A New Approach to Asset Integration: Methodology and Mystery

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Two Objectives:

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

2. Use methodology to investigate empirically a number of interesting cases
   - Find remarkably little evidence of asset integration

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

- 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^{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:

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

- 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
  - Should be equal if assets are integrated – priced with same shadow discount rate

Are Assumptions Reasonable?

- Rational expectations in financial markets at relatively high frequencies
- Firm-specific covariances (payoffs with discount rates) are either constant or have constant relations with small number of factors, for short samples

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. Only 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)
  - Standard: β (factor loadings), or second moment of δ
- Our set-up is intrinsically non-linear

- 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*

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

Implementation

Estimate:

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

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

Notes

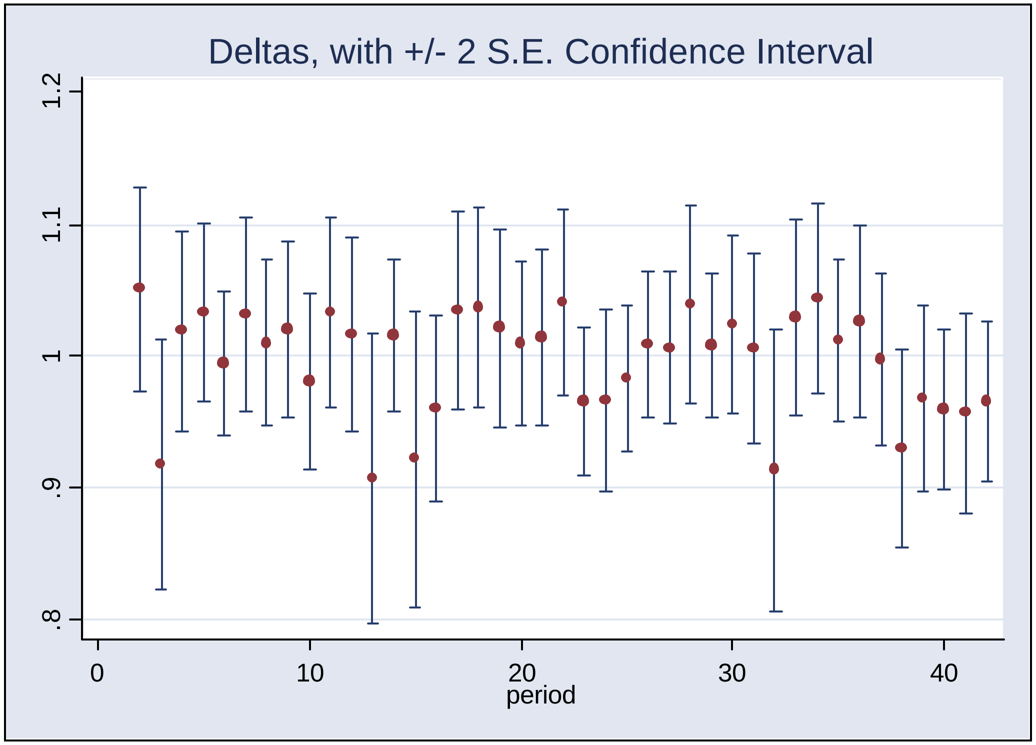
- Subsumes static CAPM through $\{ß^0\}$
- Add single factor: square of market return
  - Consistent with spirit of ICAPM (aggregate shock)
  - Unimportant in practice
- Use moderately high-frequency approach
  - Daily data for 2-month spans

First Example

- April-May 1999
- Use 100 S&P 500 firms that did not go ex-dividend
- Closing rates from "US Pricing" of Thomson Analytics
- 43 days, lose one each for lead/lag

Shadow Discount Rates

- Can easily estimate from first 50 firms (along with confidence intervals):



