A New Approach to Asset Integration: Methodology and Mystery

Robert P. Flood and Andrew K. Rose
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:

\[ p_t^j = E_t(d_{t+1}x_{t+1}) \]  \hspace{1cm} (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:

\[ p_t^j = E_t(d_{t+1} x_{t+1}^j) = COV_t(d_{t+1}, x_{t+1}^j) + E_t(d_{t+1})E_t(x_{t+1}^j). \]  

(2)

Rearrange and substitute actual for expected (WLOG):

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

\[ x_{t+1}^j = \delta_t (p_t^j - COV_t(d_{t+1}, x_{t+1}^j)) + \varepsilon_{t+1}^j \]  

(3)

where \( \delta_t = 1/E_t(d_{t+1}) \)
Impose Two (Reasonable?) Assumptions for Estimation:

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

2) *Factor Model*:

$$C_{t} (d_{t+1}, x_{t+1}^j) = \beta_0^j + \sum i \beta_i^j f_i^t , \text{ for the relevant sample.}$$
Now we have an estimable Panel Equation:

\[ x_{t+1}^j = \delta_t (p_t^j - \text{COV}_t(d_{t+1}, x_t^j)) + \varepsilon_{t+1}^j \tag{3} \]

- Use *Cross-sectional* variation to estimate the coefficients of interest \{d\} – the shadow discount rates
- Use *Time-series* variation to estimate nuisance coefficients \{β\}
- 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 $\delta$ (estimated discount rate)
  - Standard: $\beta$ (factor loadings), or second moment of $\delta$
- Our set-up is intrinsically non-linear
• Consider risk-free gov’t T-bill with price of $1, interest $i_t$:

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

• 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:

\[ x_{t+1}^j / p_{t-1}^j = \delta_t \left( (p_t^j / p_{t-1}^j) + \beta_j^0 + \beta_j^1 f_t \right) + \varepsilon_{t+1} \]  \hspace{1cm} (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 \( \{\beta^0\} \)

• Add single factor: square of market return
  
  o Consistent with spirit of ICAPM (aggregate shock)
  
  o Unimportant in practice

• Use moderately high-frequency approach
  
  o 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 $\chi^2(41)$

• 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

Deltas from 100 S&P firms, 1999 April-May
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

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<thead>
<tr>
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<tbody>
<tr>
<td>First 50 Firms</td>
<td>4192</td>
<td>4819</td>
<td>4191</td>
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<td>Second 50 Firms</td>
<td>4333</td>
<td>4899</td>
<td>4358</td>
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<td>All 100 Firms</td>
<td>8505</td>
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<td>8526</td>
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<td>Test Statistic (df) P-value</td>
<td>40 (41) .49</td>
<td>62 (42) .98</td>
<td>46 (41) .73</td>
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<td>First 50 Firms</td>
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<td>8403</td>
<td>7825</td>
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<tr>
<td>Test Statistic (df) P-value</td>
<td>48 (43) .72</td>
<td>62 (43) .97</td>
<td>82 (42) 1.00</td>
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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
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

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<tr>
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<td>3343</td>
<td>3646</td>
<td>2048</td>
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<td>Second 50 Firms</td>
<td>3354</td>
<td>3808</td>
<td>3415</td>
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<td>All 100 Firms</td>
<td>6676</td>
<td>7424</td>
<td>4999</td>
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<tr>
<td>Test Statistic (df) P-value</td>
<td>42 (41) .57</td>
<td>60 (42) .96</td>
<td>928 (41) 1.00</td>
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<td>3747</td>
<td>3427</td>
<td>3023</td>
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<td>Second 50 Firms</td>
<td>4169</td>
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<td>Test Statistic (df) P-value</td>
<td>136 (43) 1.00</td>
<td>110 (43) 1.00</td>
<td>72 (42) .997</td>
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Table 2: Tests of Market Integration inside the NASDAQ, Two-Factor Model
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<td>100 S&amp;P Firms</td>
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<tr>
<td>100 NASDAQ Firms</td>
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<td>Combined</td>
<td>14,715</td>
<td>16,483</td>
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<td>Test Statistic (df) P-value</td>
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<td>1256 (42) 1.00</td>
<td>2882 (41) 1.00</td>
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<td>8403</td>
<td>7825</td>
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<tr>
<td>100 NASDAQ Firms</td>
<td>7848</td>
<td>6457</td>
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<td>Combined</td>
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<td>14,323</td>
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<td>978 (42) 1.00</td>
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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
Deltas from April-May 2002
Degree of Market Integration Seems Low

- Can compute mean absolute difference of deltas

\[
\frac{1}{T} \sum_{t} | \delta_{t}^p - \delta_{t}^q |
\]

- Also Grubel-Lloyd Measure:

\[
(1 / T ) \sum_{t} | \delta_{t}^p - \delta_{t}^q |
\]

- Use also Brandt, Cochrane, Santa-Clara measures:

\[
1 - \left[ \sigma^2 (\ln \delta_{t}^p - \ln \delta_{t}^q) / (\sigma^2 (\ln \delta_{t}^p) + \sigma^2 (\ln \delta_{t}^q)) \right]
\]

  ○ also analogue in levels

- Ignores estimation imprecision
<table>
<thead>
<tr>
<th></th>
<th>S&amp;P 500</th>
<th>NASDAQ</th>
<th>TSE</th>
<th>AAA Bonds</th>
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<td>A+ Bonds</td>
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<td>.33</td>
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**Table 12: Degree of Market Integration, April-May 2002**
Mean Absolute Difference of Deltas below diagonal; Grubel-Lloyd Measure above diagonal

<table>
<thead>
<tr>
<th></th>
<th>S&amp;P 500</th>
<th>NASDAQ</th>
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<th>AAA Bonds</th>
<th>A+ Bonds</th>
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<td>-.58</td>
<td>.57</td>
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<td>.74</td>
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<td>TSE</td>
<td>.55</td>
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<td>-.26</td>
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<td>-.29</td>
<td>.72</td>
<td>-</td>
<td>-.29</td>
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<td>Junk Bonds</td>
<td>.27</td>
<td>-.59</td>
<td>.06</td>
<td>-.58</td>
<td>-.27</td>
<td>-</td>
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**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?