

Switching Volatility in Target Stocks During Takeover Bids

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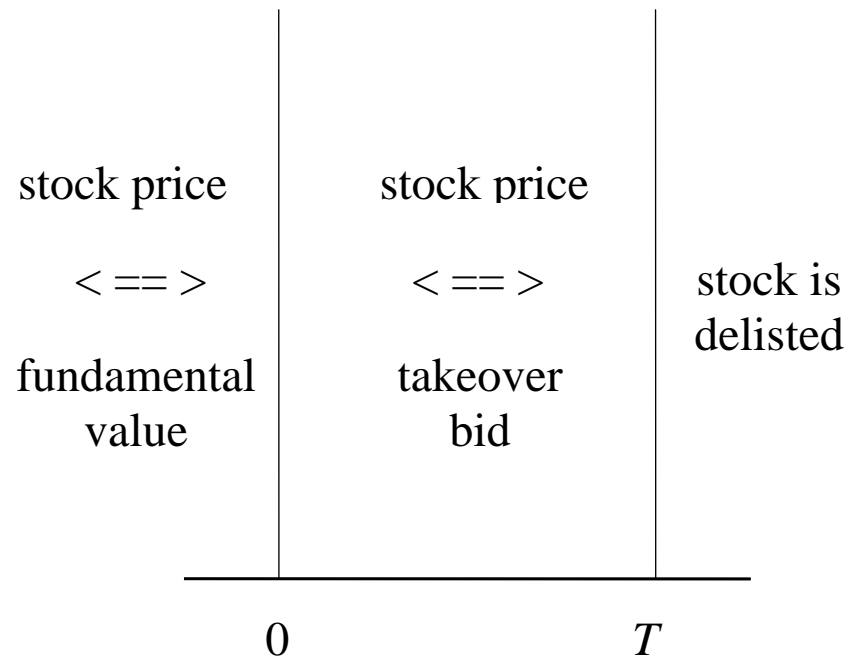
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1. Introduction

General question:

- How do stock prices of the target enterprise evolve during a takeover bid ? (*mergers and acquisitions*)



Types of takeover deals:

- *Cash bids, share swaps, mixed bids*

Empirical findings:

- *Decreasing market-betas and changing volatility*

Decreasing market-beta:

- *Stock-price return as a linear function of the market return*

$$R_t = \alpha + \beta \cdot R_t^m + \epsilon_t$$

- β decreases during the *bid period* $[0, T)$

Volatility:

- *increases* around the date 0
- *decreases* in the course of the *bid period* $[0, T)$

Literature:

- Jensen & Ruback (1983), *Journal of Financial Economics*
- Jarrell et al. (1988), *Journal of Economic Perspectives*
- Bhagat et al. (1987), *Journal of Finance*
- Hutson & Kearney (2001), *Journal of Empirical Finance*
- Hutson & Kearney (2005), *Research in International Business and Finance*

Aim of this paper:

- Focus on *volatility structure*
- *Theoretical justification for volatility regime-switching in target stock-price returns*
- *Econometric modelling*
(*Markov-Switching GARCH models*)
- *Empirical implementation*
(5 takeover deals)
- *Financial applications*
(*Option pricing*)

2. Target Stock-Price Dynamics

Literature:

- Brown & Raymond (1986), *Financial Management*
- Samuelson & Rosenthal (1986), *Journal of Finance*

Now:

- Making the model more *dynamic*
(*continuous-time modelling*)
- Restriction on *cash bids*

Model setup:

- For $t \in [0, T)$ we have

$$P(t) = \alpha \cdot v_T \cdot \exp\{-r \cdot (T - t)\} + (1 - \alpha) \cdot P^*(t)$$

- $P(t)$: target stock-price
- α : subjective takeover probability
- v_T : cash bid-price of the target stock on date T
- r : riskless interest rate
- $P^*(t)$: *stand-alone price* of the target stock

$$P(t) = \alpha \cdot v_T \cdot \exp\{-r \cdot (T - t)\} + (1 - \alpha) \cdot P^*(t)$$

Dynamics of $P^*(t)$:

- *Geometric Brownian motion*
- *Stochastic differential*

$$dP^*(t) = \mu \cdot P^*(t) \cdot dt + \sigma \cdot P^*(t) \cdot dW(t)$$

- $\mu \in \mathbb{R}, \sigma > 0$: process parameters
- $dW(t)$: increment of a *Standard-Wiener process*

Now:

- Ito's lemma yields the *infinitesimal variance* of $p(t) \equiv \log_e[P(t)]$:

$$\sigma_{\{p(t)\}}^2 = \frac{[(1 - \alpha) \cdot \sigma \cdot P^*(t)]^2}{[\alpha \cdot v_T \cdot e^{-r \cdot (T-t)} + (1 - \alpha) \cdot P^*(t)]^2}$$

- We have

$$\sigma_{\{p(t)\}}^2 \approx \text{Var}\left\{ \underbrace{\log_e[P(t+1)] - \log_e[P(t)]}_{\text{(daily) target stock-price return}} \mid \phi(t) \right\}$$

Interim conclusion:

- The *infinitesimal variance* approximates to the *conditional variance* of the (daily) *target stock-price returns*

