Chapter 3

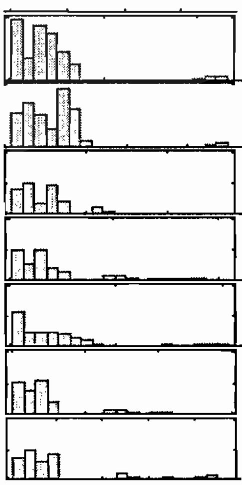
Preliminary Data Analysis

In this chapter we present a preliminary analysis of the time series of the closing prices of banking shares in Thailand during the period from 1992-1999. This analysis is based initially on graphical methods, and suggests that the time series of share price returns has changing volatility. In Chapter 4 we use a model that allows for this changing volatility.

3.1 Distributions and Trends of Share Prices

The data studied comprise time series of the closing prices of seven banking shares in Thailand on successive trading days running from 2 Mar 1992 – 30 December 1999, a total of 1919 observations. These seven banks were chosen because of their size and importance, and also because the data for them were most readily available.

We first looked at numerical summaries and distributions of each share price and their trends over time. Table 3.1 shows the numerical summaries of each daily share closing price.



col	variable	size	mean	st dev	skew	kurt	min	max
1	BAY	1919	79.725	78.955	3.102	11.559	4	464
2	BBL	1919	156.886	115.005	2.956	11.935	20	732
3	BOA	1919	45.663	33.585	2.31	8.742	6.7	278
4	IFCT	1919	85.46	91.195	1.829	2.535	4.9	420
5	KTB	1919	85.318	90.472	2.051	3.911	4.4	412
6	SCB	1919	237.805	278.566	2.289	5.032	8.6	1486
7	TFB	1919	195.129	208.182	2.088	3.469	16	952

Closing prices of bank shares in Thailand: 2 Mar 1992 - 30 Dec 1999

Table 3.1: Summaries of daily closing prices of banking shares in Thailand, 1992-1999

The result shows that these closing prices have distributions that are heavily right-skewed, particularly for BAY and BBL shares. The coefficients of kurtosis are also high, compared with the normal distribution (which has zero kurtosis coefficient). And all of these distributions have extremely wide ranges.

We also plot these data as time series, as shown in Figure 3.1.

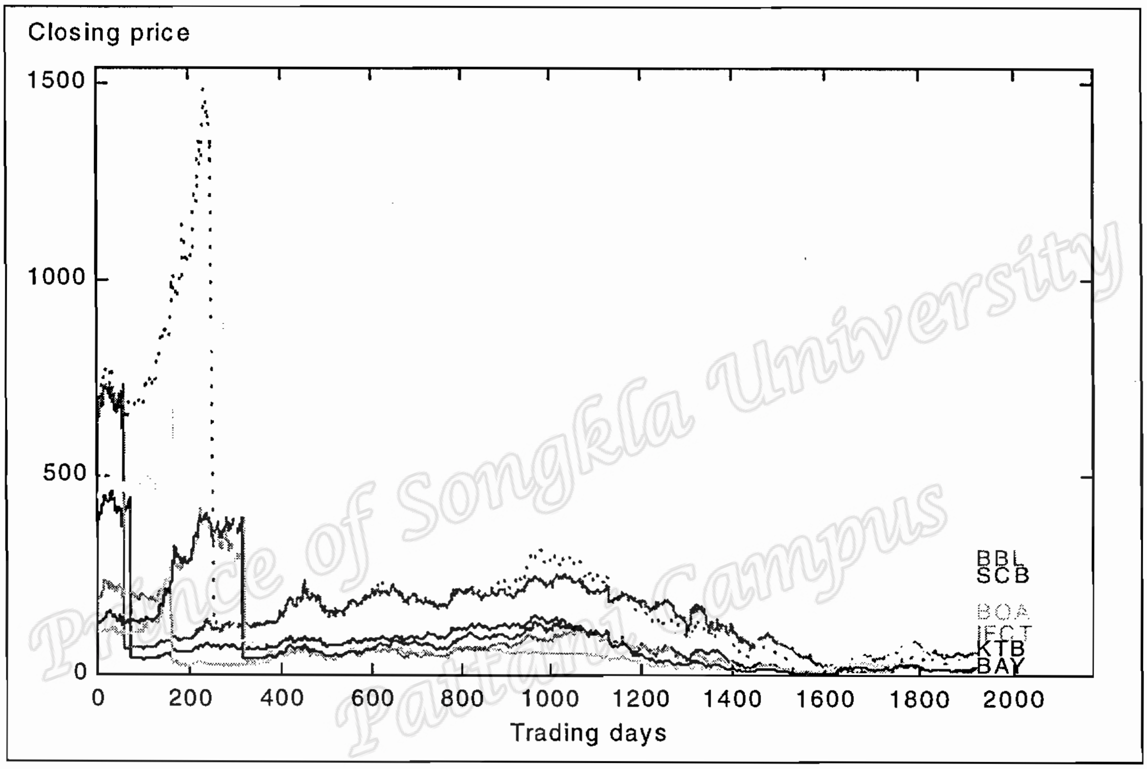
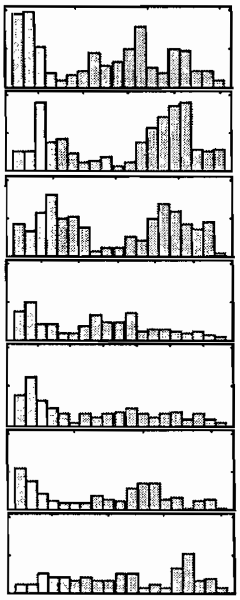


