Equity Integration in Japan:
An Application of a New Method

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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 inside Tokyo Stock Exchange

Definition of Asset Integration

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

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

- 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^{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

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 single factor (market) model
    - Fama-French: 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

- I 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
- I 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:

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

  - I 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 I am testing for integration across markets where replication is impossible

Implementation

Estimate:

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

- Normalize to make Cov() more plausibly time-invariant (with factors)
- Use Market (Nikkei) return – first-difference of log of index
- 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 time-varying factor
  - Market return

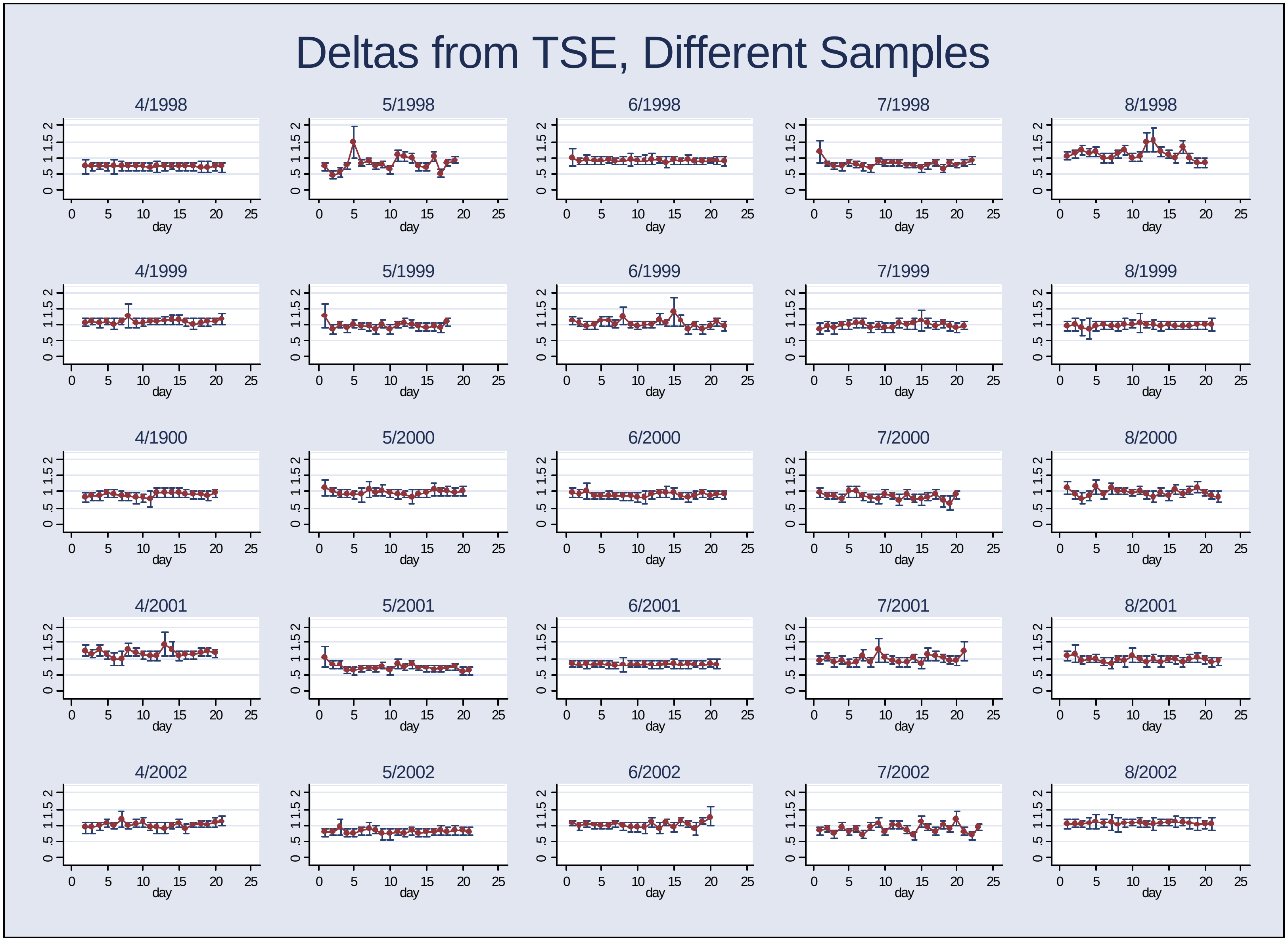
- Use moderately high-frequency approach
    - Daily data for 1-month spans
    - April through August (each month separately)
    - 1998 through 2002
- Total of 25 samples of 1 month each

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

	April	May	June	July	August
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

	April	May	June	July	August
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

	April	May	June	July	August
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?
- Can drop market (time-varying) factor
    - Table 2: similar results
- Can even drop portfolio intercepts; similar results
    - Table 3: similar results

Future Work

- Monte Carlo work for small samples

- Lower frequencies (housing? more factors? trends?)

- Higher frequencies

Most Importantly

- Causes of low integration?