Trading Strategy by Using Markov Regime Switching Models: The Malaysia Case

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- Markov regime switching model with macroeconomic variable
- Trading rules
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- Conclusion

Introduction

- Many economic and financial time series often experience dynamic changes in their behavior over reasonably long sample periods. Take for example the cycling of the economy between business cycle phases, bull and bear markets in equity returns, and high and low volatility regimes in asset prices.
- Therefore, a wide variety of linear and non-linear time series techniques have been employed to analyse the dynamic behavior of economic and financial variables. However, linear models with constant parameters might be inadequate to describe their evolution, such as asymmetry, fat tails, amplitude dependence and volatility clustering which are often denoted as stylized facts of financial markets.
- Consequently, there recently has been much interest in econometric models designed to incorporate parameter variation which allows for the existence of different states of world or regimes to explain the empirical data at different times. One approach to describe this variation is to use the "regime switching" model as a tool for establishing stylized properties about the dynamic behavior of the financial time series.
- A vital issue in regime switching models is if new regimes always differ from precedents or whether the same regimes repeat over time, as in the case of recurring recession and expansion periods.

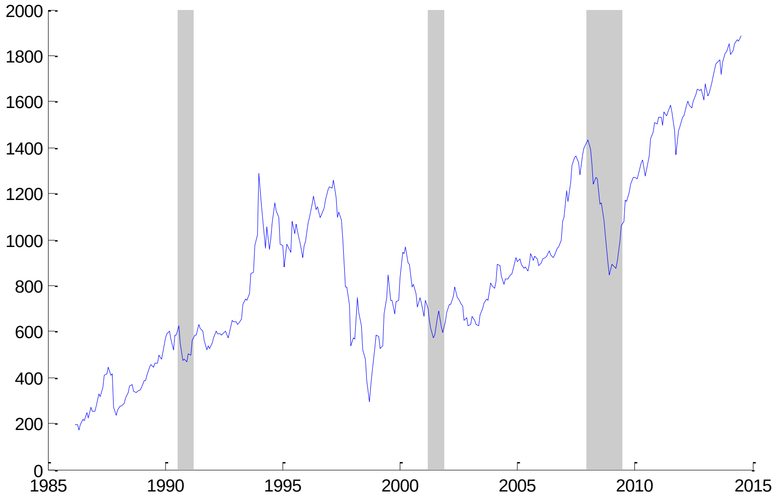
- Two types of regime switching models:
  - **Threshold model** assume that the state variable is a deterministic function of an observed variable,
  - **Markov switching model**, the state variable is assumed to follow a particular stochastic process, namely the Markov chain process.
- In this talk, we will focus on the Markov switching model in which the state variable is assumed to follow the first-order Markov chain.
- It is well documented that the advantage of using Markov regime switching model in modelling stock market return is to allow investors to generate meaningful portfolio performance that take into account the possibility of the change from one regime to another.
- The main objective of this study is to examine the profit of trading rules formed using inferences from Markov regime switching models with macroeconomic variables.
- In this talk, we do not intend to ask, as most of the literature do, which of the many competitive models fit the data best in sample, but for a given model which model will yield the most fruitful return.

Data

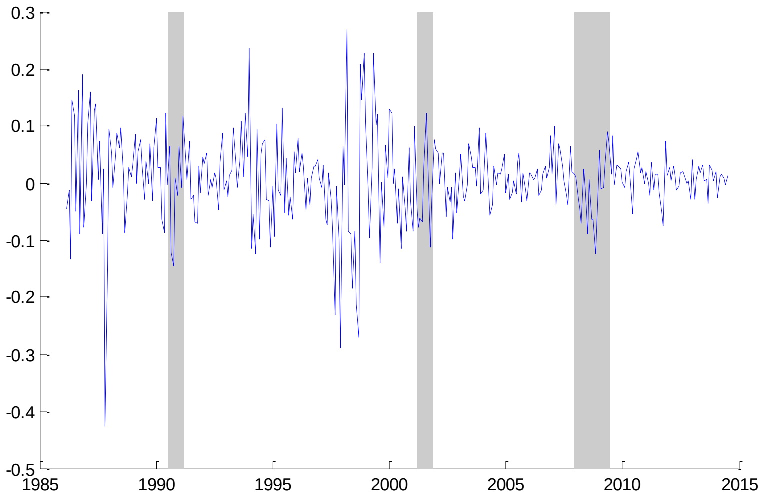
- Datastream Malaysian stock market index sampled on a monthly basis from February 1986 to July 2014 (341 data points).
- Returns are computed as the first difference of end-of-month log prices,

$$R_t = \ln\left(\frac{p_t}{p_{t-1}}\right)$$

	Price index	Returns
Mean	899.3998	0.0065
Standard deviation	412.2750	0.0746
Max.	1886.8	0.2688
Min.	169.83	-0.4266
Skewness	0.4850	-0.6613
Kurtosis	2.4960	7.8391



Malaysian monthly price index: February 1986 and July 2014.



