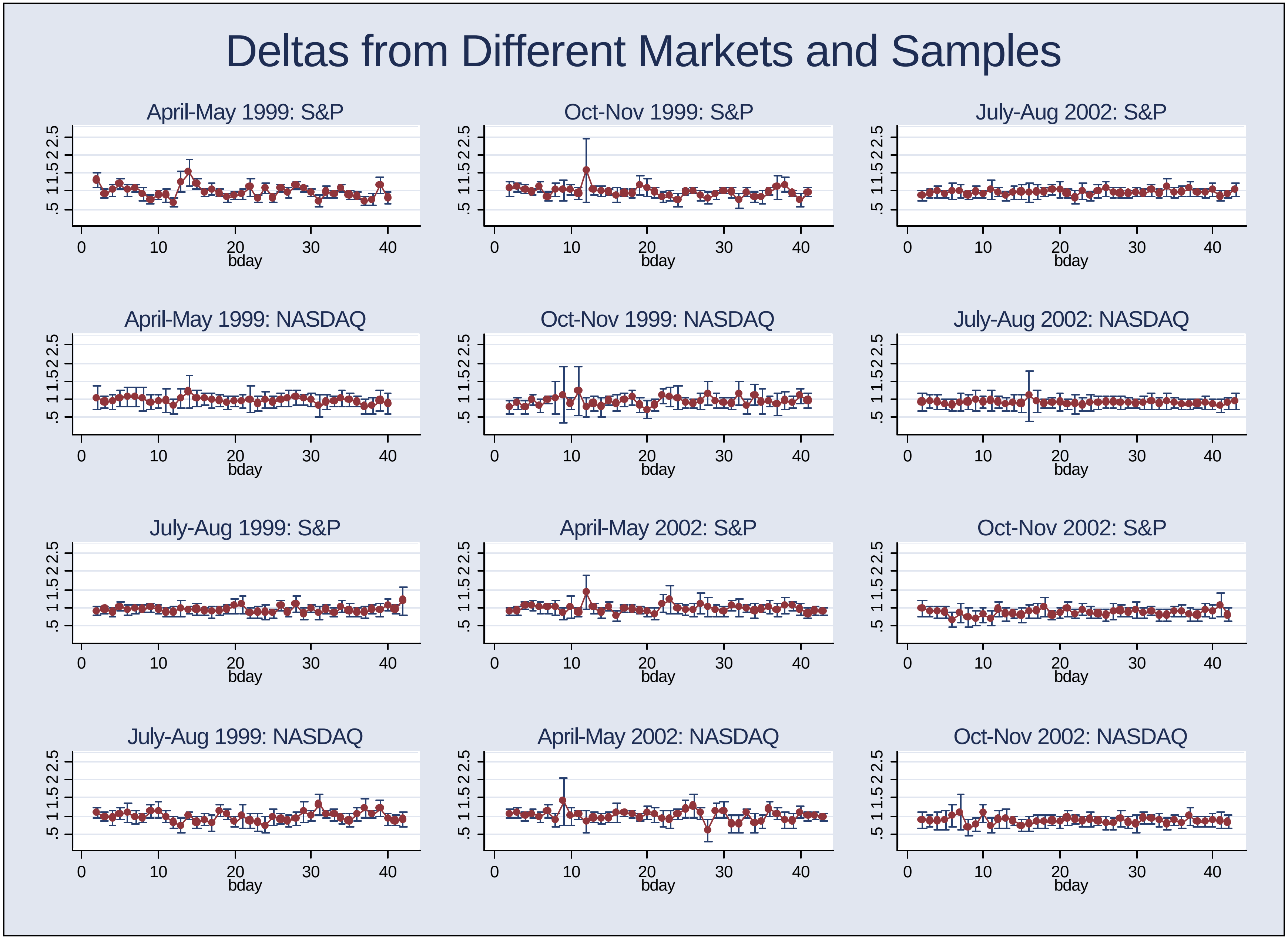
In fact, Time-Varying Factors Make Little Difference!

- 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)

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
.5 1 1.5 2 2.5
0 10 20 30 40
bday