Figure 3.1: Time series plots of daily closing prices of banking shares, 1992-1999

It is clear from Figure 3.1 that all of the share prices experienced huge collapses of varying degrees at various times during 1992, but subsequently remained relatively stable. For purposes of statistical modeling, we should thus omit the data for 1992. In fact we will also omit the data for 1993, to ensure than any follow-on effects arising from the crashes in 1992 are eliminated.

Table 3.2 shows the distributions and numerical summaries of the data for the years 1994-1999, inclusive. The skewness coefficients are now substantially reduced, and in some cases are negative. However, the kurtosis coefficients for these data are now all negative. This is not surprising, given that the distributions show bimodality. The data still cover relatively wide ranges.



colvariable		size	mean	st dev	skew	kurt	min	max
1	BAY	1468	66.53	44.295	0.049	-1.372	4	153
2	BBL	1468	146.759	70.19	-0.35	-1.4	20	256
3	BOA	1468	38.75	20.135	0.053	-1.525	6.7	75
4	IFCT	1468	48.261	30.2	0.305	-0.973	4.9	117
5	KTB	1468	53.221	38.08	0.394	-1.217	4.4	134
6	SCB	1468	139.439	91.365	0.029	-1.301	8.6	322
7	TFB	1468	114.358	53.509	-0.119	-1.311	16	206

Closing prices of bank shares in Thailand: 4 Jan 1994 - 30 Dec 1999

Table 3.2: Summaries of daily closing prices of banking shares in Thailand, 1994-1999

The time series for this reduced set of data is plotted in Figure 3.2.

