Mean Reversion in Share Price Dynamics: Evidence Through Transition Probabilities

Ravindran Ramasamy¹, Ganisen Sinnasamy², Mohd Hanif Mohd Helmi³

Abstract—Share price analysis and forecasting hitherto were carried out with traditional tools, like autocorrelation, run tests, regression methods, least squares and conventional charts. In this paper, we have attempted a Markov chain as the tool to estimate the transition probabilities their steady state and the mean reversion time. The market prices stay in a state for sometime before moving to another state. Markov chain captures these movements through transition probabilities. To estimate the transition probabilities, we selected 81 companies from consumer industry and classified them into three groups depending on current market prices. Among the groups, the third group whose market prices are more than three Ringgit show a higher steady state probability with a lesser mean reversion time indicating greater chances of price increase. The transition probabilities are higher in three situations viz., market price increase followed by price decrease, stable market prices followed by stable prices and decrease in prices followed by increase in market price. The shares whose prices are more than three RM show lower mean reversion time and high steady state probabilities for increase state than price decrease state and decrease state. These results support the notion that higher priced shares normally are popular, liquid and active therefore the probabilities of price increase are higher.

Keywords—Markov Chain; Transition Probabilities; Steady State; Share Prices; MATLAB; Reversion Time; Transition Matrix.

I. INTRODUCTION

Modern empirically intensive analytical methods have changed completely the share price analysis which was done hitherto through traditional techniques like autocorrelation, regression and charts. They include Markowitz model which estimates mean and variance, while Capital Asset Pricing Model compares the share prices to market index points to compute beta to measure its return and variability. Advanced models like GARCH (Batchelor, 2003) and EGARCH apply the drift and diffusion framework as postulated by the Brownian movements to derive ex-ante share prices. All the above models assume that future share prices depend on the past share prices, trend, drift and volatility, hence they use past prices as the basis for estimating forward prices. The efficient market hypothesis claims that the current market price of a share reflects all information (Ross et al., 1999) and share price movement is independent (Bessent and Bessent, 1980) and stochastic.

In other words, there is no connection between the historic prices and current prices or the future prices. In contrast the Markov chain process (Barkman, 1981) postulates that the forward share price depends only on the current price and the share price does not have memory and it is not dependent on the historic price (McQueen, 1991). This could be compared to weather forecasting, where rain forecast depend only on the current weather conditions and not at all connected with the historic weather conditions. The weather, share price and many other economic variables have no memory of past meaning that they do not depended on the historical data. Their future states depend only on the current state. In this paper, Markov chain process is used to observe the movements in the share price (Ryan, 1973) by linking what had happened to share price the previous day (Dryden, 1969). A Markov process is deemed to have a finite number of states (Dent, 1967; Orlando and Matchar, 2004) whereby the next price movement depends only on the current price movement. The Markov model is founded on this premise (Heneman, 1977) and it argues that the forward share prices depend only on the current price and the share price has no memory, therefore the historical prices are meaningless (Fielitz, 1973). To find forward prices it is essential to get current state of the price and its chances of moving to another state next day (Ezzati, 1986). The chances of price movement under Markov chain, is specified as transition probabilities.

II. TRANSITION PROBABILITIES

Transition probabilities are explained through three stages (Betancourt, 1999; Kennedy, et al., 1999). First they are identified in which state they stand at present and after one time step (the next day) where would they move. A state denotes the current state of a variable which is the share price for this research paper. Step is the time element that changes from day one to day two, along with it the share price also moves. The future share prices depend on the number of steps the time moves (Assoce, 1998). When time moves from $t_0$ to $t_1$, the share prices will also move in some direction. Either it may increase or remain at the same price level or it may decrease. The frequency of these changes when computed and converted into percentages, they give transition probability (Wise, 1999). The rate of change in share price from one state to another state is transition (Lahiri, 1994). These concepts are explained through transition matrix (Betancourt, 1999; Fielitz, 1975) and as well as matrix algebra as follows.
Historical share prices = \( (P_t) = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix} \)

a column vector.

