

**DYNAMICS BETWEEN MALAYSIAN EQUITY MARKET AND  
MACROECONOMIC VARIABLES: AN APPLICATION OF KALMAN FILTER  
MODEL WITH HETEROSKEDASTIC ERROR**

**by**

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- 1 Cheah, L. H. and Arsad, Z. (2006). Estimating And Forecasting Volatility Of Malaysian Stock Market Using A Combination Of Kalman Filter And GARCH Models. *Capital Market Reviews*, 14, (1 & 2), 27-42.

# DINAMIK ANTARA PASARAN EKUITI MALAYSIA DAN PEMBOLEHUBAH-PEMBOLEHUBAH MAKROEKONOMI: SATU APLIKASI MODEL PENAPIS KALMAN DENGAN RALAT HETEROSKEDASTIK

## ABSTRAK

Sejak diperkenalkan oleh Kalman dan Bucy (1960), model penapis Kalman telah mendapat penggunaan yang luas dalam dalam program ruang angkasa dan bidang kejuteraan kawalan. Namun begitu, pengaplikasiannya dalam bidang siri masa kewangan masih jarang digunakan dan jauh ketinggalan. Model penapis Kalman adalah satu set persamaan yang membenarkan nilai anggaran dikemaskini sebaik sahaja satu cerapan baru diperolehi. Satu model untuk data bulanan Indeks Komposit Kuala Lumpur dari April 1986 hingga Februari 2005 dicadang dan dikaji. Model ini membenarkan aras berbalik purata bagi Index Komposit Kuala Lumpur dimodelkan secara stokastik. Perbandingan dilakukan menggunakan keputusan-keputusan di antara model ringkas penapis Kalman AR(1) dan penapis Kalman tulen yang dicadang. Model terbaik dipilih berdasarkan nilai log kebolehjadian maksimum, *Akaike Information Criterion* dan *Bayesian Information Criterion*.

Tesis ini juga menggunakan model penapis Kalman untuk menganalisa ruang keadaan dengan ralat bersifat ARCH seperti yang dicadangkan oleh Harvey, Ruiz and Sentana (1992). Analisis difokuskan terhadap model-model yang mana sebutan-sebutan ralat dalam persamaan pengukuran adalah heteroskedastik. Lima model dari jenis ARCH termasuk ARCH, GARCH, GARCH-M, EGARCH dan TARCH dipertimbangkan. Keputusan menunjukkan bahawa model-model dengan kombinasi penapis Kalman dan jenis ARCH memberikan ralat sampel dalaman dan ralat telahan sampel luaran yang lebih kecil daripada nilai-nilai yang dihitung daripada model penapis Kalman tulen.

Model penapis Kalman juga diaplikasikan untuk mengkaji dinamik di antara model bergabung bagi Index Komposit Kuala Lumpur, kadar tukaran wang *Pound Sterling* dan kontrak hadapan Indeks Komposit Kuala Lumpur. Bentuk ruang keadaan membenarkan satu siri tak tercerap diperkenalkan ke dalam struktur model tersebut. Siri tak tercerap ini dianggap sebagai kombinasi pembolehubah-pembolehubah lain yang tidak dipertimbangkan ke dalam model-model yang dikaji. Data bulanan dari Januari 1997 hingga Februari 2005 telah digunakan bagi analisis dan prosedur pemodelan. Bentuk ruang keadaan model penapis Kalman digunakan bagi mengkaji sekiranya kadar tukaran wang *Pound Sterling* dan kontrak hadapan Indeks Komposit Kuala Lumpur mempunyai kesan yang signifikan terhadap telatah Indeks Komposit Kuala Lumpur. Tambahan pula, matrik keadaan membolehkan kajian terhadap arah sesuatu hubungan yang wujud. Model-model yang diketengahkan seterusnya dibandingkan dengan model *Vector Autoregressive*.