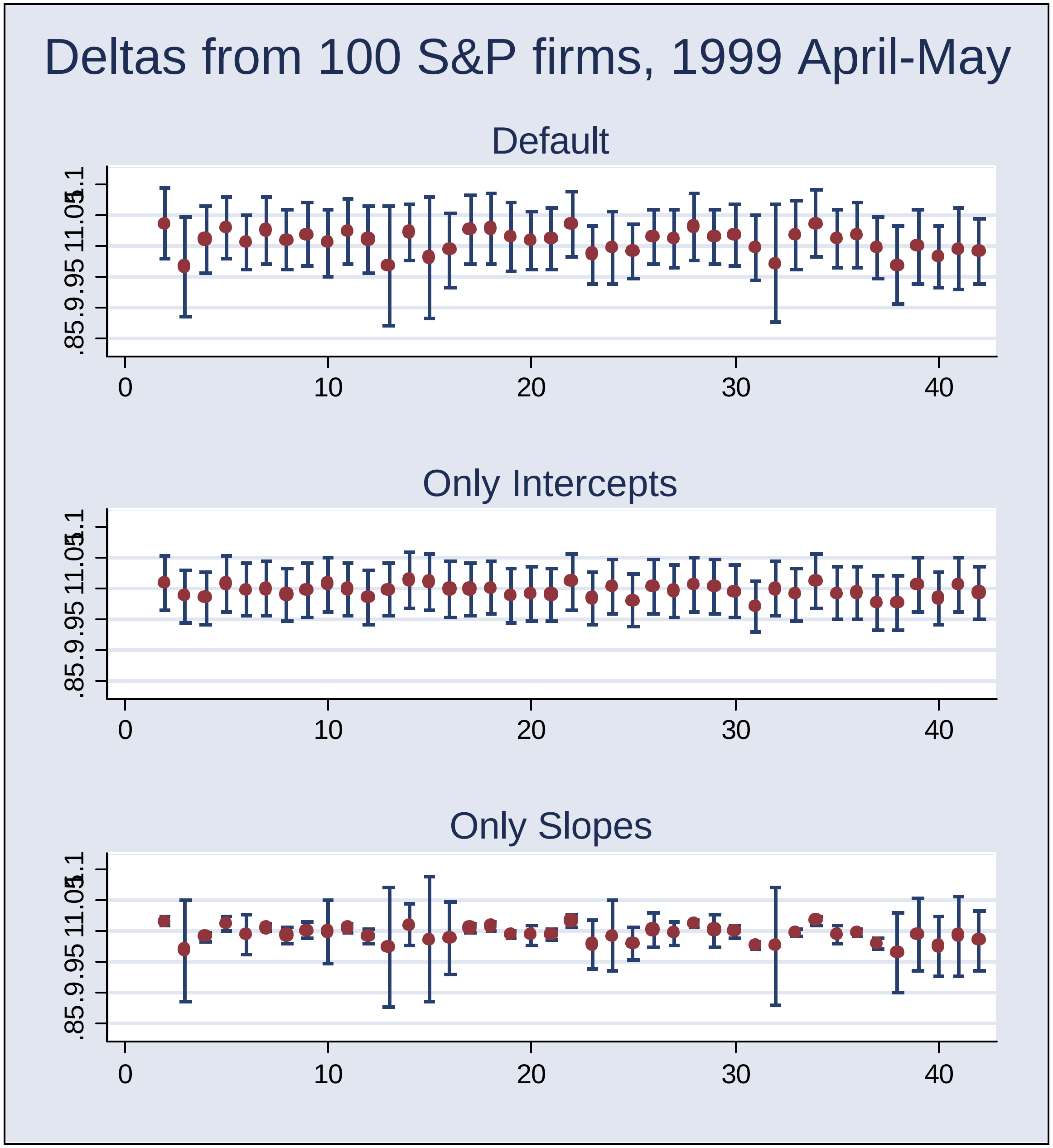
- Can also compare with those from second 50 firms:

- Look reasonably close, one by one

- Lots of time-series variation (Hansen-Jagannathan)

