Volume and Volatility in Dual Markets: Lessons from Chinese ADR

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Research Context: Volume volatility nexus

- H-shares and ADRs are identical securities traded in home (SEHK) and host (NYSE) exchanges
- Volatility indicates securities/market performance
- Volatility estimation through lagged and implied volatility measures fail to accurately forecast volatility (Canina and Figlewski RFS); spillovers across countries and securities are time variant and inconsistent
- Volume moves prices (Kyle 1984, Easley and O’Hara 1987); Trading preferences of heterogeneous investors (He and Wang 1995, Harris and Raviv 1993) lead to volume volatility correlation
Research Question

- Do volume and volatility move together OR one leads to the other for Chinese H-shares and their corresponding ADRs?

- In notation,
  - $V(t) = \text{volume}$
  - $h(t) = \text{volatility}$
  - $V(t) = \rho h(t) \Rightarrow \text{Correlation test}$
  - $V(t) \rightarrow h(t) \Rightarrow \text{One way causality}$
  - $h(t) \rightarrow V(t) \Rightarrow \text{Reverse one way causality}$
  - $h(t) \leftrightarrow V(t) \Rightarrow \text{Two way causality}$
Research Question (contd.)

• Do expected and unexpected volumes contribute to price discovery through volatilities of each H-share and its corresponding ADR? In notation,
  • ADR: \( h(t) = h(.....EV(t), UV(t)) \)
  • H-share: \( h(t) = h(.....EV(t), UV(t)) \)

• Do expected and unexpected volumes further contribute to price discovery through the covariance function? In notation,
  • \( \text{Cov} (ADR-r(t), H-share-r(t)) = \text{Cov} (.....EV(t), UV(t)) \)
Motivation -
Empirical tests and results

- Volume volatility relations are tested mostly with respect to market or country portfolios; Results are tested against the predictions of MDH or SIAH. The applicability of MDH and SIAH to individual securities is questionable.

- Empirical evidence limited and mixed for volume volatility at individual securities level (Harris 1987, Jones et al. 1994, Darrat et al. 2003, Deuskar 2009)
Motivation- Econometrics

- Volatility is unobservable; hence researchers estimate volatility using a model, most commonly GARCH
  - Very powerful ex-post fit but poor forecast
  - Many variations to improve forecast
  - Including ‘out of model’ parameters improve model performance- volume is a natural candidate
  - Multivariate extensions are promising but computationally challenging (Engle 2004)
    - Return and volatility transmission/spillover studies
    - Different forms of non-stationarity among multiple time series is a BIG problem
Empirical testing: Road map

- Define and estimate volume and volatility. Note volume is observable, volatility needs to be estimated.
- Choose an appropriate model for volatility (Criteria?)
- Check stationarity conditions for volume and volatility.
- Consider an appropriate model to separate between expected and unexpected volume.
- Test the relation between
  - volatility and volume
  - Volatility and expected/unexpected volume
Sample

- 14 Chinese H-shares traded in SEHK and corresponding ADRs traded at NYSE
- Period: From initial registration to Oct 2010
- Descriptive statistics
- Table 1
  - Means and variances are not different; most differences are in higher moments
  - Minimum value (left tail) heavier for H-shares
  - Nos. of observations and hence time duration do not seem to affect standard error
Volume trend stationary?

- Table 2
  - ADF test indicate no unit root and KPSS tests indicate trend stationary. Caveat: fractional integration.
  - Include linear and non-linear (square) trends; residuals must be stationary.
  - Trend equation: \[ V_{ol_t} = \alpha + \beta t + \chi t^2 + \varepsilon_t \]
Volatility GARCH Effect?