Malaysian monthly stock market returns: February 1986 and July 2014.

*Shaded region: U.S. recession periods determined by National Bureau of Economic Research (NBER).

Two States Markov Regime Switching Model

- Assume that the return of a stock market is generated by the following switching regression:

$$R_t = \mu_{S_t} + \sigma_{S_t}\epsilon_t, \qquad \epsilon_t \sim N(0,1),$$

for $t = 1,2,\ldots,T$, and $S_t \in \{1,2\}$ is the unobserved state indicator variable with $S_t = 1$ represents the bull/expansion state and $S_t = 2$ represents the bear/recession state.

  – Bull market- high return coupled with low volatility,
  – Bear market- low return and high volatility.

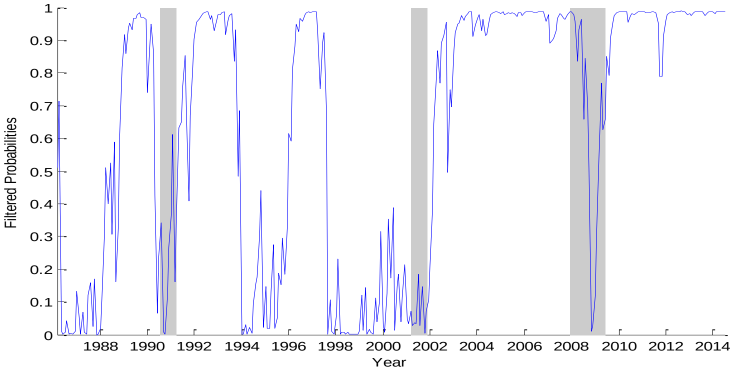
- S_t is assumed to follow a first order, homogenous Markov chain, i.e,

$$\Pr(S_t|S_{t-1}, S_{t-2}, \ldots) = \Pr(S_t|S_{t-1})$$

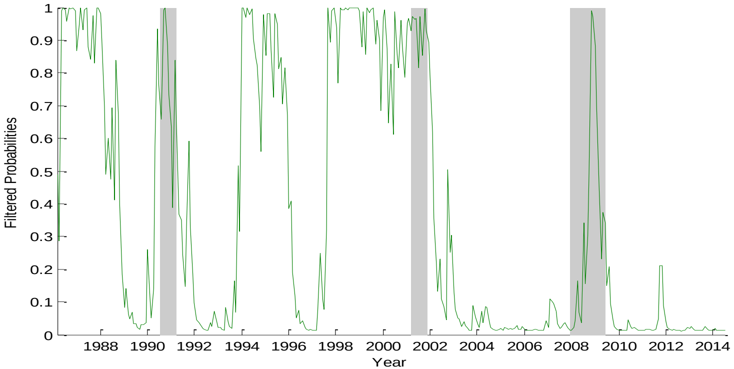
The transition probability p_{ij} can be written as

$$p_{ij} = \Pr(S_t = j|S_{t-1} = i)$$

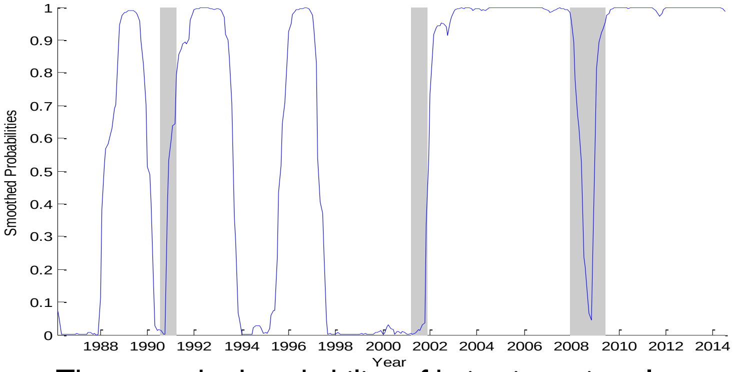
with $\sum_j p_{ij} = 1$.