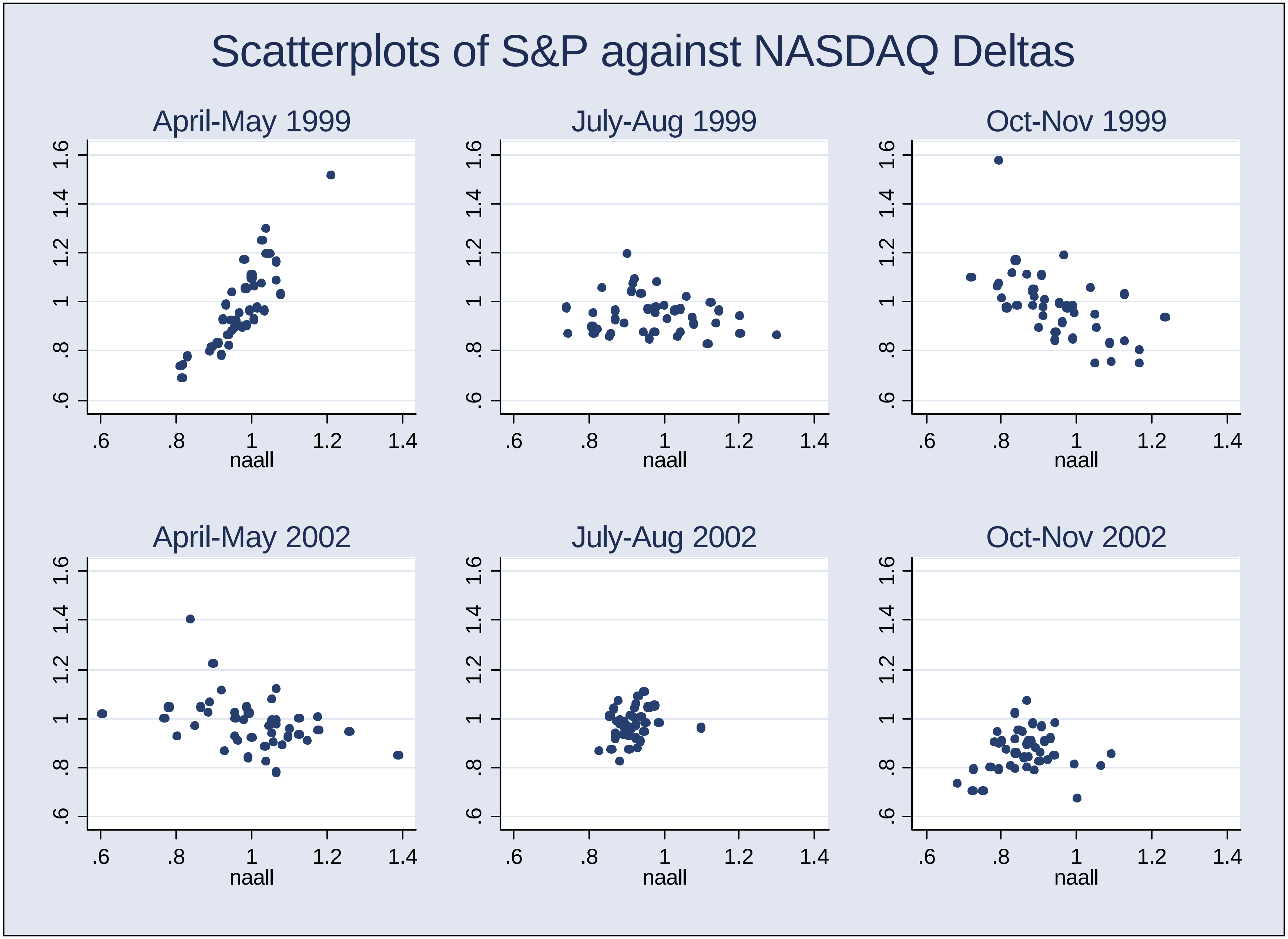

Scatterplots of S&P against NASDAQ Deltas
April-May 1999
July-Aug 1999
Oct-Nov 1999
April-May 2002
July-Aug 2002
Oct-Nov 2002
.6
.8
1
1.2
1.4
1.6
naall

Illustration #2: Tokyo Stock Exchange

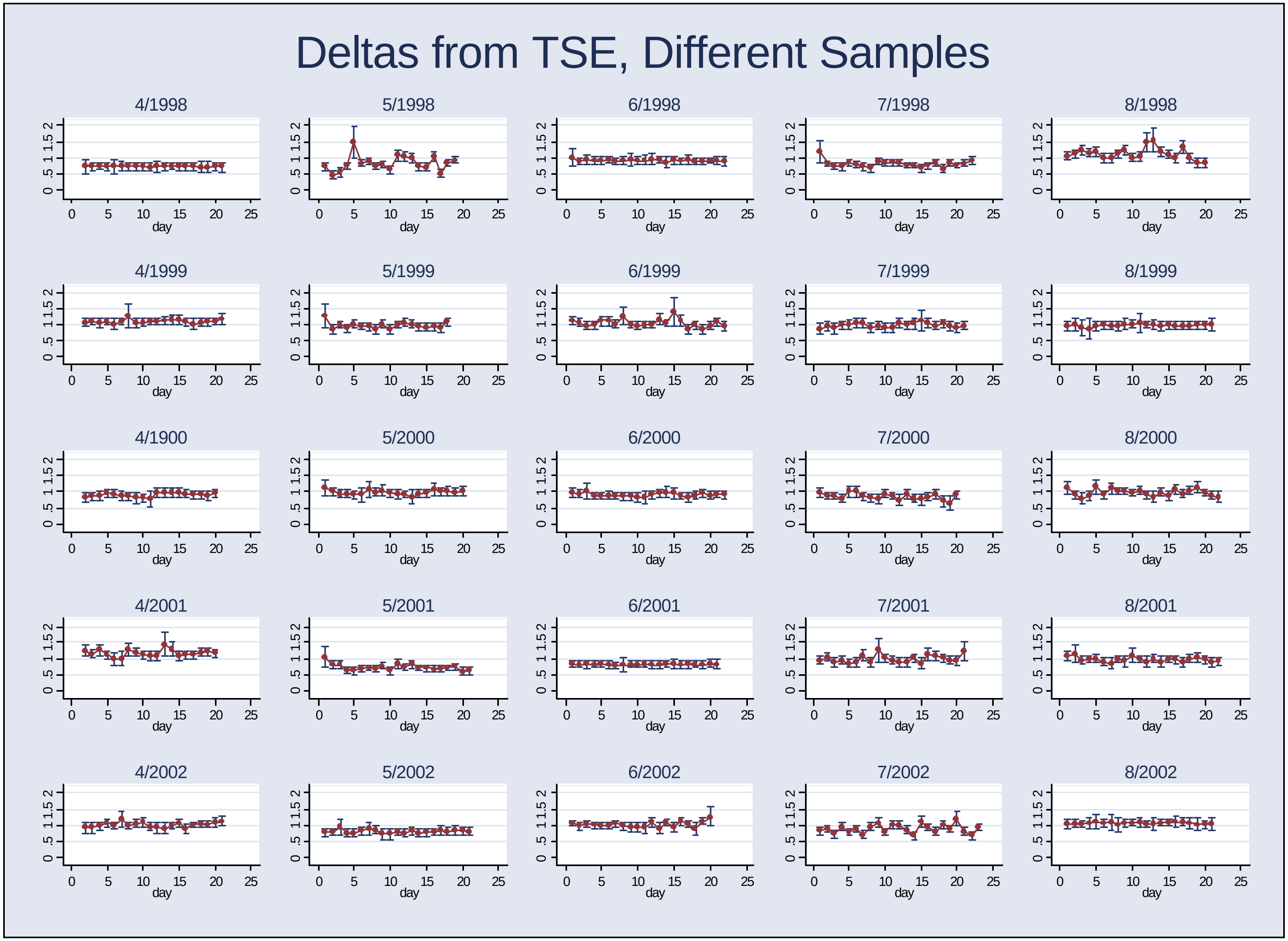
- 25 samples of 1 month each:
    - Daily data for 1-month spans
    - April through August (each month separately)
    - 1998 through 2002

Explore Importance of Grouping

- Have 360 firms for each sample
- Group into 20 portfolios of 18 firms each
- Group in three ways:
    1. Randomly (firm name)
    2. Industry (SIC codes)
    3. Size (gross assets)

Shadow Discount Rates

- Can easily estimate from sets of 20 portfolios (along with confidence intervals)
    - Estimated under assumption of integration (!)