Likelihood-Ratio (Joint) Test for Asset Integration

- 2((4192+4333) - 8505) = 40
  - sits virtually at the median of $c^{2}(41)$
  - Can’t reject null Ho of asset integration
  - Results not sensitive to exact factor model
    - Other models deliver similar results: Figure 3
  - Assumes Normality
  - Results somewhat sensitive to ordering of firms

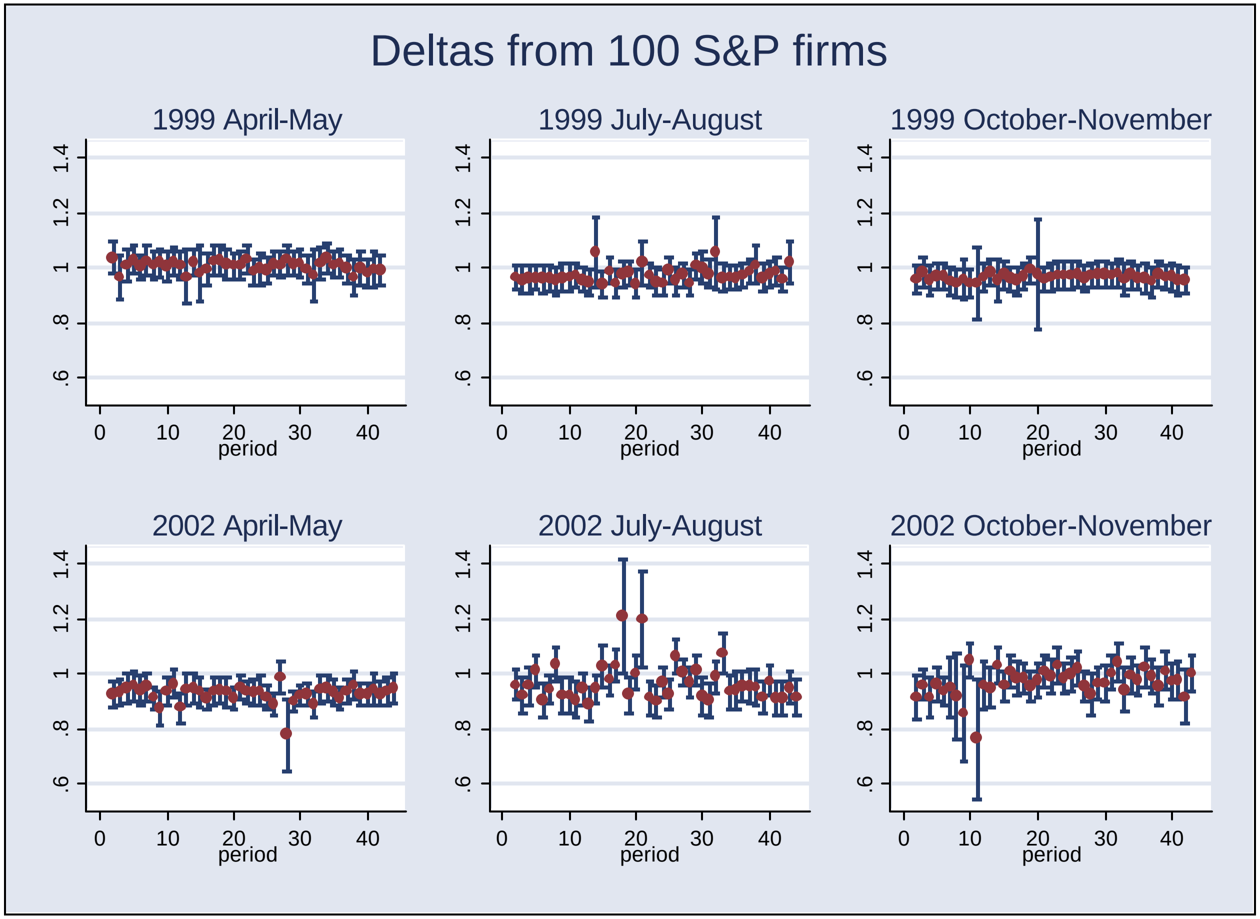

Deltas from 100 S&P firms, 1999 April-May
Default
Only Intercepts
Only Slopes
.85
.9
.95
1
1.05
1.1
0
10
20
30
40