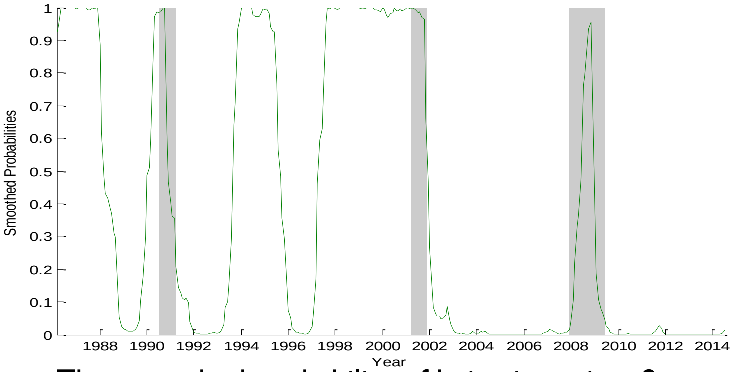
The filtered probability of being in regime 1, $\Pr(S_t = 1|\psi_t)$



The filtered probability of being in regime 2, $\Pr(S_t = 2|\psi_t)$



The smoothed probability of being in regime 1, $\Pr(S_t = 1|\psi_T)$



The smoothed probability of being in regime 2, $\Pr(S_t = 2|\psi_T)$

	Switching in mean	Switching in variance	Switching in both mean and variance
μ_1	0.0126* (3.7376e-03)	0.0107* (2.8360e-03)	0.0124* (2.9885e-03)
μ_2	-0.2126* (4.3527e-02)		-0.0031 (1.0291e-02)
σ_1	0.004248* (3.3760e-04)	0.001495* (1.9979e-04)	0.001481* (1.8598e-04)
σ_2		0.012528* (1.8291e-03)	0.012339* (1.7667e-03)
p_{11}	0.9869	0.9785	0.9780
p_{22}	0.5173	0.9568	0.9560
$\mathbb{E}(D_1)$	76.31	46.55	45.50
$\mathbb{E}(D_2)$	2.07	23.17	22.73

* indicates that the *p*-value is significant at 1% level

Markov Regime Switching Model with Macroeconomic Variables

- The model

$$R_t = \mu_{S_t} + x_t\beta + \sigma_{S_t}\epsilon_t, \epsilon_t \sim N(0,1),$$

  where $S_t \in \{1,2,\ldots,k\}$ is the unobserved state indicator variable with k different possible states. x_t is a $l \times 1$ vector of exogenous or predetermined explanatory variable at time t such as dividend yields, price-earning ratio, etc.

- The state indicator variable S_t is assumed to follow a first order, homogenous Markov process with the following transition probabilities

$$p_{ij} = \Pr(S_t = j | S_{t-1} = i), \qquad \text{for } i,j = 1,2,\ldots k.$$

- For two states Markov regime switching model, we assume that $S_t = 1$ is an indicator of an economic is in the expansion state, $S_t = 2$ is in the recession state. For three states Markov regime switching model, $S_t = 1$ denotes the expansion state, $S_t = 2$ denotes the normal state and $S_t = 3$ denotes the recession state.

- We consider 18 different types of Markov regime switching models
  - Three types of switching:
    - Switching in mean (10)

$$R_t = \mu_{S_t} + x_t\beta + \sigma\epsilon_t, \epsilon_t \sim N(0,1)$$

    - Switching in variance (01)

$$R_t = \mu + x_t\beta + \sigma_{S_t}\epsilon_t, \epsilon_t \sim N(0,1)$$

    - Switching in both mean and variance (11)

$$R_t = \mu_{S_t} + x_t\beta + \sigma_{S_t}\epsilon_t, \epsilon_t \sim N(0,1)$$

  - Number of regime:
    - Two regimes (k2)
    - Three regimes (k3)
  - x_t:
    - Price-earning ratio (DSPE)
    - Dividend yield (DSDY)
    - Without any macroeconomic variable, $x_t = 0$.