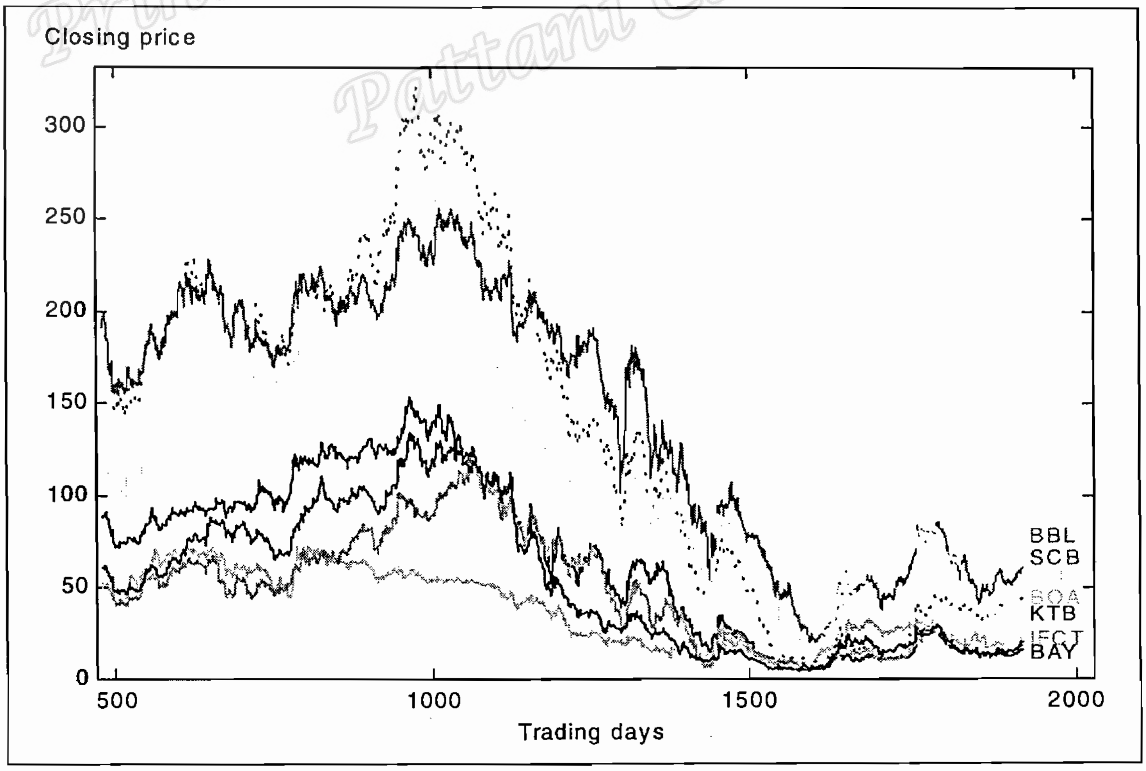
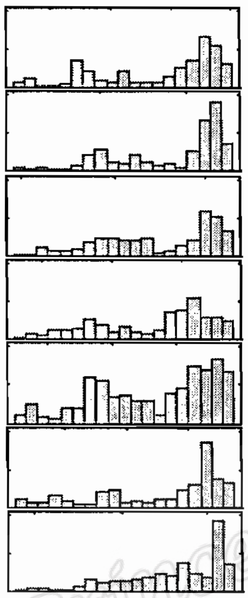


Figure 3.2: Time series plots of daily closing prices of banking shares, 1994-1999

It is clear from Figure 3.2 that the variability in the share prices is greater when the prices are higher. This suggests that the data need to be transformed. Table 3.3 shows the frequency distributions and numerical summaries of the share prices after taking natural logarithms, while Figure 3.3 shows the time series plots of these transformed data.



col	variable	size	mean	st dev	skew	kurt	min	max
1	BAY	1468	3.824	1.004	-0.734	-0.805	1.386	5.03
2	BBL	1468	4.82	0.646	-0.883	-0.444	2.996	5.545
3	BOA	1468	3.486	0.625	-0.493	-0.973	1.902	4.317
4	IFCT	1468	3.606	0.813	-0.592	-0.87	1.589	4.762
5	KTB	1468	3.623	0.924	-0.445	-0.988	1.482	4.898
6	SCB	1468	4.564	1.017	-0.83	-0.617	2.152	5.775
7	TFB	1468	4.59	0.601	-0.897	-0.018	2.773	5.328

log of closing prices of bank shares in Thailand: 4 Jan 1994 - 30 Dec 1999

Table 3.3: Distributions of ln(closing price) of Thai banking shares, 1994-1999

It is now clear from Figure 3.3 that the variability in the share prices is greater when the prices are lower. This suggests that the log transformation for these data is too strong, and that perhaps square roots would be more effective in stabilising the variability. Table 3.4 shows the frequency distributions and numerical summaries of the share prices after taking square roots, while Figure 3.4 shows the time series plots again.