Current share price may be 0 or a scalar and cannot be a negative figure.

\[
\begin{pmatrix}
I & S & D \\
T_p &=& \begin{pmatrix} P_{ii} & P_{is} & P_{id} \\
P_{si} & P_{ss} & P_{sd} \\
P_{di} & P_{ds} & P_{dd} \end{pmatrix} \\
\end{pmatrix}
\]

\( P_{ii} \) = Probability of increase in price followed by a price increase

\( P_{is} \) = Probability of Increase in price followed by stable price

\( P_{id} \) = Probability of increase in price followed by price decrease

\( P_{si} \) = Probability of stable in price followed by a price increase

\( P_{ss} \) = Probability of stable in price followed by stable price

\( P_{sd} \) = Probability of stable in price followed by price decrease

\( P_{di} \) = Probability of decrease in price followed by a price increase

\( P_{ds} \) = Probability of decrease in price followed by stable price

\( P_{dd} \) = Probability of decrease in price followed by price decrease

The above matrix is the first step transition matrix. To get the second step transition probability and up to n step probabilities the following procedure will be applied.

\[
T_p^2 = T_p \times T_p \text{ or } T_p^2
\]

\[
T_p^3 = T_p^2 \times T_p \text{ or } T_p^3
\]

\[
T_p^4 = T_p^3 \times T_p \text{ or } T_p^4
\]

\[
T_p^5 = T_p^4 \times T_p \text{ or } T_p^5
\]

\[
T_p^n = T_p \times T_p \times \cdots \times T_p \text{ or } T_p^n
\]

\( T_p^n \) will be the same even after multiplying by the current state Probability matrix will be the same even if the \( t \) is increased to any number. This convergence of probabilities is known as steady state and it is useful to deduce the long-term behaviour of the variable and the time spent by the variable in one state before moving to another state, which is the mean reversion time. The mean reversion time (Poterba, 1988) or the time spent in a state by the variable before moving to another state could be found by the following process. The reciprocal of the steady state probabilities will give the mean reversion time.

\[
MRT = 1/T^a
\]

\( MRT= \) Mean Reversion Time

\( T^a = \) Steady State Probability

IV. SIGNIFICANCE

The transition probabilities are useful in evaluating portfolio decisions in terms of cost. The steady state probabilities show the long term behaviour of share prices. The portfolio manager can estimate, plan and control the share price movements and also he can plan in advance the man power requirements based on the number of transactions to be carried out in future. The transaction costs of dealing in shares and the opportunity cost of holding liquid cash can be minimized through this information. Mean reversion time is useful information, which could be used in finding efficiency and effectiveness of transactions.

Our interest is

- To investigate whether the transition probabilities and the steady state probabilities of share prices behave in similar way if the shares are grouped as low, medium and higher prices.
- At what time step transition probabilities attain steady state?
- What is the average time spent in each state before moving to another state by these share prices?

This information will add more insight in selecting shares for portfolio construction, also in estimating mean reversion time and the number of transactions to be carried out in making buy, hold and sell decisions.

V. METHODOLOGY

In Markov process, it is assumed that the probability of the share price moving from one state to another state solely depends on the state that existed just before and certainly it does not vary with time. Share price is independent of time. It is like dice through. First throw result is in no way connected with the second throw result. The time element has no role in dice throw. Similarly the share price movements are independent and do not depend on time. Future share price either will increase, decrease or will not change from the previous level. The share price follows a trinomial lattice. The share prices will have nine states in a time step depending on the current state. In the current state the share price may increase and in the next time step it may
increase or remain stable or may decrease. The second possibility is that the current state may be a decrease, followed by another decrease and so on. The share prices have nine states in their movements as follows. Mathematically it could be in any one of the following nine states.