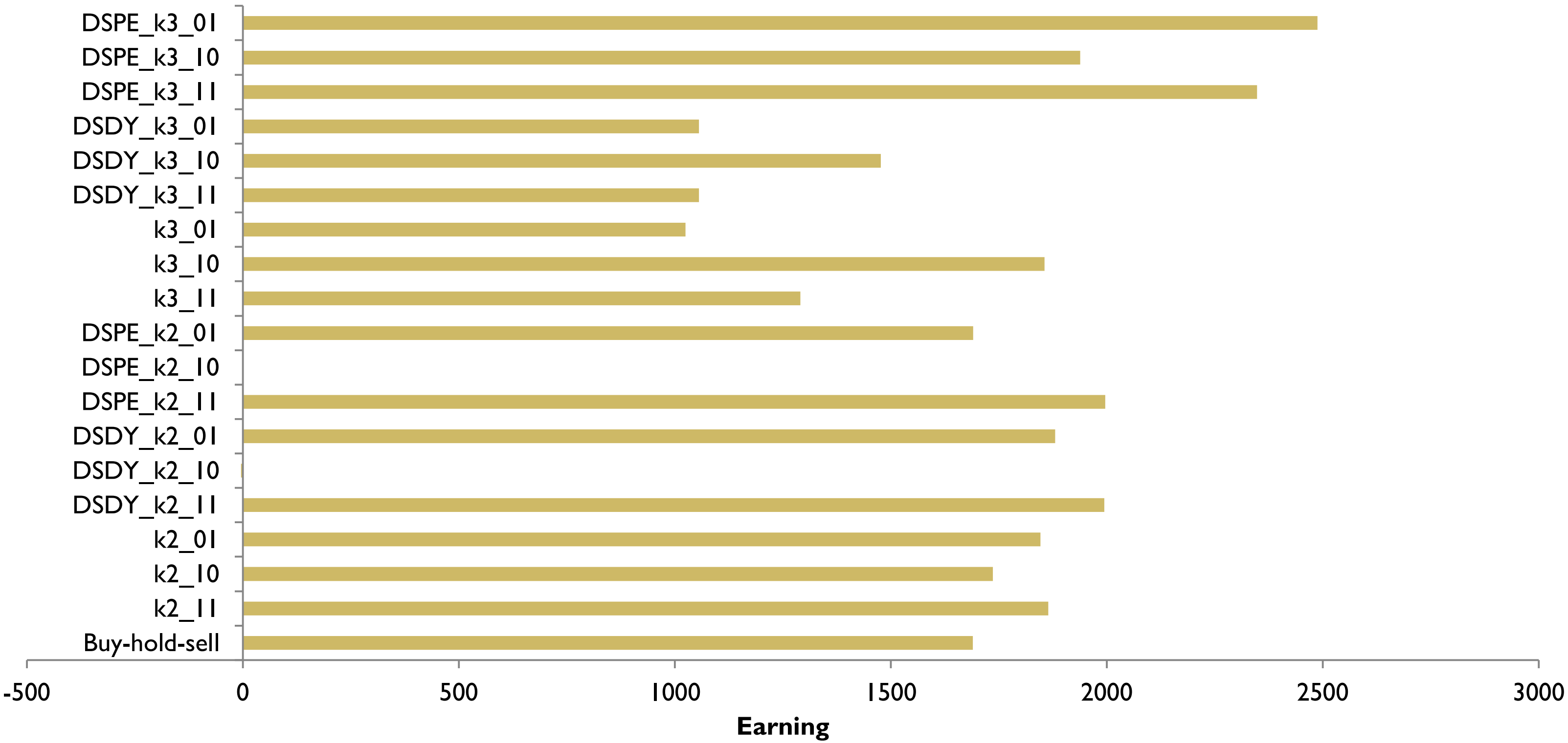
Abbreviation	Model
k2_11	Two regime switching in both mean and variance model
k2_10	Two regime switching in mean model
k2_01	Two regime switching in variance model
DSDY_k2_11	Dividend yield dependent two regime switching in both mean and variance model
DSDY_k2_10	Dividend yield dependent two regime switching in mean model
DSDY_k2_01	Dividend yield dependent two regime switching in variance model
DSPE_k2_11	Price-earnings ratio dependent two regime switching in both mean and variance model
DSPE_k2_10	Price-earnings ratio dependent two regime switching in mean model
DSPE_k2_01	Price-earnings ratio dependent two regime switching in variance model
k3_11	Three regime switching in both mean and variance model
k3_10	Three regime switching in mean model
k3_01	Three regime switching in variance model
DSDY_k3_11	Dividend yield dependent three regime switching in both mean and variance model
DSDY_k3_10	Dividend yield dependent three regime switching in mean model
DSDY_k3_01	Dividend yield dependent three regime switching in variance model
DSPE_k3_11	Price-earnings ratio dependent three regime switching in both mean and variance model
DSPE_k3_10	Price-earnings ratio dependent three regime switching in mean model
DSPE_k3_01	Price-earnings ratio dependent three regime switching in variance model