Deltas from TSE, Different Samples
4/1998
5/1998
6/1998
7/1998
8/1998
4/1999
5/1999
6/1999
7/1999
8/1999
4/1900
5/2000
6/2000
7/2000
8/2000
4/2001
5/2001
6/2001
7/2001
8/2001
4/2002
5/2002
6/2002
7/2002
8/2002
day
0 .5 1 1.5 2
0 5 10 15 20 25

- Lots of time-series variation (Hansen-Jagannathan)
- Can reject hypothesis that δ = Treasury bill return (sluggish at almost zero => MRS should be 1)

Likelihood-Ratio (Joint) Test for Asset Integration

- Easy to compute by splitting sample into two sets of ten portfolios each
- Table 1:
  - A few rejections of integration with random portfolios
  - *Many rejections with industry/size sorted portfolios*
  - Bootstrapping (leptokurtosis!) to avoid assuming normality

	April	May	June	July	August
Random Portfolios					
1998	55.9* (.03) [.00]	16.0 (.91) [.65]	131.1** (.00) [.00]	26.6 (.65) [.23]	43.0 (.08) [.00]
1999	26.8 (.47) [.14]	16.7 (.87) [.55]	61.5 (.08) [.00]	49.4* (.02) [.00]	24.2 (.81) [.28]
2000	28.3 (.34) [.08]	23.7 (.58) [.26]	32.4 (.32) [.07]	47.7** (.00) [.00]	43.5 (.10) [.00]
2001	35.3 (.12) [.01]	40.4 (.07) [.01]	41.0 (.08) [.01]	33.9 (.20) [.04]	37.1 (.23) [.02]
2002	21.8 (.69) [.37]	14.5 (1.0) [.85]	21.3 (.69) [.38]	18.4 (.95) [.57]	17.2 (.93) [.70]
Industry-Based Portfolios					
1998	85.5** (.00) [.00]	56.4** (.00) [.00]	143.0** (.01) [.00]	71.4** (.01) [.00]	94.5** (.00) [.00]
1999	41.6 (.06) [.00]	34.9 (.10) [.01]	88.3* (.04) [.00]	24.7 (.60) [.27]	24.0 (.81) [.29]
2000	75.8** (.00) [.00]	101.4** (.00) [.000	79.3** (.00) [.00]	35.4 (.16) [.02]	59.9** (.00) [.00]
2001	48.5** (.00) [.00]	41.0* (.05) [.01]	71.3** (.00) [.00]	38.3 (.10) [.02]	50.5* (.02) [.00]
2002	48.4** (.03) [.00]	39.4** (.00) [.01]	37.4 (.15) [.01]	21.8 (.83) [.37]	30.6 (.33) [.08]
Size-Based Portfolios					
1998	66.3** (.00) [.00]	89.6** (.00) [.00]	61.6* (.02) [.00]	47.2 (.09) [.00]	112.5** (.00) [.00]
1999	94.0** (.00) [.00]	123.0** (.00) [.00]	48.1 (.13) [.00]	119.5** (.00) [.00]	138.5** (.00) [.00]
2000	38.7* (.04) [.01]	16.5 (.91) [.69]	29.9 (.43) [.13]	32.4* (.02) [.04]	38.8 (.12) [.02]
2001	32.2 (.20) [.03]	75.7** (.00) [.00]	30.9 (.33) [.08]	48.2* (.02) [.00]	28.0 (.58) [.18]
2002	48.1 (.09) [.00]	58.4** (.00) [.00]	34.3 (.20) [.03]	30.2 (.52) [.09]	38.1 (.11) [.02]

Table 1: Likelihood-Ratio Tests for Integration on Tokyo Stock Exchange

(bootstrapped p-values for null hypothesis in parentheses) * (**) indicates rejection of null hypothesis at .05 (.01)
[normal p-values for null hypothesis in brackets]

	April	May	June	July	August
Random Portfolios					
1998	54.0* (.03)	14.0 (.92)	133.8** (.00)	36.7 (.23)	24.9 (.62)
1999	25.9 (.41)	12.4 (.92)	55.3 (.10)	39.7 (.08)	24.1 (.67)
2000	23.4 (.49)	23.9 (.50)	31.8 (.24)	43.6 (.03)	46.6 (.02)
2001	31.6 (.18)	22.4 (.68)	40.4* (.03)	38.1 (.09)	37.8 (.15)
2002	20.6 (.69)	13.7 (.94)	19.3 (.77)	13.2 (1.0)	17.3 (.85)
Industry-Based Portfolios					
1998	84.2** (.00)	55.2** (.00)	147.0** (.00)	98.1** (.00)	96.8** (.00)
1999	31.9 (.19)	44.8** (.01)	92.0** (.01)	30.7 (.22)	23.6 (.75)
2000	69.8** (.00)	97.4** (.00)	80.7** (.00)	33.8 (.13)	58.4** (.00)
2001	33.0 (.12)	40.4 (.06)	67.7** (.00)	42.7 (.03)	50.6 (.04)
2002	51.8** (.00)	40.3** (.00)	42.7 (.05)	20.0 (.85)	31.0 (.22)
Size-Based Portfolios					
1998	58.9** (.00)	65.5** (.00)	57.8* (.02)	31.3 (.40)	104.1** (.00)
1999	93.1** (.00)	106.7** (.00)	43.7 (.18)	112.3** (.00)	136.7** (.00)
2000	34.3 (.07)	15.7 (.93)	27.4 (.45)	27.4 (.36)	42.9* (.05)
2001	26.0 (.37)	62.6** (.01)	29.3 (.24)	41.8 (.09)	27.4 (.44)
2002	44.4* (.05)	46.6** (.01)	26.0 (.56)	34.9 (.26)	37.0 (.13)

Table 2: Likelihood-Ratio Tests for Integration on Tokyo Stock Exchange
Covariance Model includes only portfolio-specific intercepts

(bootstrapped p-values for null hypothesis in parentheses)

* (**) indicates rejection of null hypothesis at .05 (.01)