1) Preceding day price increase in share price followed by:
   a) next day price increase in \( (P_{ii}) \)
   b) next day price stable \( (P_{is}) \)
   c) next day price decrease in \( (P_{id}) \)

2) Preceding day stable share price followed by:
   a) next day price increase in \( (P_{si}) \)
   b) next day price stable \( (P_{ss}) \)
   c) next day price decrease in \( (P_{sd}) \)

3) Preceding day decrease in share price followed by:
   a) next day price increase in \( (P_{di}) \)
   b) next day price stable \( (P_{ds}) \)
   c) next day price decrease in \( (P_{dd}) \)

In general, the share price moves at random and therefore a probability term is attached to describe it. The table below shows the technique of calculation of the transition probabilities.

Table 1 Empirical example of transition probability

<table>
<thead>
<tr>
<th>Day</th>
<th>Initial State</th>
<th>Increase</th>
<th>No change</th>
<th>Decrease</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t_0 )</td>
<td>Increase</td>
<td>24 days</td>
<td>26 days</td>
<td>38 days</td>
<td>88 days</td>
</tr>
<tr>
<td>( t_0 )</td>
<td>No change</td>
<td>31 days</td>
<td>29 days</td>
<td>23 days</td>
<td>83 days</td>
</tr>
<tr>
<td>( t_0 )</td>
<td>Decrease</td>
<td>33 days</td>
<td>28 days</td>
<td>20 days</td>
<td>81 days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transition Probability</th>
<th>Increase</th>
<th>No change</th>
<th>Decrease</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( P_{ii} ) (24/88)</td>
<td>( P_{is} ) (26/88)</td>
<td>( P_{id} ) (38/88)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>( P_{si} ) (31/83)</td>
<td>( P_{ss} ) (29/83)</td>
<td>( P_{sd} ) (23/83)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>( P_{di} ) (33/81)</td>
<td>( P_{ds} ) (28/81)</td>
<td>( P_{dd} ) (20/81)</td>
<td>1</td>
</tr>
</tbody>
</table>

To investigate the research questions we have selected the consumer industry companies. To compute the transition probabilities, the steady state probabilities and the average time taken by the share price to move from one state to another state we have selected consumer industry. The companies in consumer industry are growing fast in terms of sales and assets. They also expand geographically and establish centers even in semi-urban areas. These companies are more transparent in disseminating more information to investors and shareholders in the form of disclosure. Moreover, the consumer companies are directly deal with the public and practice business to consumer B2C. The sample includes 81 consumer companies listed in the main board of Bursa Malaysia. Share prices of these 81 companies were downloaded from the Yahoo finance for the year 2009. First, we have calculated the transition probabilities individually through a self written MATLAB program, which is annexed at the end. The transition probabilities were classified in three different groups based on market share prices (Betancourt, 1999). The first group consists 34 companies whose market prices are less than RM 1 whereas the second group consists of 33 companies.
<table>
<thead>
<tr>
<th>FROM</th>
<th>TO</th>
<th>Increase</th>
<th>Stable</th>
<th>Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Price less than 1 RM</td>
<td></td>
<td>0.210</td>
<td>0.318</td>
<td>0.472</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.266</td>
<td>0.483</td>
<td>0.251</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.397</td>
<td>0.362</td>
<td>0.241</td>
</tr>
<tr>
<td>Market Price between 1 and 3 RM</td>
<td></td>
<td>0.273</td>
<td>0.297</td>
<td>0.430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.261</td>
<td>0.448</td>
<td>0.291</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.400</td>
<td>0.320</td>
<td>0.280</td>
</tr>
<tr>
<td>Market Price more than 3 RM</td>
<td></td>
<td>0.323</td>
<td>0.297</td>
<td>0.380</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.301</td>
<td>0.392</td>
<td>0.307</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.408</td>
<td>0.350</td>
<td>0.241</td>
</tr>
<tr>
<td>All Companies</td>
<td></td>
<td>0.255</td>
<td>0.306</td>
<td>0.439</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.270</td>
<td>0.453</td>
<td>0.277</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.400</td>
<td>0.343</td>
<td>0.257</td>
</tr>
</tbody>
</table>

Group two and group three companies also show similar pattern. All anti principal diagonal probabilities are higher. When transition probabilities are combined for all companies they also show similar pattern. The non leading diagonal $p_{ad}$, $p_{ad}$, and $p_{ad}$ shows the maximum probabilities. It implies that when the previous state is increase there is a greater chance of price decrease. Similarly when the previous state is decrease there is a greater chance of price increase.