Trading Rules

- Benchmark Strategy: buy-hold-sell
  - Buy at Feb 1986, hold through the whole sample period and sell at Jul 2014.
- Investors will only purchase when the probability of good state is high and sell if the probability of bad state is high.
  - Two regimes
    - $S_t = 1$ expansion, $S_t = 2$ recession
    - Buy and hold if $\Pr(S_t = 1|\psi_t) > 0.5$
    - Sell if $\Pr(S_t = 2|\psi_t) > 0.5$
  - Three regimes
    - $S_t = 1$ expansion, $S_t = 3$ recession
    - Buy and hold if $\Pr(S_t = 1|\psi_t) > 0.5$
    - Sell if $\Pr(S_t = 3|\psi_t) > 0.5$
    - Neither sell nor buy if $\Pr(S_t = 2|\psi_t) > 0.5$
- Sell all stock at Jul 2014.

Modal	Number of transaction	Earning	Gain/ Loss
(Benchmark) Buy-hold-sell	2	**1689.93**	-
k2_11	26	1864.45	174.52
k2_10	12	1736.72	46.79
k2_01	18	1846.72	156.79
DSDY_k2_11	20	1994.63	304.7
DSDY_k2_10	2	-4.06	-1693.99
DSDY_k2_01	14	1880.32	190.39
DSPE_k2_11	20	1996.65	306.72
DSPE_k2_10	0	0	-1689.93
DSPE_k2_01	16	1690.85	0.92
k3_11	6	1290.49	-399.44
k3_10	8	1856.26	166.33
k3_01	2	1024.44	-665.49
DSDY_k3_11	2	1056.16	-633.77
DSDY_k3_10	10	1476.86	-213.07
DSDY_k3_01	2	1056.16	-633.77
DSPE_k3_11	8	2348.11	658.18
DSPE_k3_10	18	1938.79	248.86
DSPE_k3_01	8	2487.61	**797.68**

Earnings from all the 18 different types of Markov regime switching models and the benchmark strategy



Modal	Pr(Expansion)	Pr(Normal)	Pr(Recession)	Pr(Unidentified)
k2_11	0.6393	-	0.3607	-
k2_10	0.9795	-	0.0205	-
k2_01	0.6334	-	0.3666	-
DSDY_k2_11	0.6540	-	0.3460	-
DSDY_k2_10	0.0088	-	0.9912	-
DSDY_k2_01	0.6569	-	0.3431	-
DSPE_k2_11	0.6569	-	0.3431	-
DSPE_k2_10	0.0000	-	1.0000	-
DSPE_k2_01	0.6657	-	0.3343	-
k3_11	0.2287	0.5894	0.1818	-
k3_10	0.9736	0.0117	0.0147	0.0029
k3_01	0.1672	0.6452	0.1818	0.0059
DSDY_k3_11	0.2434	0.5865	0.1701	-
DSDY_k3_10	0.9707	0.0205	0.0088	-
DSDY_k3_01	0.2405	0.5894	0.1701	-
DSPE_k3_11	0.6774	0.2845	0.0293	0.0088
DSPE_k3_10	0.9208	0.0528	0.0264	-
DSPE_k3_01	0.6686	0.0000	0.3050	0.0264