	April	May	June	July	August
Random Portfolios					
1998	59.8* (.02)	17.6 (.87)	121.1** (.00)	33.7 (.35)	25.1 (.58)
1999	24.6 (.54)	12.0 (1.00)	50.6 (.15)	32.8 (.26)	23.0 (.84)
2000	24.8 (.54)	20.8 (.80)	30.8 (.40)	43.6* (.02)	40.2 (.14)
2001	29.3 (.27)	27.2 (.50)	39.5 (.13)	32.9 (.25)	37.2 (.18)
2002	19.0 (.81)	14.0 (.98)	18.1 (.88)	13.7 (.99)	18.2 (.87)
Industry-Based Portfolios					
1998	85.8** (.00)	57.2** (.01)	145.4** (.00)	91.3** (.00)	99.1** (.00)
1999	30.5 (.32)	47.2** (.01)	83.8** (.01)	24.8 (.57)	19.9 (.92)
2000	72.9** (.00)	99.7** (.00)	72.7** (.00)	33.0 (.18)	63.0** (.00)
2001	28.3 (.36)	34.1 (.23)	63.3** (.01)	39.7 (.09)	52.6* (.02)
2002	53.1* (.02)	40.6 (.07)	41.9 (.09)	20.2 (.89)	30.0 (.39)
Size-Based Portfolios					
1998	37.4 (.15)	58.0** (.01)	53.2* (.02)	33.8 (.41)	49.3* (.03)
1999	99.1** (.00)	88.9** (.00)	44.6 (.20)	107.8** (.00)	134.6** (.00)
2000	34.9 (.10)	14.3 (.97)	27.2 (.59)	24.4 (.51)	42.9 (.07)
2001	22.4 (.60)	60.0** (.00)	25.3 (.54)	41.8 (.08)	24.3 (.75)
2002	42.4 (.09)	46.2* (.02)	24.9 (.58)	32.0 (.46)	37.2 (.13)

Table 3: Likelihood-Ratio Tests for Integration on Tokyo Stock Exchange
Covariance Model includes no portfolio-specific features

(bootstrapped p-values for null hypothesis in parentheses)

* (**) indicates rejection of null hypothesis at .05 (.01)

TSE is not always integrated!

- Sorting matters!
  - Rejections worse for sorted data

Sensitivity Analysis

- Does exact factor model matter? As always, no …
- Can drop market (time-varying) factor
  - Table 2: similar results
- Can even drop portfolio intercepts; similar results
  - Table 3: similar results

Illustration #3: NYSE during the LTCM Crisis

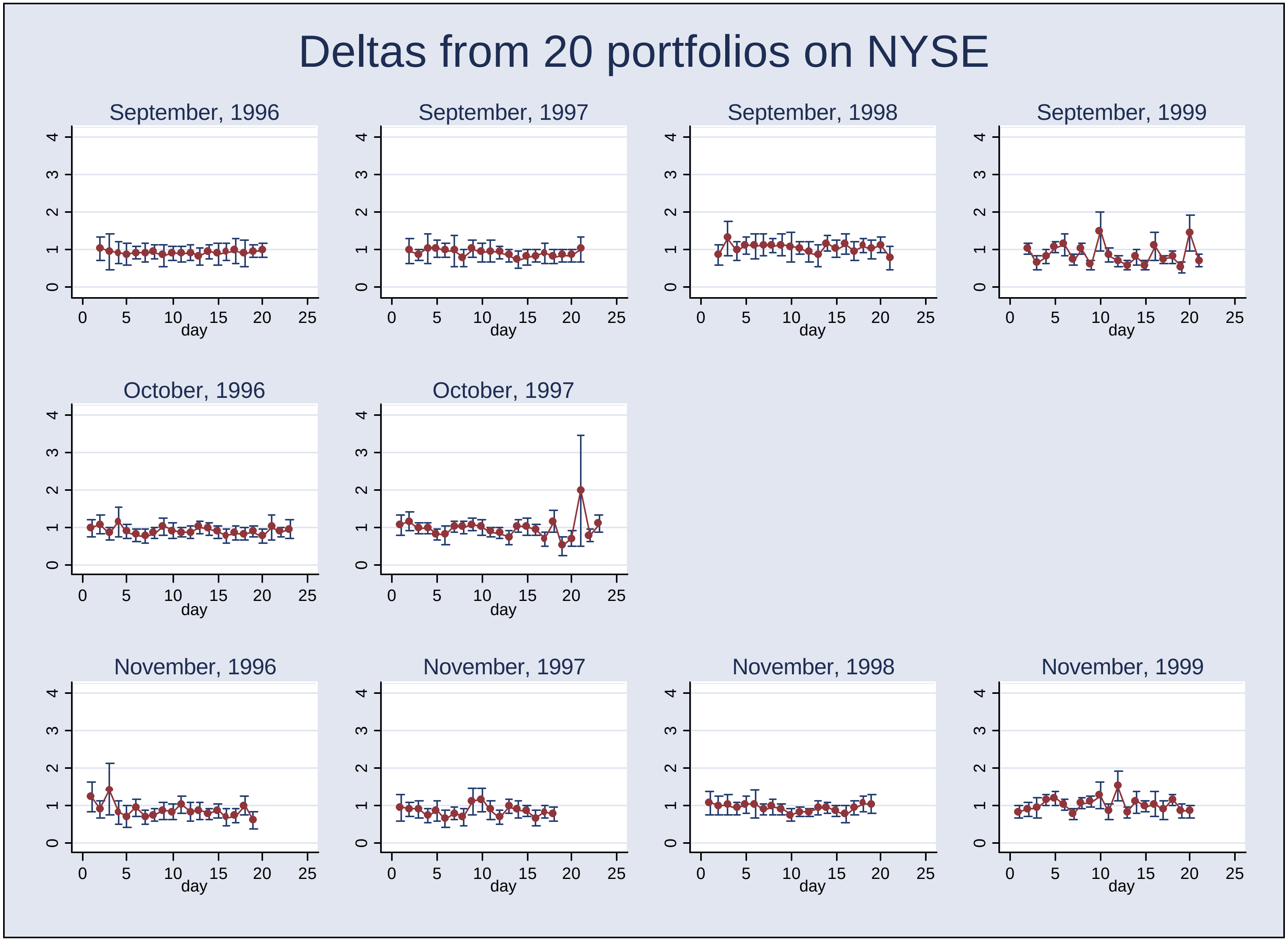
- Use moderately high-frequency approach
  - Daily data for 1-month span
  - September through November (each month separately)
  - 1996 through 1999
- Total of 12 samples of 1 month each
- Use Fama-French model

Portfolios

- Have 120 S&P 500 firms for each sample
- Group into 20 portfolios of 6 firms each (no dividends)
- Equally weighted

Shadow Discount Rates

- Can easily estimate from sets of 20 portfolios (along with confidence intervals)
  - Estimated under assumption of integration (!)