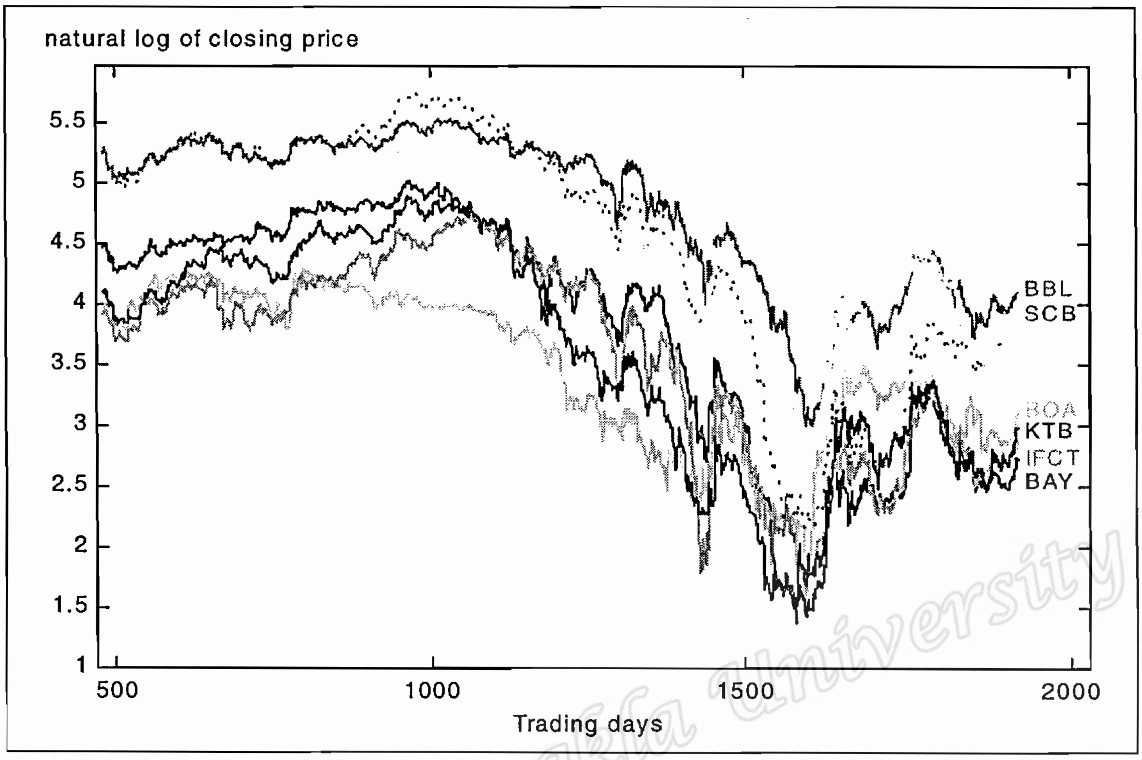
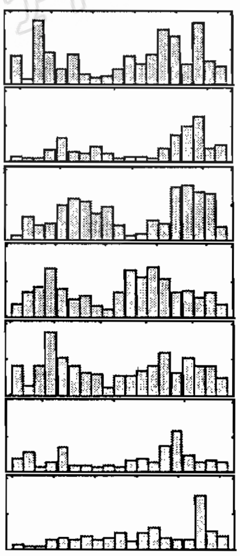


Figure 3.3: Logarithms of daily closing prices for banking shares, 1994-1999



col	variable	size	mean	st dev	skew	kurt	min	max
1	BAY	1468	7.548	3.092	-0.308	-1.364	2	12.369
2	BBL	1468	11.671	3.249	-0.576	-1.149	4.472	16
3	BOA	1468	5.984	1.717	-0.18	-1.409	2.588	8.66
4	IFCT	1468	6.543	2.334	-0.136	-1.194	2.214	10.817
5	KTB	1468	6.75	2.769	0.03	-1.389	2.098	11.576
6	SCB	1468	10.941	4.444	-0.363	-1.277	2.933	17.944
7	TFB	1468	10.341	2.727	-0.447	-0.963	4	14.353

square roots of closing prices of bank shares in Thailand: 4 Jan 1994 - 30 Dec 1999

Table 3.4: Distributions of square roots of banking share prices, 1994-1999

From Table 3.4 we see that the distributions are still negatively skewed, but the skewness coefficients are much lower than after taking logarithms. From Figure 3.4 we see that the variability is approximately constant, and, in contrast to the time series graphed in Figures 3.2 and 3.3, does not depend on the level.

To summarise, during the period from January 1994 to December 1999, the closing prices of banking shares in Thailand have approximately constant daily variability when expressed as logarithm. Looking at the trend over this period, we see that during the first two years (from January 1994 to December 1995) the prices tended to increase on the whole, except for Bank of Asia, whose shares declined in 1995. From January 1996 until March 1998, this trend reversed, with the share prices decreasing rapidly and steadily until reaching minimal values. During the final 21 months from April 1998 until December 1999, the shares recovered, but were still substantially below the levels in January 1994.