Results do not stem from lack of power

- Five other samples (2 different sets of 2-month periods in 1999; same 3 sets of months in 2002) lead to 1 rejection, 2 marginal cases

Log Likelihoods	**April-May 1999**	**July-Aug. 1999**	**Oct.-Nov. 1999**
First 50 Firms	4192	4819	4191
Second 50 Firms	4333	4899	4358
All 100 Firms	8505	9687	8526
Test Statistic (df) P-value	40 (41) .49	62 (42) .98	46 (41) .73
	April-May 2002	**July-Aug. 2002**	**Oct.-Nov. 2002**
First 50 Firms	5091	4108	3794
Second 50 Firms	5130	4326	4072
All 100 Firms	10197	8403	7825
Test Statistic (df) P-value	48 (43) .72	62 (43) .97	82 (42) 1.00

Table 1: Tests of Market Integration inside the S&P 500, Two-Factor Model


Deltas from 100 S&P firms
1999 April-May
1999 July-August
1999 October-November
2002 April-May
2002 July-August
2002 October-November
.6
.8
1
1.2
1.4
0
10
20
30
40
period

Add Different Asset Classes

- NASDAQ firms
- TSE firms (measured in US$)
- Bonds: AAA, A+, Junk
- All with same timing, samples

Rarely Find Integration Elsewhere

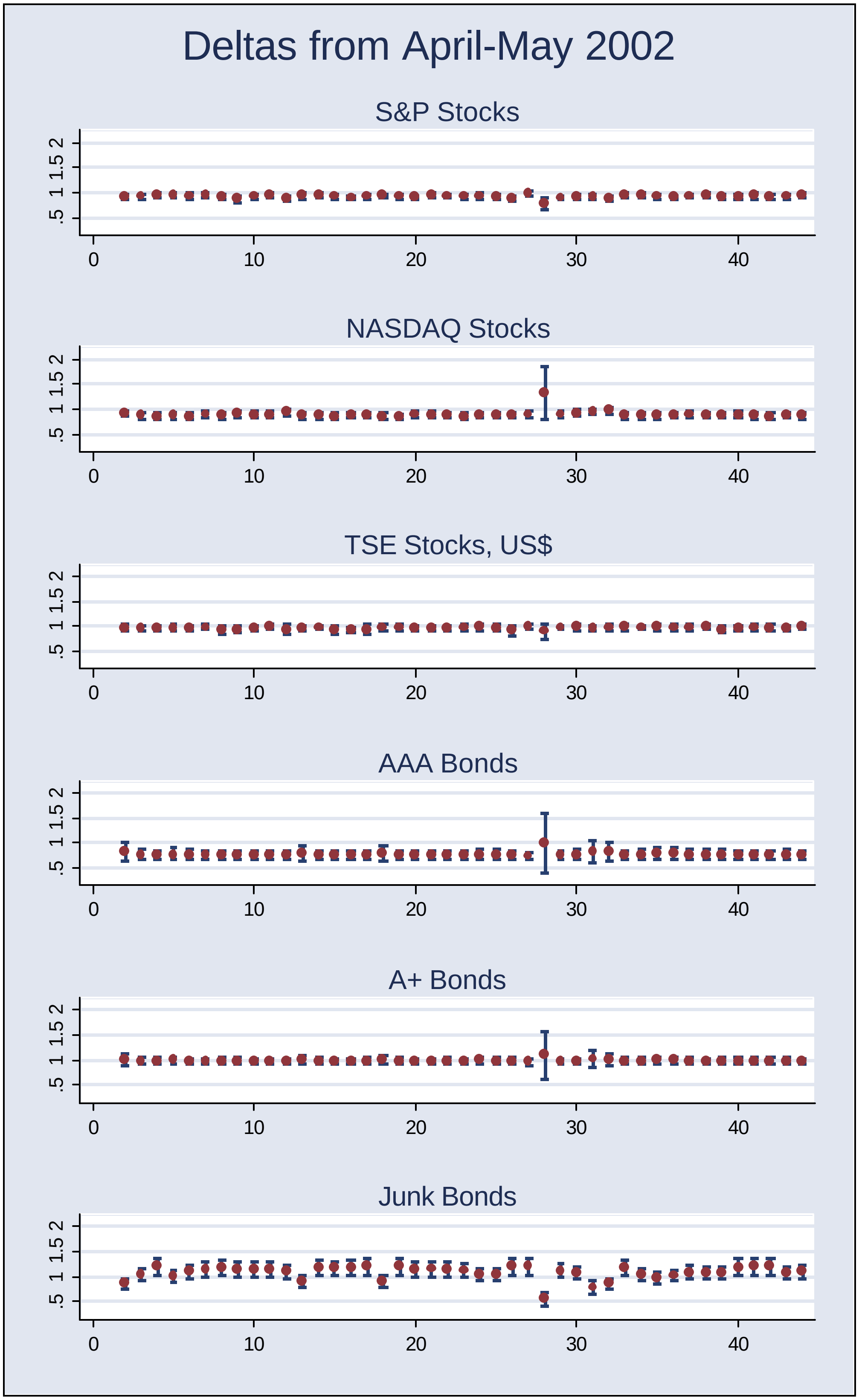
- Either Within Other Assets or Across Asset Classes