Deltas from 20 portfolios on NYSE
September, 1996
September, 1997
September, 1998
September, 1999
October, 1996
October, 1997
November, 1996
November, 1997
November, 1998
November, 1999
day

- Lots of time-series variation (Hansen-Jagannathan)
- Can reject hypothesis that δ = Treasury bill return (sluggish at almost zero => MRS should be 1)

Likelihood-Ratio (Joint) Test for Asset Integration

- Easy to compute by splitting sample into two sets of ten portfolios each
- Table 1:
    - Reject integration for October 1998
    - Bizarre, sensitive rejection for October 1999
    - Results insensitive to factor model
    - Bootstrapping (leptokurtosis!) to avoid assuming normality

A: Fama-French-Factor Model (intercepts, 3 time-varying factors)

	September	**October**	**November**
1996	34.7 (.33)	26.6 (.83)	32.3 (.40)
1997	39.7 (.17)	37.5 (.39)	32.2 (.05)
1998	34.4 (.40)	55.5 (.02)	27.6 (.56)
1999	16.6 (.97)	57.1 (.00)	30.3 (.43)

B: One-Factor Model (intercepts, market return factor)

	September	**October**	**November**
1996	24.2 (.55)	25.9 (.64)	41.2 (.05)
1997	29.6 (.34)	36.3 (.26)	29.7 (.19)
1998	25.4 (.49)	53.1 (.01)	22.6 (.61)
1999	15.9 (.95)	24.7 (.65)	26.3 (.42)

C: Model without Time-Varying Factors (intercepts only)

	September	**October**	**November**
1996	20.0 (.67)	25.8 (.59)	28.1 (.31)
1997	21.1 (.66)	38.3 (.66)	28.5 (.22)
1998	25.1 (.42)	54.2 (.01)	21.4 (.55)
1999	12.9 (.95)	26.4 (.50)	23.6 (.47)

D: Model without Asset-Specific Covariances

	September	**October**	**November**
1996	20.0 (.65)	24.8 (.61)	27.8 .25)
1997	20.6 (.59)	36.8 (.17)	31.1 (.10)
1998	20.9 (.60)	52.3 (.00)	22.4 (.43)
1999	10.9 (.98)	28.5 (.34)	22.2 (.47)

Table 1: Integration inside the American S&P 500

Likelihood-ration test statistics (bootstrap P-value)

NYSE is not integrated after LTCM/Russia Crisis

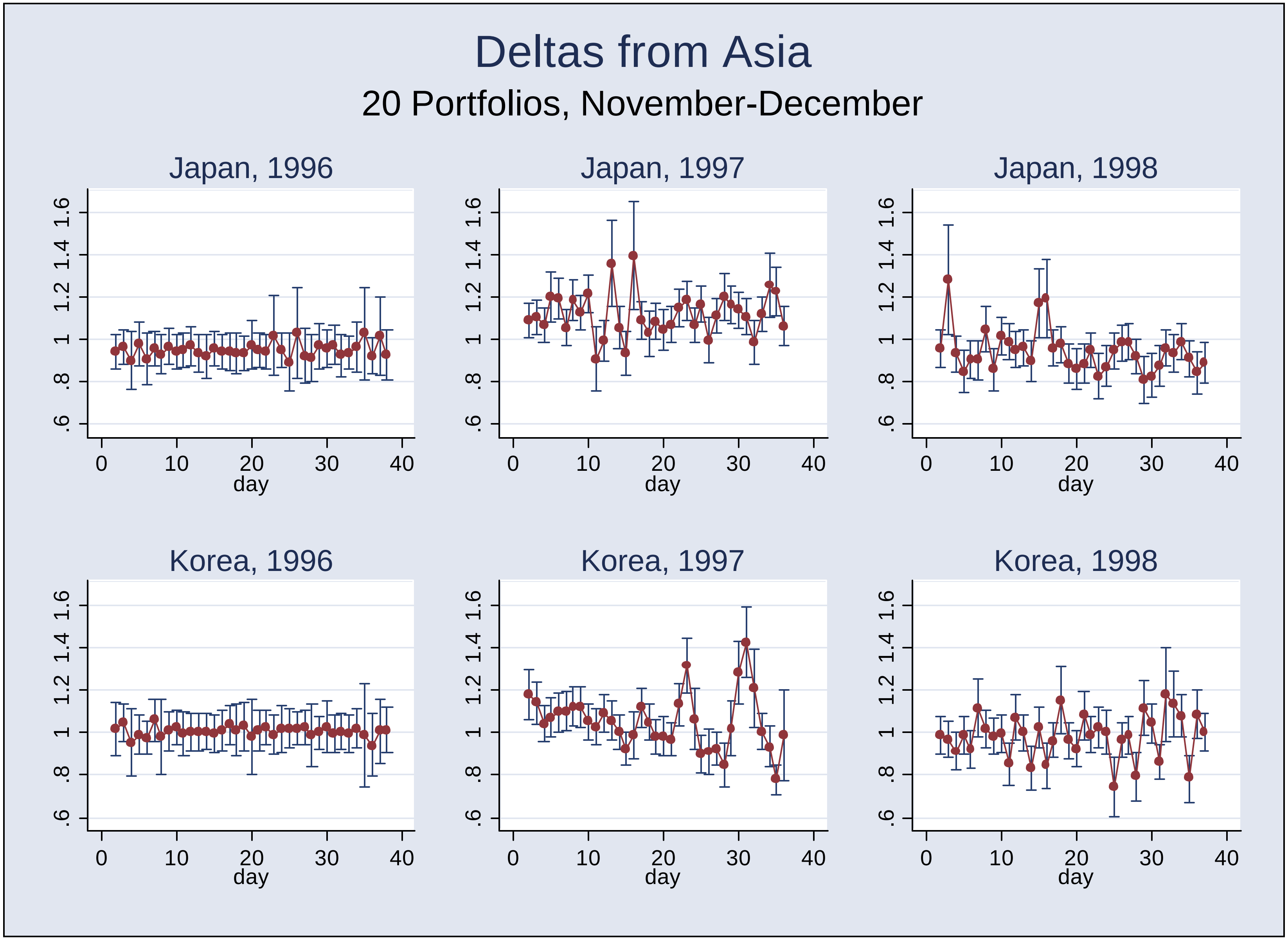
- Robust result
- Very transient
- Robust to choice of precise factor model

Illustration #4: The Asian Crisis of 1997

- Focus on Korea, and financial integration with Japan
  - November and December (separately/combined)
  - 1996 through 1998
- Use domestic market return as factor (foreign too)