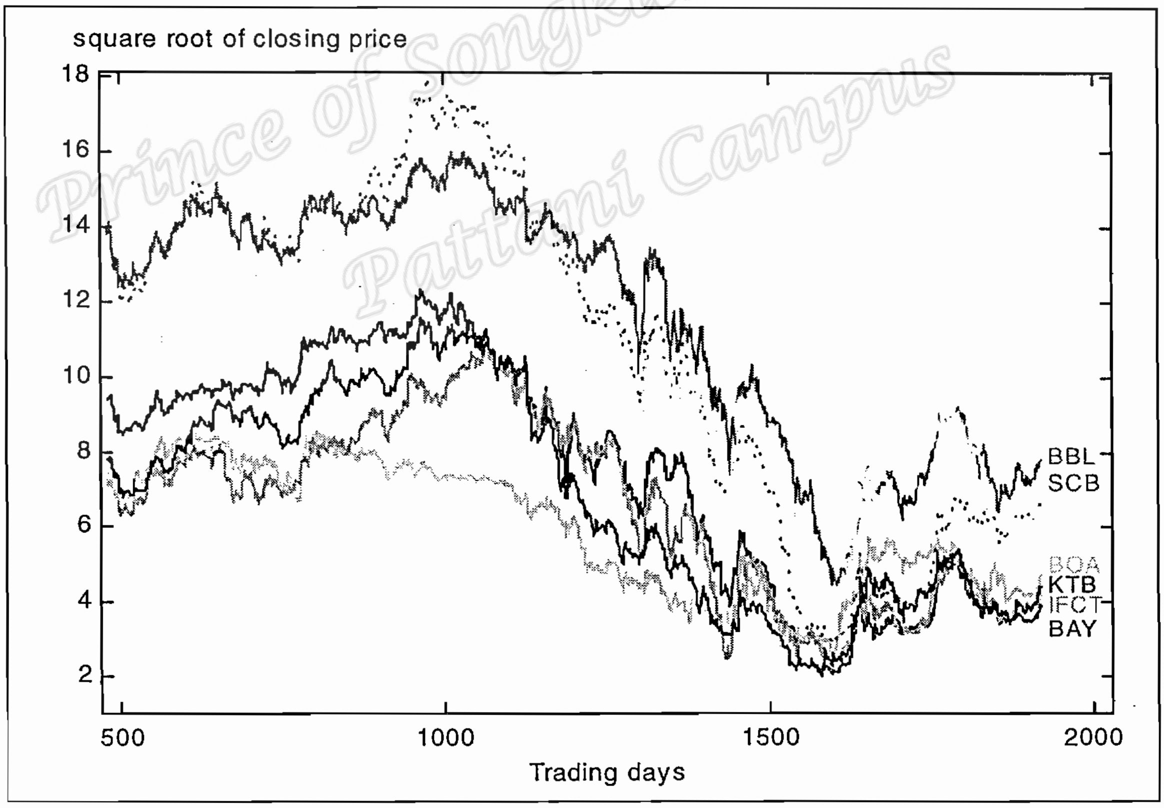


Figure 3.4: Square root of daily closing prices for banking shares, 1994-1999

3.2 Distributions and Trends of Share Price Returns

While the share price is an important economic indicator, investors are more interested in share price returns. The return on a market variable is defined as its relative movement from one trading day to the next. Positive movements in returns indicate a growing economy (known as a *bull market*), while negative returns indicate a contracting economy (or *bear market*).

If S_t is the price of a share on trading day *t*, the return on the share price is thus

$$u_t = \frac{S_t - S_{t-1}}{S_t}$$

(see Chapter 2). Table 3.5 shows numerical summaries of the daily compounded returns for the seven banking shares, expressed as percentages. We can see that the mean returns are all slightly negative, and the standard deviations vary between 3.32%, for BBL and 4.93% for IFCT. The skewness coefficients are positive, indicating right-skewness. The kurtoses coefficients for these data are all relatively large and positive.

Numerical Summaries: Banking shares: Compounded returns (%)							
Variable	Size	Mean	StDev	Skew	Kurt	Min	Max
BAY	1468	-0.129	4.056	0.226	6.769	-29.000	26.000
BBL	1468	-0.090	3.318	0.521	4.469	-14.000	17.000
BOA	1468	-0.092	4.280	0.492	5.663	-25.000	26.000
IFCT	1468	-0.095	4.924	0.510	4.807	-21.000	26.000
KTB	1468	-0.103	4.278	0.991	6.504	-21.000	26.000
SCB	1468	-0.101	3.827	0.423	7.783	-28.000	26.000
TFB	1468	-0.091	3.462	0.254	8.860	-29.000	23.000
Closing price of bank shares in Thailand: 4 Jan 1994-30 Dec 1999							

Table 3.5: Compounded returns (%) of closing price of banking shares in Thailand

Figure 3.5 shows histograms of these returns for the seven financial institutions. Despite the skewness coefficients being positive, these histograms look symmetric, and it is difficult to distinguish them from normal distributions purely by looking at the histograms. The returns range mostly from −10% to 10%.