Log Likelihoods	**April-May 1999**	**July-Aug. 1999**	**Oct.-Nov. 1999**
First 50 Firms	3343	3646	2048
Second 50 Firms	3354	3808	3415
All 100 Firms	6676	7424	4999
Test Statistic (df) P-value	42 (41) .57	60 (42) .96	928 (41) 1.00
	April-May 2002	**July-Aug. 2002**	**Oct.-Nov. 2002**
First 50 Firms	3747	3427	3023
Second 50 Firms	4169	3085	3045
All 100 Firms	7848	6457	6032
Test Statistic (df) P-value	136 (43) 1.00	110 (43) 1.00	72 (42) .997

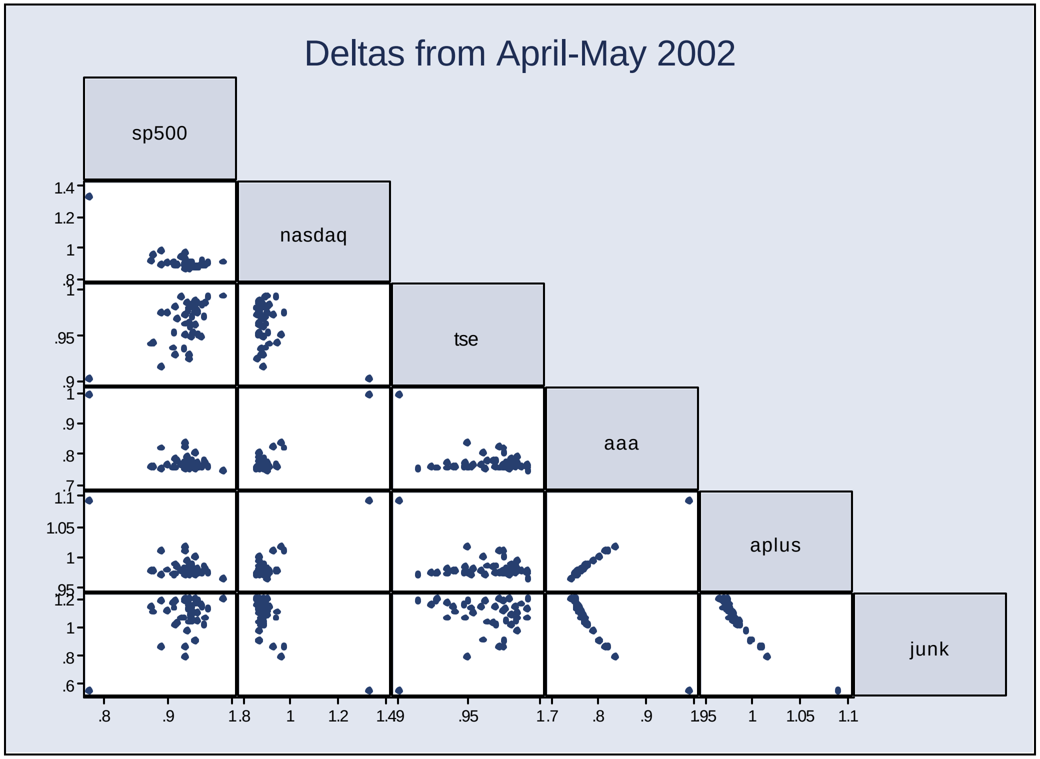
Table 2: Tests of Market Integration inside the NASDAQ, Two-Factor Model