- Table 3
  - Auto correlated residuals 3/14; auto correlated squared residuals 14/14

- Table 4
  - TARCH:
    \[ \sigma_t^2 = \alpha + \psi \varepsilon_{t-1}^2 + \gamma \varepsilon_{t-1} d_{t-1} + \lambda \sigma_{t-1}^2 \]
  - TARCH model fit for all 14 pairs of ADRs and H-shares
  - Asymmetry denoting bad and good news significant for 8/14 H-shares and 9/14 ADRs
  - Volatility persistence decays slowly (≈0.9) over time
Volatility model with volume

- Table 4
  - TARCH model fit with volume
  - Model: \[ \sigma_t^2 = \alpha + \psi \varepsilon_{t-1}^2 + \gamma \varepsilon_{t-1} d_{t-1} + \lambda \sigma_{t-1}^2 + \kappa V_{t-1} \]
  - Volume is significant for 9/14 ADRs and 5/14
  - Volatility persistence parameter unchanged – confirms Girard and Biswas (2007)
Volatility model with volume

- Table 5
  - One way Granger causality Wald test
  - Model:

\[
\sigma_t^2 = \alpha_1 + \sum_{k=1}^{p} \beta_k \sigma_{t-k}^2 + \sum_{k=1}^{q} \theta_k V_{t-k} + \varepsilon_{1t}
\]

\[
V_t = \alpha_2 + \sum_{k=1}^{m} \delta_k \sigma_{t-k}^2 + \sum_{k=1}^{n} \phi_k V_{t-k} + \varepsilon_{2t}
\]

- Volume to volatility 14/14
- Volatility to volume 10/14 ADRs 4/14 H-shares
Bivariate GARCH Model

\[ \varepsilon_t \mid \Omega_{t-1} = \begin{bmatrix} \varepsilon_{n,t} \\ \varepsilon_{h,t} \end{bmatrix} \sim N(0, H_t) \]

\[ H_{n,t} = M_{11} + A_{11} \varepsilon_{n,t-1}^2 + B_{11} H_{n,t-1} + C_{11} EV_{n,t-1} + D_{11} UV_{n,t-1} + e_{n,t} \ldots \ldots(9) \]

\[ H_{h,t} = M_{22} + A_{22} \varepsilon_{h,t-1}^2 + B_{22} H_{h,t-1} + C_{22} EV_{h,t-1} + D_{22} UV_{h,t-1} + e_{h,t} \ldots \ldots(10) \]

\[ H_{h_{nt}} = M_1 + A_1 \varepsilon_{n,t-1} \varepsilon_{h,t-1} + B_1 H_{h_{nt-1}} + C_1 EV_{n,t-1} EV_{h,t-1} + D_1 UV_{n,t-1} UV_{h,t-1} + e_{h_{nt}} \ldots(11) \]

ARMA (1,1) with seasonality

\[ V_t = \alpha + \sum_{i=1}^{p} \beta_i V_{t-i} + \sum_{j=1}^{q} \delta_j \varepsilon_{t-j} + \eta_k dum_k + \varepsilon_t \]
# Bivariate GARCH with/out volume

<table>
<thead>
<tr>
<th></th>
<th>$A(1,1)$</th>
<th>$A(1,2)$</th>
<th>$A(2,2)$</th>
<th>$B(1,1)$</th>
<th>$B(1,2)$</th>
<th>$B(2,2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>No volume</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
</tr>
<tr>
<td>With E(V) and U(V)</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
<td>14/14 (+)</td>
</tr>
<tr>
<td></td>
<td>$C(1,1)$</td>
<td>$C(1,2)$</td>
<td>$C(2,2)$</td>
<td>$D(1,1)$</td>
<td>$D(1,2)$</td>
<td>$D(2,2)$</td>
</tr>
<tr>
<td>With E(V) and U(V)</td>
<td>12/14 (+)</td>
<td>10/14 8 + / 2 -</td>
<td>7/14 6 + / 1 -</td>
<td>8/14 (+)</td>
<td>14/14 (+)</td>
<td>6/14 (+)</td>
</tr>
</tbody>
</table>
Conclusion

- Modeling daily volatility of ADR and corresponding H-shares listed in Hong Kong Stock Exchange (SEHK)
- Empirical evidence finds
  - Volume and conditional volatility estimated from a GARCH model are contemporaneously correlated
  - Mixed evidence for contemporaneous correlation and lead lag relation between detrended volume and conditional volatility
  - Strong support for bivariate GARCH model in which expected and unexpected volume contribute to volatility directly as well as indirectly through the covariance function
- Volume denotes liquidity in volume volatility relation. EV and UV denote inventory and information components respectively