Modal	Empirical			Theoretical		
	$Pr(S_t = e)$	$Pr(S_t = n)$	$Pr(S_t = r)$	$Pr(S_t = e)$	$Pr(S_t = n)$	$Pr(S_t = r)$
k2_11	0.6393	-	0.3607	0.6667	-	0.3333
k2_1 0	0.9795	-	0.0205	0.9736	-	0.0264
k2_01	0.6334	-	0.3666	0.6677	-	0.3323
DSDY_k2_11	0.6540	-	0.3460	0.7026	-	0.2974
DSDY_k2_10	0.0088	-	0.9912	0.0000	-	1.0000
DSDY_k2_01	0.6569	-	0.3431	0.7004	-	0.2996
DSPE_k2_11	0.6569	-	0.3431	0.6984	-	0.3016
DSPE_k2_10	0.0000	-	1.0000	0.3699	-	0.6301
DSPE_k2_01	0.6657	-	0.3343	0.7024	-	0.2976
k3_11	0.2287	0.5894	0.1818	0.3135	0.5476	0.1389
k3_10	0.9736	0.0147	0.0117	0.9579	0.0138	0.0283
k3_01	0.1672	0.6452	0.1877	0.3606	0.4797	0.1597
DSDY_k3_11	0.2434	0.5865	0.1701	0.3104	0.5485	0.1411
DSDY_k3_10	0.9707	0.0088	0.0205	0.9562	0.0118	0.0320
DSDY_k3_01	0.2405	0.5894	0.1701	0.3121	0.5475	0.1403
DSPE_k3_11	0.6774	0.2845	0.0293	0.6890	0.2388	0.0722
DSPE_k3_10	0.9208	0.0264	0.0528	0.9162	0.0284	0.0554
DSPE_k3_01	0.6686	0.0000	0.3050	0.6984	0.0750	0.2265

Modal	$Pr(S_t=1\|S_{t-1}=1)$	$Pr(S_t=2\|S_{t-1}=2)$	$Pr(S_t=3\|S_{t-1}=3)$
k2_11	0.9780	0.9560	-
k2_10	0.9869	0.5173	-
k2_01	0.9785	0.9568	-
DSDY_k2_11	0.9837	0.9615	-
DSDY_k2_10	0.9362	1.0000	-
DSDY_k2_01	0.9837	0.9619	-
DSPE_k2_11	0.9832	0.9611	-
DSPE_k2_10	0.0000	0.4130	-
DSPE_k2_01	0.9836	0.9613	-
k3_11	0.9572	0.9614	0.9442
k3_10	0.9849	0.0000	0.0000
k3_01	0.9864	0.9699	0.9096
DSDY_k3_11	0.9590	0.9627	0.9452
DSDY_k3_10	0.9657	0.0000	0.3303
DSDY_k3_01	0.9579	0.9618	0.9446
DSPE_k3_11	0.9755	0.7684	0.0000
DSPE_k3_10	0.9727	0.6389	0.5485
DSPE_k3_01	0.9841	0.0000	0.6688

Discussion

- In the context of two regimes switching models, all models support that Malaysian stock market return favour the period of expansionary than recession state with $\Pr(S_t = 1) > 0.5$ except for the models DSDY_k2_10 and DSPE_k2_10.

- The models DSDY_k2_10 and DSPE_k2_10 favour in bad state over the long run with the unconditional probability being in recession state, $\Pr(S_t = 2)$, equal to 0.9912 and 1, respectively.

- The Models DSDY_k2_11 and DSPE_k2_11 outperform than buy-hold-sell strategy.

- In the context of three regimes switching models, models such as k3_11, k3_01, DSDY_k3_11 and DSDY_k3_01 show that Malaysian stock market is partly dominated by the normal state with $\Pr(S_t = 2)$ of around 0.59 to 0.65. Due to the relatively high probability of being in normal state as compared to the bull and bear states, investors are unable to grasp the right chance and opportunity to trade and thus cause these models to perform unsatisfactory.

- Models such as k3_10, DSDY_k3_10, DSPE_k3_11, DSPE_k3_01 and DSPE_k3_10 show that Malaysian stock market return favour the period of expansionary state the most. All these models give a substantial earning yield except for Model DSDY_k3_10. One of the reason might the investor had made a wrong assumption that the bad state will persist and decided to sell when it is in the bad state.

- The most appealing model which gives the highest earning yield is Model DSPE_k3_01, a total of 2487.61 earning points gained from 8 transactions.

Conclusion

- One thing very interesting in an economic point of view is that our regime switching model captures well the effect of the world financial crisis to Malaysian stock market. For instance, it switches to a high regime of variance during the period 1987-1988, 1994, 1998-2001 and 2008 following the advent of Black Monday, US bond market crash, Asian financial crisis and global financial crisis.
- Estimation of regime switching is crucial for investors, portfolio managers and policy makers, as they are able to predict financial crises and to estimate the duration in order to determine how they should progress to a better decision.
- Knowing the turning points early also helps investor to reallocate assets among alternative investments and select the appropriate stocks in their portfolio accordingly.