The stable state has more chances of stability in prices. These probabilities imply that the consumer companies’ share prices do not change most of the days and they are moderately stable. They do not follow any conceivable trend, increase would not follow a consistent increase and similarly, a decrease will not follow a decrease, instead, most of the days they move in opposite directions.
Table 3 Two Step Transition Probabilities of Share Prices

<table>
<thead>
<tr>
<th>From</th>
<th>GROUP 1</th>
<th>GROUP 2</th>
<th>GROUP 3</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.316</td>
<td>0.324</td>
<td>0.349</td>
<td>0.323</td>
</tr>
<tr>
<td>S</td>
<td>0.284</td>
<td>0.304</td>
<td>0.341</td>
<td>0.302</td>
</tr>
<tr>
<td>D</td>
<td>0.275</td>
<td>0.305</td>
<td>0.336</td>
<td>0.298</td>
</tr>
</tbody>
</table>

The above table exhibits the transition probabilities in two time steps. A closer observation reveals that the first column and the third column in each group including all companies group, gain probability and the stable column shows a reduction in probability. It implies that as time goes the stability in share price decreases and the prices become more volatile.

Table 4 Three Step Transition Probabilities of Share Prices

<table>
<thead>
<tr>
<th>From</th>
<th>GROUP 1</th>
<th>GROUP 2</th>
<th>GROUP 3</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.287</td>
<td>0.324</td>
<td>0.341</td>
<td>0.305</td>
</tr>
<tr>
<td>S</td>
<td>0.290</td>
<td>0.304</td>
<td>0.342</td>
<td>0.307</td>
</tr>
<tr>
<td>D</td>
<td>0.295</td>
<td>0.305</td>
<td>0.343</td>
<td>0.309</td>
</tr>
</tbody>
</table>

Three time step probabilities of all three groups and all companies are given in the above table. The first columns of group one and group two companies show a reduction probabilities and the third column show an application in probabilities The middle column probabilities are more or less stable. Group three and all companies increase column show probability increase and the decrease column probabilities show a reduction. This is quite contrast to the first two groups. As time increases these probabilities begin to converge to a stable level.

Table 5 Four Step Transition Probabilities of Share Prices

<table>
<thead>
<tr>
<th>From</th>
<th>GROUP 1</th>
<th>GROUP 2</th>
<th>GROUP 3</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.292</td>
<td>0.311</td>
<td>0.342</td>
<td>0.308</td>
</tr>
<tr>
<td>S</td>
<td>0.290</td>
<td>0.310</td>
<td>0.342</td>
<td>0.307</td>
</tr>
<tr>
<td>D</td>
<td>0.290</td>
<td>0.310</td>
<td>0.342</td>
<td>0.307</td>
</tr>
</tbody>
</table>

The fourth time step transition probabilities are more or less stable in all columns. Group one, two and all company’s increase column shows lesser probability while the third group’s increase column shows higher probability. The first group and all companies stable column (second) show higher probabilities (39.7% and 37.2%). Group two and group three middle columns (stable) show probabilities of 36% and 35% approximately, respectively.
Table 6 Five Step Transition Probabilities of Share Prices

<table>
<thead>
<tr>
<th>From</th>
<th>GROUP 1</th>
<th></th>
<th>GROUP 2</th>
<th></th>
<th>GROUP 3</th>
<th></th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.290</td>
<td>S</td>
<td>0.397</td>
<td>D</td>
<td>0.312</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.291</td>
<td>S</td>
<td>0.397</td>
<td>D</td>
<td>0.312</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.291</td>
<td>S</td>
<td>0.397</td>
<td>D</td>
<td>0.312</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The five step time transition probabilities are almost converged and almost all columns show in each group equal probabilities. A clear long term pattern is emerging though it is not perfectly converged yet.