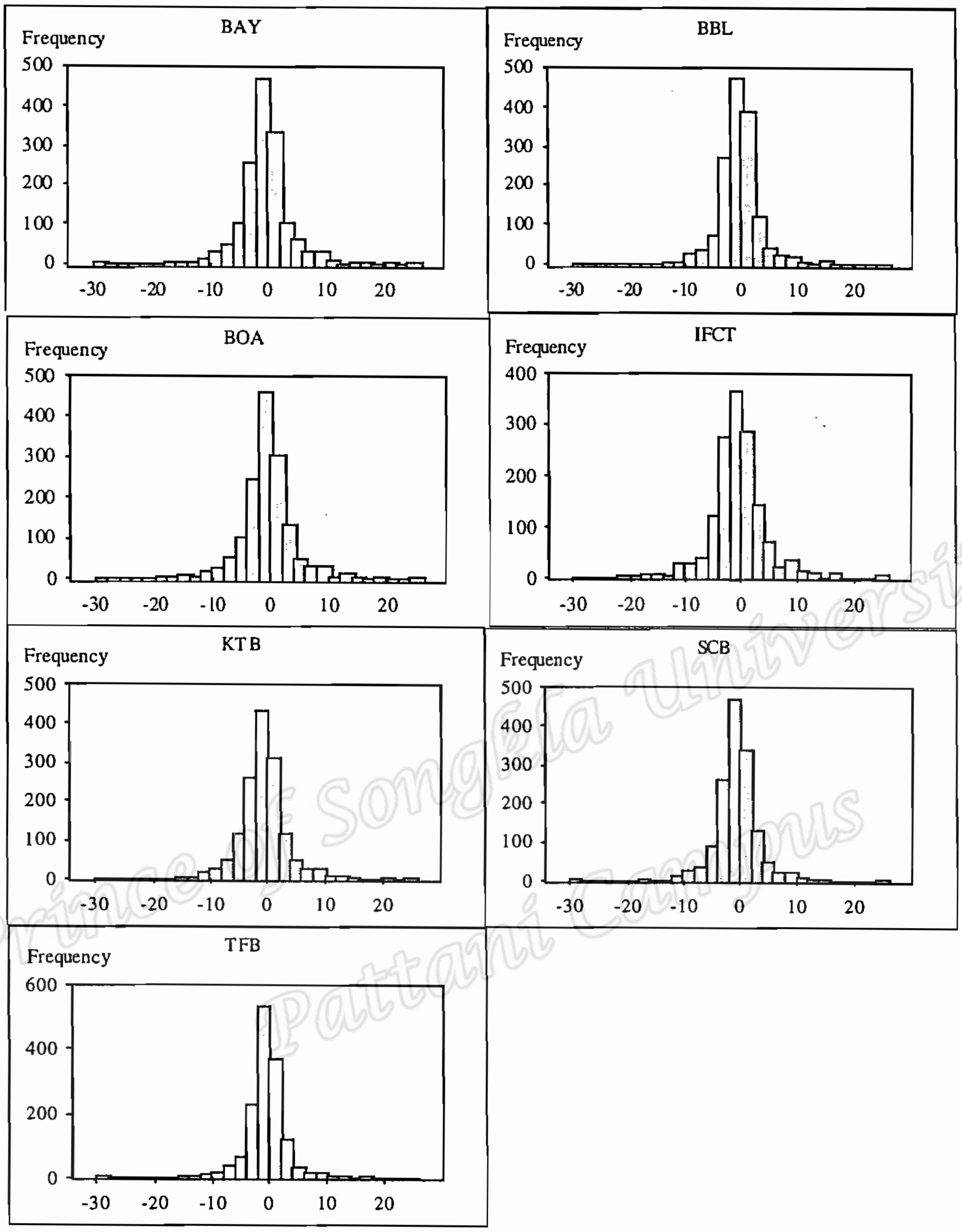


Figure 3.5 Histograms of compounded returns of banking shares

Table 3.6 shows the distributions of the returns for each institution, grouping the data into the following ranges: below –10%, –10% to –2.5%, –2.5% to 2.5%, 2.5% to 10%, and above 10%. Now we know that for a normal distribution with mean 0, approximately 68% of the data have magnitude less than one standard deviation, and in practice no observations exceed four standard deviations in magnitude. However, we see from Table 3.6 that about 68% of the returns (on average) have magnitude below 2.5%, but more than 2% exceed 10% in magnitude. This shows that the distributions of the returns have heavier than normal tails.