Portfolios

- 400 TSE stocks in 20 portfolios
- 360 Korean stocks in 20 portfolios
    - Converted into yen
- Equally weighted


Deltas from Asia
20 Portfolios, November-December
Japan, 1996
Japan, 1997
Japan, 1998
Korea, 1996
Korea, 1997
Korea, 1998
day
.6 .8 1 1.2 1.4 1.6
0 10 20 30 40

Again:

- Lots of time-series variation

Likelihood-Ratio (Joint) Test for Asset Integration

- Easy to compute by comparing Japanese and Korean MRSs
- Table 3-4:
  - Reject integration throughout
  - Worse in December 1997
  - Doesn't depend on factor model
- Table 2 shows that cause is NOT lack of integration inside Seoul stock exchange

	November	December	November-December
1996	32.8 (.19)	27.3 (.32)	50.8 (.26)
1997	33.3 (.20)	27.0 (.29)	51.6 (.23)
1998	54.1 (.13)	10.5 (.97)	31.7 (.92)

Table 2: Integration inside the Korean Stock Exchange
One-Factor Model (intercepts, market return factor)
Likelihood-ration test statistics (bootstrap P-value)

	November	December	November-December
1996	389.9	259.2	640.3
1997	639.1	1716.2	2480.5
1998	269.3	591.3	876.3

Table 3: Integration between Korea and Japan
One-Factor Model (intercepts, domestic market return factor)
Likelihood-ration test statistics (all p-values =.00)

	November	December	November-December
1996	439.0	261.8	645.6
1997	626.5	1595.1	2401.1
1998	284.7	519.0	814.3

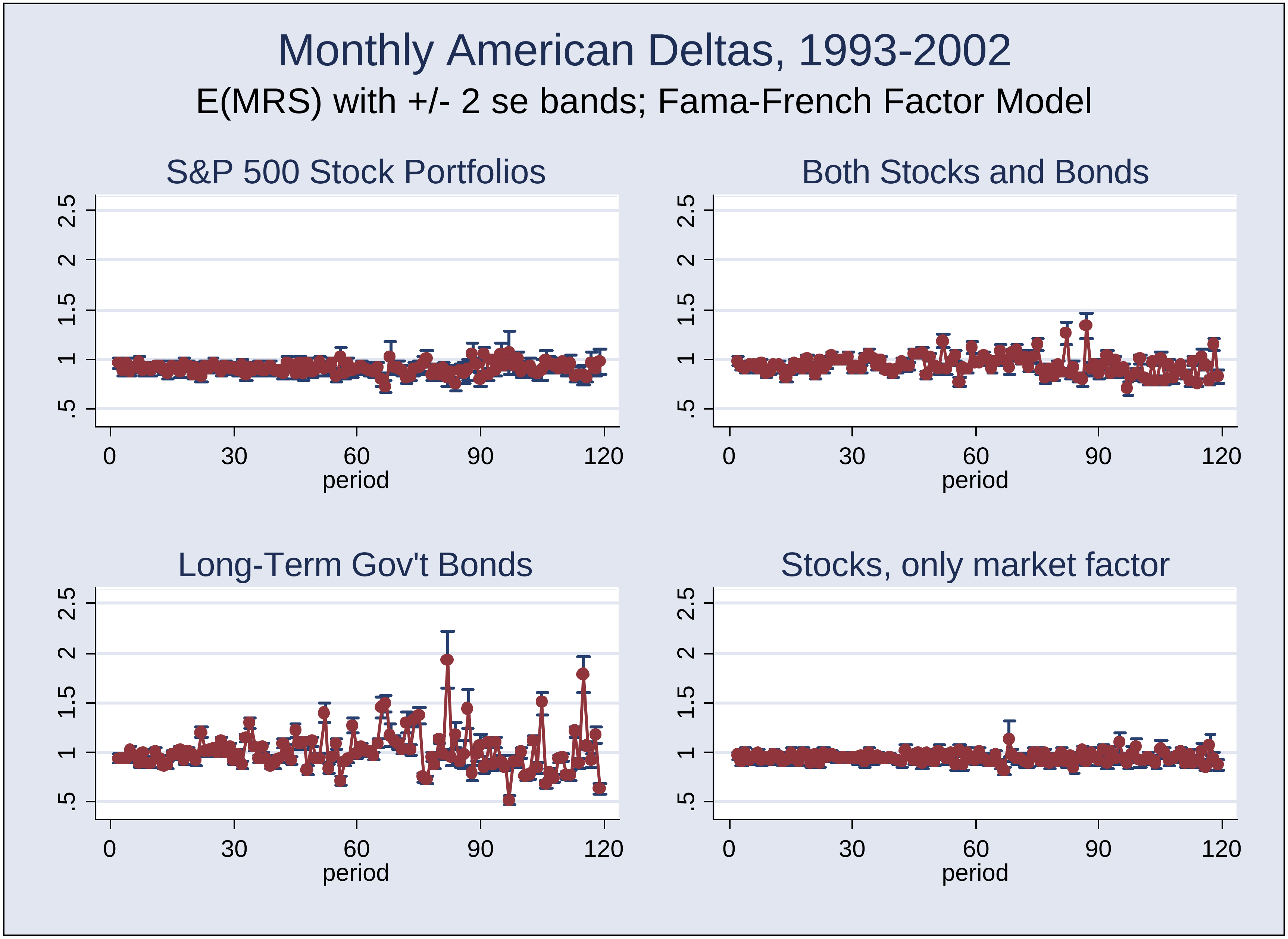
Table 4: Integration between Korea and Japan
Two-Factors Model (intercepts, domestic and foreign market return factors)
Likelihood-ration test statistics (all p-values =.00)