Kajian secara keseluruhannya menunjukkan bahawa model penapis Kalman dengan ralat pengukuran sifar dan model penapis Kalman dengan ralat jenis EGARCH merupakan model terbaik daripada kategori model penapis Kalman tulen yang dicadangkan dan model dengan kombinasi penapis Kalman dan jenis ARCH, masing-masing. Keputusan menunjukkan bahawa kedua-dua model penapis Kalman tulen dan *Vector Autoregressive* menunjukkan hubungan satu hala dari harga saham kepada kadar tukaran wang. Tambahan pula, didapati bahawa kedua-dua pembolehubah tersebut berkorelasi negatif. Walau bagaimanapun, telah didapati bahawa pasaran saham dan kontrak hadapan adalah tak sandar antara satu sama lain, yang bermaksud bahawa tiada terdapat hubungan yang signifikan antara dua pembolehubah tersebut. Bagi model-model dengan kombinasi penapis Kalman dan jenis ARCH, andaian varians berubah terhadap masa menghasilkan lebih banyak hubungan yang signifikan di kalangan pembolehubah yang dikaji. Keputusan menunjukkan hubungan satu hala di antara harga saham dan kadar tukaran wang. Di

samping itu, didapati wujud hubungan dua hala di antara harga saham dan kontrak hadapan. Juga, keputusan-keputusan menunjukkan bahawa harga saham tidak dipengaruhi secara signifikan oleh siri tak tercerap bagi kedua-dua model penapis Kalman tulen dengan ralat pengukuran sifar dan model dengan kombinasi penapis Kalman dan jenis ARCH menandakan bahawa harga saham berkemungkinan tidak dipengaruhi secara signifikan oleh pembolehubah-pembolehubah lain.

Akhir sekali, analisis dan kajian yang serupa juga dilakukan dengan menggunakan model penapis Kalman dengan ralat pengukuran sifar dan model penapis Kalman dengan ralat jenis EGARCH bagi data harian untuk ketiga-tiga pembolehubah di atas. Data-data telah dibahagikan kepada tiga sub-sampel iaitu tempoh *World Recession* dari 2 Januari 2001 sehingga 21 Mei 2002 and dua sub-sampel *Recovery* dari 22 Mei 2002 sehingga 30 September 2004 hingga 1 Oktober 2004 hingga 28 Februari 2005 masing-masing. Bagi model penapis Kalman dengan ralat jenis EGARCH, didapati siri tak tercerap mempunyai kesan yang signifikan terhadap harga saham. Namun begitu, kejadian ini tidak dilihat bagi model penapis Kalman tulen. Kajian simulasi berdasarkan model penapis Kalman tulen dengan ralat pengukuran sifar dan model penapis Kalman dengan ralat jenis EGARCH bagi kedua-dua data bulanan dan harian, menunjukkan bahawa model terpilih berjaya menghasilkan realisasi yang baik bagi ketiga-tiga siri masa yang dicerap.

# **DYNAMICS BETWEEN MALAYSIAN EQUITY MARKET AND MACROECONOMIC VARIABLES: AN APPLICATION OF KALMAN FILTER MODEL WITH HETEROSKEDASTIC ERROR**

## **ABSTRACT**

Ever since the pioneering work of Kalman and Bucy (1960), Kalman filter model has become widely used in the space programme and control engineering. However, its applications in financial time series have been very few and far in between. Kalman filtering is a set of equations which allows an estimator to be updated once a new observation becomes available. A model for the monthly Kuala Lumpur Composite Index from April 1986 to February 2005 is proposed and investigated. The model allows the mean reversion level of Kuala Lumpur Composite Index to be modeled stochastically. Comparisons of results between the simpler Kalman filter AR(1) and the proposed models are made. The best models are chosen with reference to the value of maximum log likelihood, Akaike Information Criterion and Bayesian Information Criterion.

This thesis also makes use of Kalman filtering model to analyse state-space model with ARCH disturbances proposed by Harvey, Ruiz and Sentana (1992). The analyses are focused on models in which the disturbances terms of the measurement equations are heteroskedastic. Five ARCH-type models including ARCH, GARCH, GARCH-M, EGARCH and TARCH are considered. The results show that the Kalman filter and ARCH-type combination models give smaller both within sample and out-of-sample forecast errors than those calculated from the pure Kalman filter model.

The Kalman filter model is also applied to investigate the dynamics between a combined model for the Kuala Lumpur Composite Index, Pound Sterling exchange rates and Kuala Lumpur Composite Index Futures. The state-space form allows an