Log Likelihoods	**April-May 1999**	**July-Aug. 1999**	**Oct.-Nov. 1999**
100 S&P Firms	8505	9687	8526
100 NASDAQ Firms	6676	7424	4999
Combined	14,715	16,483	12,084
Test Statistic (df) P-value	932 (41) 1.00	1256 (42) 1.00	2882 (41) 1.00
	April-May 2002	**July-Aug. 2002**	**Oct.-Nov. 2002**
100 S&P Firms	10197	8403	7825
100 NASDAQ Firms	7848	6457	6032
Combined	17,387	14,323	13,368
Test Statistic (df) P-value	1316 (43) 1.00	1074 (43) 1.00	978 (42) 1.00

Table 3: Tests for Market Integration between S&P 500 and NASDAQ, Two-Factor Model



Deltas from April-May 2002
S&P Stocks
NASDAQ Stocks
TSE Stocks, US$
AAA Bonds
A+ Bonds
Junk Bonds
.5 1 1.5 2
0 10 20 30 40


Deltas from April-May 2002
sp500
nasdaq
tse
aaa
aplus
junk

Degree of Market Integration Seems Low

- Can compute mean absolute difference of deltas
- Also Grubel-Lloyd Measure: $(1/T)\Sigma_t\,|d_t^p - d_t^q|$
- Use also Brandt, Cochrane, Santa-Clara measures:

$$1-[s^2(\ln d_t^p - \ln d_t^q)/(s^2(\ln d_t^p)+s^2(\ln d_t^q))]$$

  - o also analogue in levels

- Ignores estimation imprecision

	S&P 500	NASDAQ	TSE	AAA Bonds	A+ Bonds	Junk Bonds
S&P 500	-	.07	.04	.19	.06	.17
NASDAQ	.06	-	.09	.15	.10	.23
TSE	.04	.08	-	.23	.03	.15
AAA Bonds	.16	.13	.19	-	.24	.35
A+ Bonds	.06	.09	.03	.21	-	.15
Junk Bonds	.17	.23	.15	.33	.15	-

Table 12: Degree of Market Integration, April-May 2002
Mean Absolute Difference of Deltas below diagonal; Grubel-Lloyd Measure above diagonal

	S&P 500	NASDAQ	TSE	AAA Bonds	A+ Bonds	Junk Bonds
S&P 500	-	-.58	.57	-.65	-.59	.23
NASDAQ	-.67	-	-.22	.74	.45	-.59
TSE	.55	-.24	-	-.26	-.29	.04
AAA Bonds	-.64	.80	-.23	-	.81	-.52
A+ Bonds	-.56	.46	-.29	.72	-	-.29
Junk Bonds	.27	-.59	.06	-.58	-.27	-

Table 15: Degree of Market Integration, April-May 2002
Brandt et al measure in logs below diagonal; in levels above diagonal

Future Work

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

Most Importantly

- Causes of low integration?