Table 7 Six Step Transition Probabilities of Share Prices

<table>
<thead>
<tr>
<th>From</th>
<th>GROUP 1</th>
<th></th>
<th>GROUP 2</th>
<th></th>
<th>GROUP 3</th>
<th></th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.291</td>
<td>S</td>
<td>0.397</td>
<td>D</td>
<td>0.312</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.291</td>
<td>S</td>
<td>0.397</td>
<td>D</td>
<td>0.312</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0.291</td>
<td>S</td>
<td>0.397</td>
<td>D</td>
<td>0.312</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

At the sixth time step within each group the column probabilities are absolutely equal. In the later time steps these probabilities do not change. They reveal the long term behaviour of share price. If current share prices are given, then one can easily calculate the expected share price in the future. In low price companies in higher time steps the chances of price increase is not bright, the chances of stability is normal and the chances of share price fall is more. This may be due to the non popularity and illiquidity of these low priced shares. The second group i.e. companies whose share price is between RM1 and RM3, the chances of price increase is slim than the price decrease. As exhibited by group one this group’s price stability is also fair. This could be attributed to the same causes of non popularity and illiquidity of these medium priced shares. The group three companies results show a diametrically opposite pattern. The chances of price increase are more than the chances of price fall. The stable probabilities are lesser when compared to other the two groups. This could be due to the excitement, popularity and the liquidity provided by these companies’ shares. The above results are on the expected lines. The low priced shares are normally illiquid and normally not active and therefore, the chances of the price increase will be slim. The medium price shares are also not so attractive to the investors for the same reasons stated above. The companies whose prices are higher will be popular among the investors. Normally these shares are highly liquid, active, and popular. Therefore, the chances of price increase are greater than the price decrease.

Figure 1 Steady state probabilities
The steady state stable probabilities are larger in the first two groups which show lesser volatility. The third group’s increase and stable probabilities are almost equal. The decrease probabilities are more than the increase probabilities in the first two groups. The all companies group reveals more stable prices for consumer industry. The reciprocal of the steady state probabilities is the mean time the share prices stay in one state before moving to another state on an average. Table 8 shows the average days the share prices stay in each state. The first group of shares whose share market prices are less than one RM stays for 3.44 mean days before moving to another state if it starts with an increase. If it starts with stability or decrease, then it stays for 2.52 mean days and 3.20 mean days before moving to another state respectively.

Table 8 Mean Reversion Time (Days)

<table>
<thead>
<tr>
<th>FROM</th>
<th>GROUP 1</th>
<th>GROUP 2</th>
<th>GROUP 3</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>S</td>
<td>D</td>
<td>I</td>
</tr>
<tr>
<td>I</td>
<td>3.44</td>
<td>2.52</td>
<td>3.20</td>
<td>3.22</td>
</tr>
<tr>
<td>S</td>
<td>3.44</td>
<td>2.52</td>
<td>3.20</td>
<td>3.22</td>
</tr>
<tr>
<td>D</td>
<td>3.44</td>
<td>2.52</td>
<td>3.20</td>
<td>3.22</td>
</tr>
</tbody>
</table>

Similarly other columns could be interpreted. In the low priced share groups the first column shows more mean days than the third column. But in contrast the third group shows higher mean days of 3.21 in decrease first column’s state and the mean days are 2.92. It implies that the third group companies share prices often increase than decrease, but in other two groups the price decreases is more often registered than price increase. The all companies group shows more mean days for price increase 3.26, than price decrease, 3.12 mean days. Yet another information the mean days convey is the rate of turnover. Share market operated for 254 days in 2009. One can expect on 87 (254/2.92) occasions in 2009 price increase in shares while the chances of price decrease are 79 times only (254/3.21) in the same year. Similarly the group 2 companies whose share prices are between one RM and three RM stays for 3.22 mean days, 2.79 mean days and 3.03 mean days respectively in each state before moving to other state. The shares whose prices are more than three RM stays for 2.92 mean days, 2.89 mean days and 31.21 mean days in each stage. The lower share prices are staying longer in increase stage and in stable stage than the third group share prices.