Tokyo and Seoul are never integrated

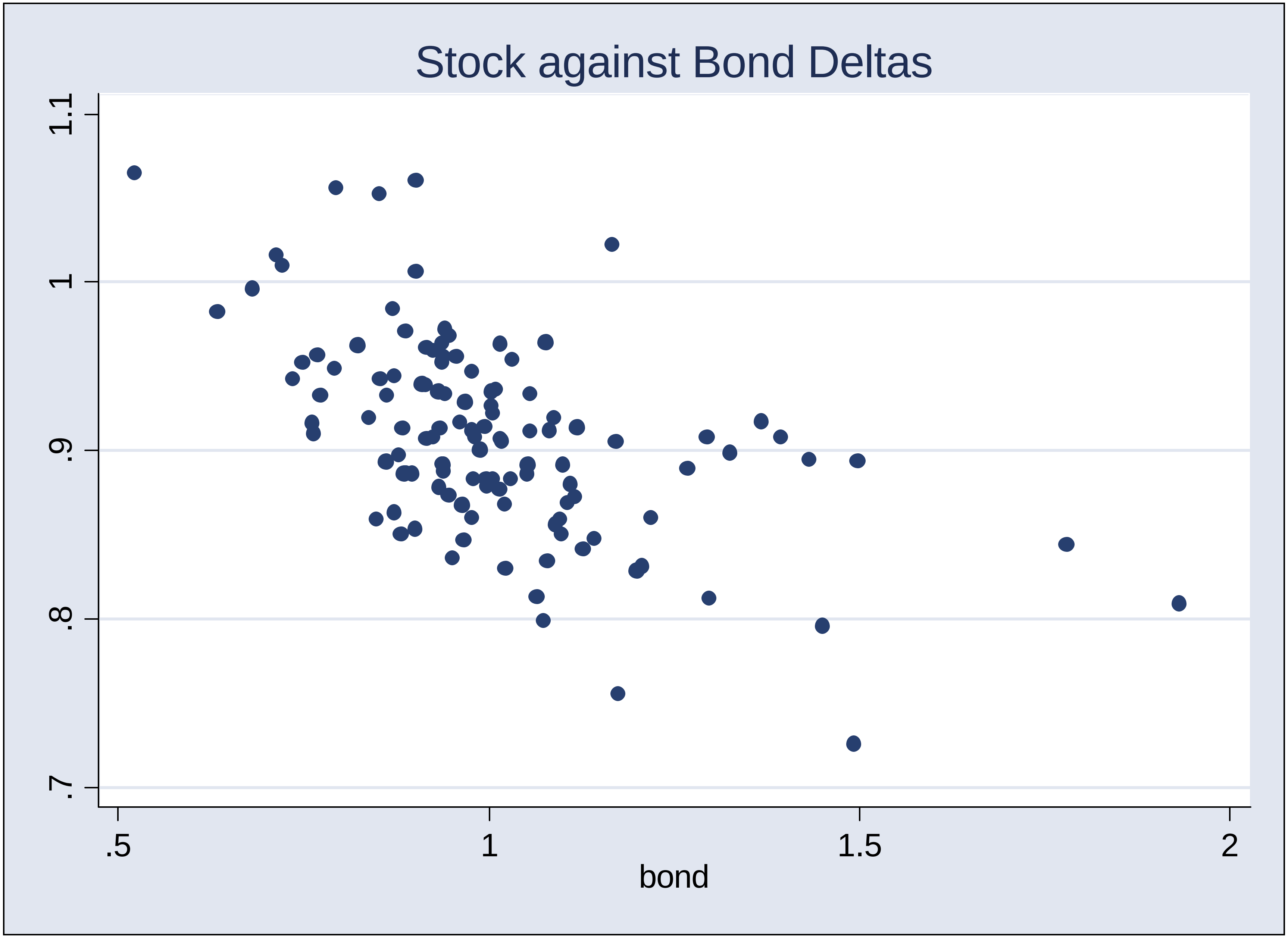
- Integration worsens during Asian crisis
- But integration never works

Illustration #5: American Securities 1993-2002

- Does integration work at lower frequencies?
- Monthly Portfolios of S&P stocks (ticker-arranged) and (31) Long-Term US treasury bonds
- Use Fama-French factors (and intercepts) as factors



Monthly American Deltas, 1993-2002
E(MRS) with +/- 2 se bands; Fama-French Factor Model
S&P 500 Stock Portfolios
Both Stocks and Bonds
Long-Term Gov't Bonds
Stocks, only market factor
.5
1
1.5
2
2.5
0
30
60
90
120
period


Stock against Bond Deltas
1.1
1
.9
.8
.7
.5
1
1.5
2
bond

American Stocks and Bonds are not Integrated

- LR Tests >11,000!

- Results again insensitive to exact factor model

Deltas are uncorrelated with Stock Market and T-bill returns!