Properties of the *infinitesimal variance*:

- $\sigma_{\{p(t)\}}^2$ depends on α
- For $\alpha = 0$ we have $\sigma_{\{p(t)\}}^2 = \sigma_{\{\log_e[P^*(t)]\}}^2 = \sigma^2$
- For $\alpha = 1$ we have $\sigma_{\{p(t)\}}^2 = 0$
- $\sigma_{\{p(t)\}}^2$ is *strictly monotone decreasing* in $\alpha \in [0, 1]$

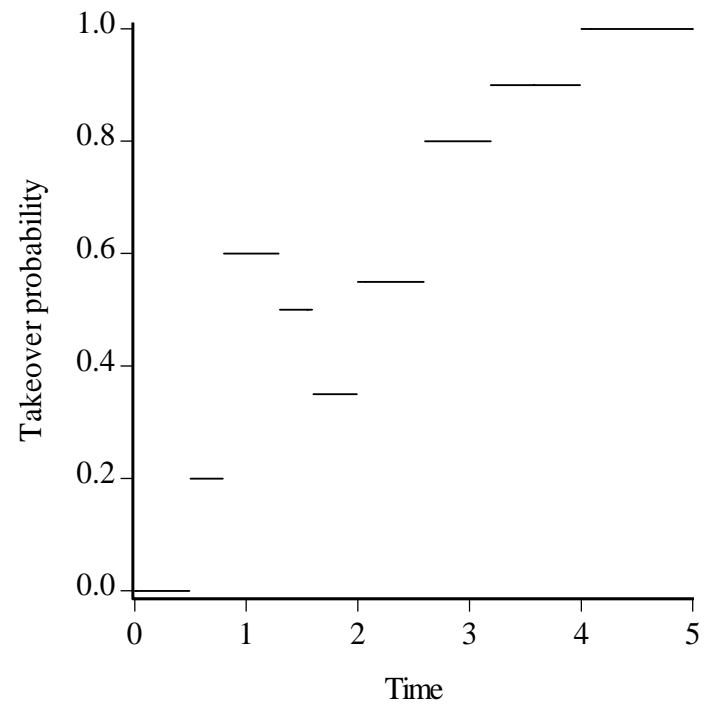
Why changes in α ?

- "News" on the takeover deal
 - *revised market assessment*
 - *revisions in α*

Evidently:

- Each α -revision induces a *shift in the variance-path*

$$\sigma_{\{p(t)\}}^2 \approx \text{Var}\{\underbrace{\log_e[P(t+1)] - \log_e[P(t)]}_{\text{target stock-price returns}} | \phi(t)\}$$



Interim conclusion:

- *Data-generating process* of the target stock-price returns is subject to *volatility regime-switching*
- *Number of volatility-regimes = number of distinct α -values*
- *Two extreme (enveloping) regimes:*
 - $\alpha = 0 \implies \sigma_{\{p(t)\}}^2 = \sigma^2$ (*high-volatility regime*)
 - $\alpha = 1 \implies \sigma_{\{p(t)\}}^2 = 0$ (*low-volatility regime*)
- *Intermediate volatility regimes:*
 - $\alpha \in (0, 1) \implies \sigma^2 > \sigma_{\{p(t)\}}^2 > 0$

Remark:

- Pattern of α -revisions on slide 12 can explain why
 - *volatility increases* around date 0
 - *volatility decreases* during the *bid period* $[0, T)$

3. Regime-Switching Analysis

Aim:

- Econometric detection of volatility-regimes in the data-generating process of target stock-price returns (indirect model test)

Specification problem:

- Number of volatility-regimes

Simplification:

- Specification of the two enveloping regimes (high- and low-volatility regimes)

Econometric technique:

- Fit of *Markov-switching-GARCH* models for the daily stock-price returns of 5 target enterprises

Literature:

- Gray (1996), *Journal of Financial Economics*
- Dueker (1997), *Journal of Business and Economic Statistics*
- Wilfling (2009), *Journal of International Money and Finance*, *forthcoming*

Results (1):

- Parameter estimates:
 - 72 % of the parameters are *statistically significant*
 - *Decreasing market-betas*
 - *Statistically significant t-distributions* within the regimes
 - *Persistent regimes*
 - *Stationary conditional variance-processes*

Results (2):

- Specification tests:
 - *Squared (standardized) residuals autocorrelation-free*
 - *Econometric evidence for the existence of a 2. regime*
 - *Statistically significant volatility regime-switches*
(*"more significant" for cash bids*)

4. Concluding Remarks

1. Theoretical modelling:

- Justification for *volatility regime-switching in target stock-price returns*
- Explanation for well-known *empirical facts* with regard to stock-price volatility

2. Econometric modelling:

- *Statistically significant volatility regime-switching* (for all types of takeover deals)
- *"Most significant" regime-switching for cash bids*

3. Conclusion:

- *Econometric misspecification* when neglecting the *regime-switching structure*
- Pricing of target stock-options:
 - *Pricing of options under M&A very relevant*
(Subramanian, A., 2004, *Journal of Finance*)
 - *Conventional models generate pricing errors under volatility regime-switching*
(Bollen, N., 1998, *Journal of Derivatives*)