Figure 2 Steady state stable time

The above graph exhibits the mean time a share stays in a particular state. The stable state takes less time in all groups which implies that the shares do not stay stable for long. They frequently move from one state to another. Similarly the time taken to move from increase is larger in almost all groups except the third group. This shows that these share prices quickly move to another state. The time taken in the decrease state is high which implies that more often these prices do not change from decrease mode.

VI. CONCLUSION

Markov chain is another powerful tool to analyze and understand the share price behaviour. Transition probabilities and the current state determine the future
prices. The steady state probabilities not only give the long term behaviour of the share prices but also they are useful in estimating the mean reversion time. We applied Markov chain methodology and estimated the transition probabilities on three groups of consumer companies’ share prices. The transition probabilities are lower for increase followed by increase state, and decrease followed by decrease state. The results further show robust probabilities for increase followed by decrease state, stable followed by stable state and decrease followed by increase state. These transition probabilities converge in six time steps and attain steady state. In steady state the group 3 (Share prices more than RM3) shows higher stable probabilities for increase rather than decrease. Moreover, the average reversion time is also lesser for this group implying that more chances of price increase rather than price decrease. The higher price shares are more active, highly liquid and enjoy reputation among investors and this is the reason for their higher transition probabilities.

VII. REFERENCES

5) Bessent, E.W. and Bessent, A.M. (1980), Student Flow in a University Department: Results of a Markov Analysis. Interfaces, 10(2), 52-59.

Appendix: MATLAB code for computing transition probabilities

Close all
clear all
cle
load co81
s=[ ];
for q=1:81
a=data(:,q);
b=diff(a);
x1=0;x2=0;x3=0;x4=0;x5=0;x6=0;x7=0;x8=0;x9=0;
for i=1:252
p=b(i);
p1=b(i+1);

if (p>0)&(p1>0)  % Increase followed by an increase
  x1=x1+1;  % Number of days
elseif (p>0)&(p1==0)  % Increase followed by no change
  x2=x2+1;
elseif (p>0)&(p1<0)  % Increase followed by decrease
  x3=x3+1;
elseif (p==0)&(p1>0)  % No change followed by an increase
  x4=x4+1;
elseif (p==0)&(p1<0)  % No change followed by decrease
  x5=x5+1;
elseif (p==0)&(p1==0)  % No change followed by no change
  x6=x6+1;
elseif (p<0)&(p1>0)  % Decrease followed by an increase
  x7=x7+1;
elseif (p<0)&(p1==0)  % Decrease followed by no change
  x8=x8+1;
else  % Decrease followed by decrease
  x9=x9+1;
end

y1=x1+x2+x3;  % Row total
y2=x4+x5+x6;
y3=x7+x8+x9;

% Transition Matrix (days/total days)
T0=[x1/y1 x2/y1 x3/y1 % Increase followed by I,S,D
  x4/y2 x5/y2 x6/y2 % Stable followed by I,S,D
  x7/y3 x8/y3 x9/y3]; % Decrease followed by I,S,D
s=[s;T0];  % Store all data in matrix S
end

trm1=[];trm2=[];trm3=[];  % Dummy Matrix
for w=1:3:243  % Take 3 rows at a time
  trm1=[trm1;(s(w,:))];  % All increase followed by I,S,D
  trm2=[trm2;(s(w+1,:))]; % All stable followed by I,S,D
  trm3=[trm3;(s(w+2,:))]; % All decrease followed by I,S,D
end

r1=sum(trm1)./81;  % All companies row probability
r2=sum(trm2)./81;
r3=sum(trm3)./81;
allcotrm=[r1;r2;r3];  % All companies transition Probability