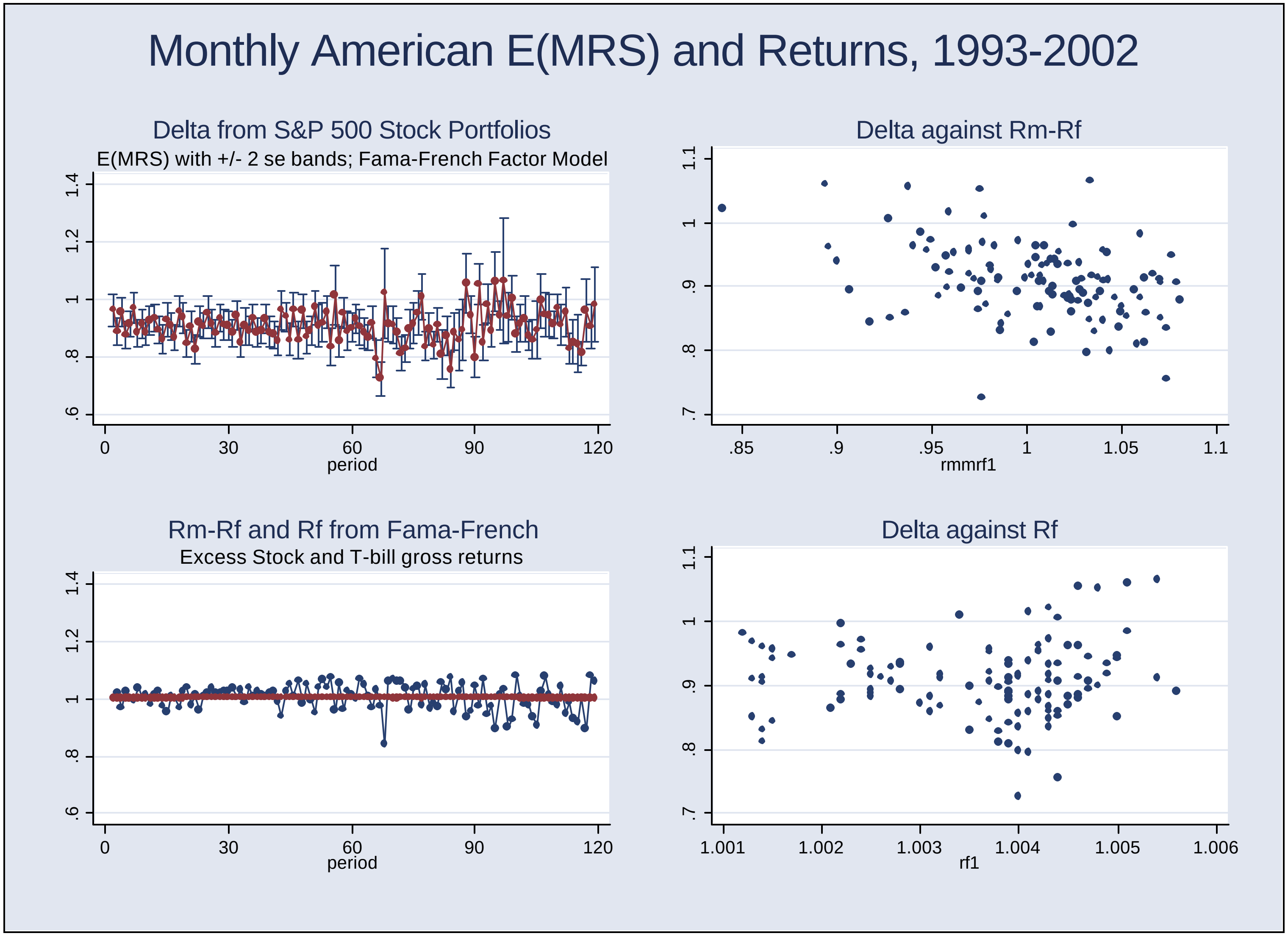
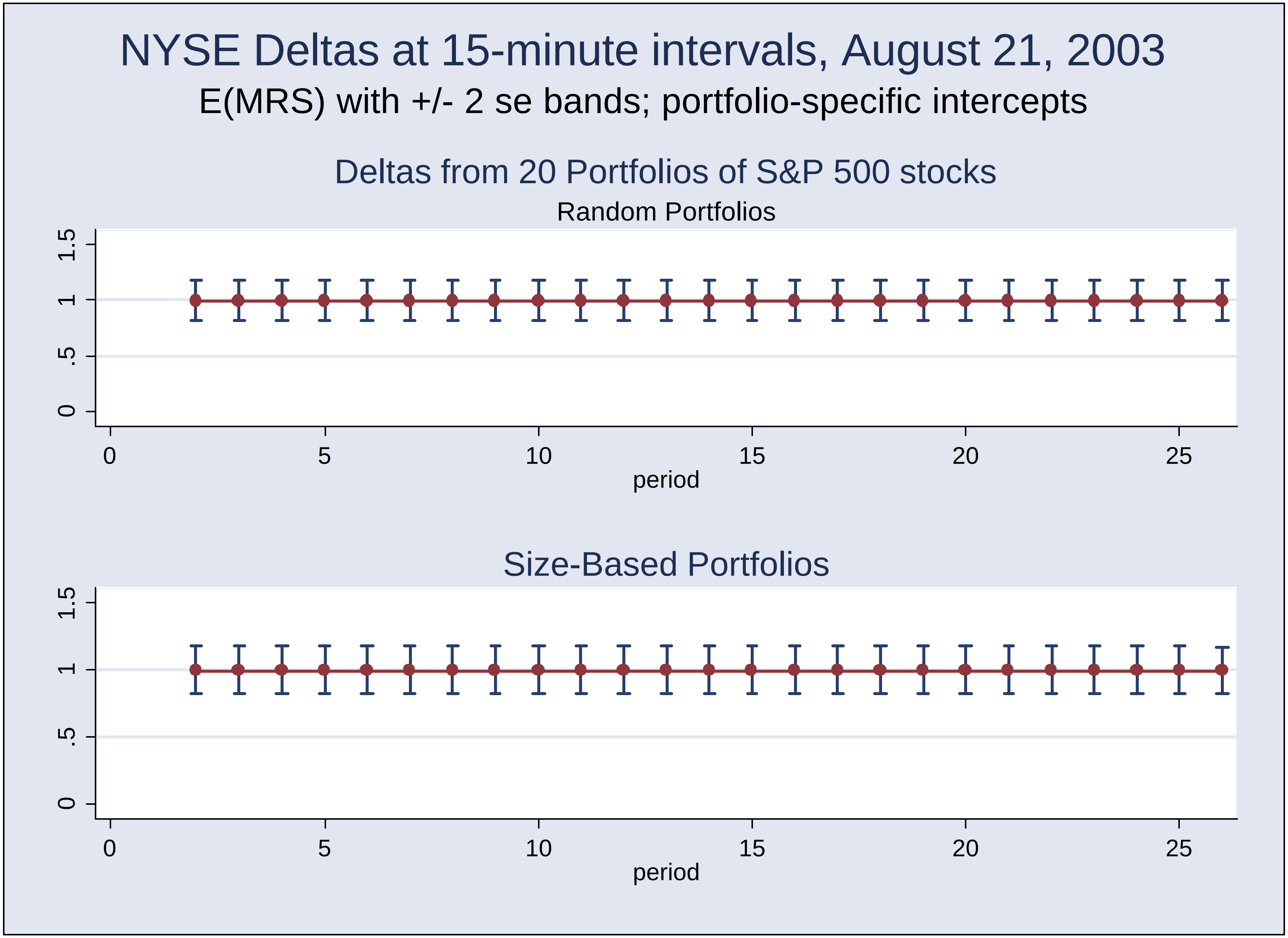


Illustration #6: August 21, 2003

- 20 Portfolios of S&P 500 stocks (ticker-arranged and size-based) at 15-minute intervals
- Use portfolio-specific intercepts


NYSE Deltas at 15-minute intervals, August 21, 2003
E(MRS) with +/- 2 se bands; portfolio-specific intercepts
Deltas from 20 Portfolios of S&P 500 stocks
Random Portfolios
0
.5
1
1.5
0
5
10
15
20
25
period
Size-Based Portfolios
0
.5
1
1.5
0
5
10
15
20
25
period

Plausible Results

- MRS ≈ 1 at very high frequencies (as it should!)
- Integration works well too (ditto)
- Grouping has no effect

Future Work

- Monte Carlo work for small samples
- Can lack of integration be exploited financially?

Most Importantly

- Causes of low integration?