TR2=allcotrm^2;  % Step 2 transition probabilities
TR3=allcotrm^3;
TR4=allcotrm^4;
TR5=allcotrm^5;
TR6=allcotrm^6;

alltime=1./TR6;  % Average time between switching states
f34r1=trm1(1:34,:);  % First 34 companies price less than 1 RM
m33r1=trm1(35:67,:); % Next 33 companies price between 1 & 3 RM
l14r1=trm1(68:end,:);  % Final 14 companies price more than 3 RM
\[
\begin{align*}
\text{f34r2} &= \text{trm2}(1:34,:) ; \\
\text{m33r2} &= \text{trm2}(35:67,:) ; \\
\text{l14r2} &= \text{trm2}(68:end,:) ; \\
\text{f34r3} &= \text{trm3}(1:34,:) ; \\
\text{m33r3} &= \text{trm3}(35:67,:) ; \\
\text{l14r3} &= \text{trm3}(68:end,:) ;
\end{align*}
\]

\[
\begin{align*}
\text{af34r1} &= \text{sum(f34r1)}/34 ; & \% \text{Average group row probability} \\
\text{am33r1} &= \text{sum(m33r1)}/33 ; & \% \text{Average group row probability} \\
\text{al14r1} &= \text{sum(l14r1)}/14 ; & \% \text{Average group row probability} \\
\text{af34r2} &= \text{sum(f34r2)}/34 ; \\
\text{am33r2} &= \text{sum(m33r2)}/33 ; \\
\text{al14r2} &= \text{sum(l14r2)}/14 ; \\
\text{af34r3} &= \text{sum(f34r3)}/34 ; \\
\text{am33r3} &= \text{sum(m33r3)}/33 ; \\
\text{al14r3} &= \text{sum(l14r3)}/14 ;
\end{align*}
\]

\[
\begin{align*}
\text{g1} &= [\text{af34r1}; \text{af34r2}; \text{af34r3}] ; & \% \text{Transition probabilities of group 1} \\
\text{g2} &= [\text{am33r1}; \text{am33r2}; \text{am33r3}] ; & \% \text{Transition probabilities of group 2} \\
\text{g3} &= [\text{al14r1}; \text{al14r2}; \text{al14r3}] ; & \% \text{Transition probabilities of group 3}
\end{align*}
\]

\[
\begin{align*}
\text{G1TR2} &= \text{g1}^2 ; & \% \text{Step 2 transition probabilities} \\
\text{G1TR3} &= \text{g1}^3 ; & \% \text{Step 3 transition probabilities} \\
\text{G1TR4} &= \text{g1}^4 ; & \% \text{Step 4 transition probabilities} \\
\text{G1TR5} &= \text{g1}^5 ; & \% \text{Step 5 transition probabilities} \\
\text{G1TR6} &= \text{g1}^6 ; & \% \text{Step 6 transition probabilities}
\end{align*}
\]

\[
\begin{align*}
\text{g1time} &= 1/\text{G1TR6} ; & \% \text{Average time between switching states}
\end{align*}
\]

\[
\begin{align*}
\text{G2TR2} &= \text{g2}^2 ; & \% \text{Step 2 transition probabilities} \\
\text{G2TR3} &= \text{g2}^3 ; & \% \text{Step 3 transition probabilities} \\
\text{G2TR4} &= \text{g2}^4 ; & \% \text{Step 4 transition probabilities} \\
\text{G2TR5} &= \text{g2}^5 ; & \% \text{Step 5 transition probabilities} \\
\text{G2TR6} &= \text{g2}^6 ; & \% \text{Step 6 transition probabilities}
\end{align*}
\]

\[
\begin{align*}
\text{g2time} &= 1/\text{G2TR6} ; & \% \text{Average time between switching states}
\end{align*}
\]

\[
\begin{align*}
\text{G3TR2} &= \text{g3}^2 ; & \% \text{Step 2 transition probabilities} \\
\text{G3TR3} &= \text{g3}^3 ; & \% \text{Step 3 transition probabilities} \\
\text{G3TR4} &= \text{g3}^4 ; & \% \text{Step 4 transition probabilities} \\
\text{G3TR5} &= \text{g3}^5 ; & \% \text{Step 5 transition probabilities} \\
\text{G3TR6} &= \text{g3}^6 ; & \% \text{Step 6 transition probabilities}
\end{align*}
\]

\[
\begin{align*}
\text{g3time} &= 1/\text{G3TR6} ; & \% \text{Average time between switching states}
\end{align*}
\]