Range	Financial Institution						
	BAY	BBL	BOA	IFCT	KTB	SCB	TFB
< −10	0.010	0.005	0.013	0.020	0.009	0.007	0.008
−10 to −2.5	0.162	0.144	0.184	0.210	0.198	0.167	0.133
−2.5 to 2.5	0.671	0.712	0.624	0.562	0.622	0.663	0.720
2.5 to10	0.138	0.125	0.159	0.178	0.147	0.143	0.126
>10	0.020	0.014	0.020	0.029	0.025	0.020	0.013

Table 3.6: Distributions of compounded returns

Figures 3.6a and 3.6b show the normal scores plots of the returns for the seven financial institutions. The curvature in these plots shows clearly the non-normality.

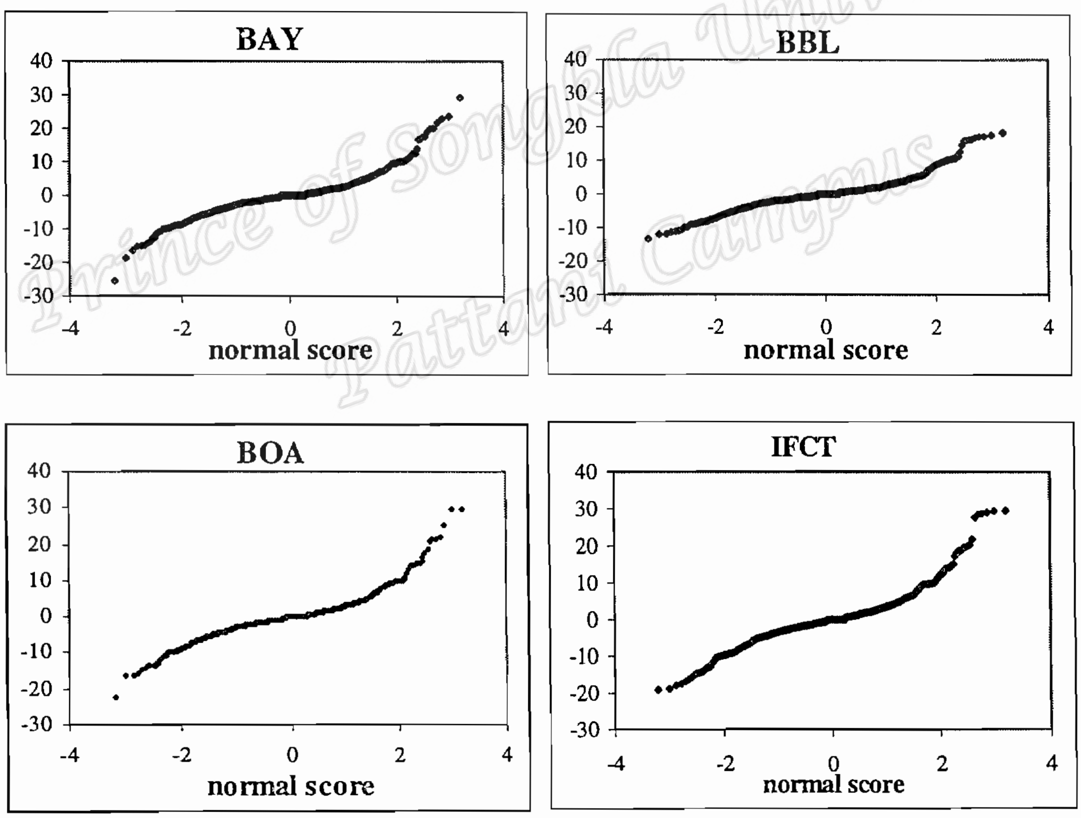


Figure 3.6a: Normal scores plots of the returns of BAY, BBL. BOA and IFCT

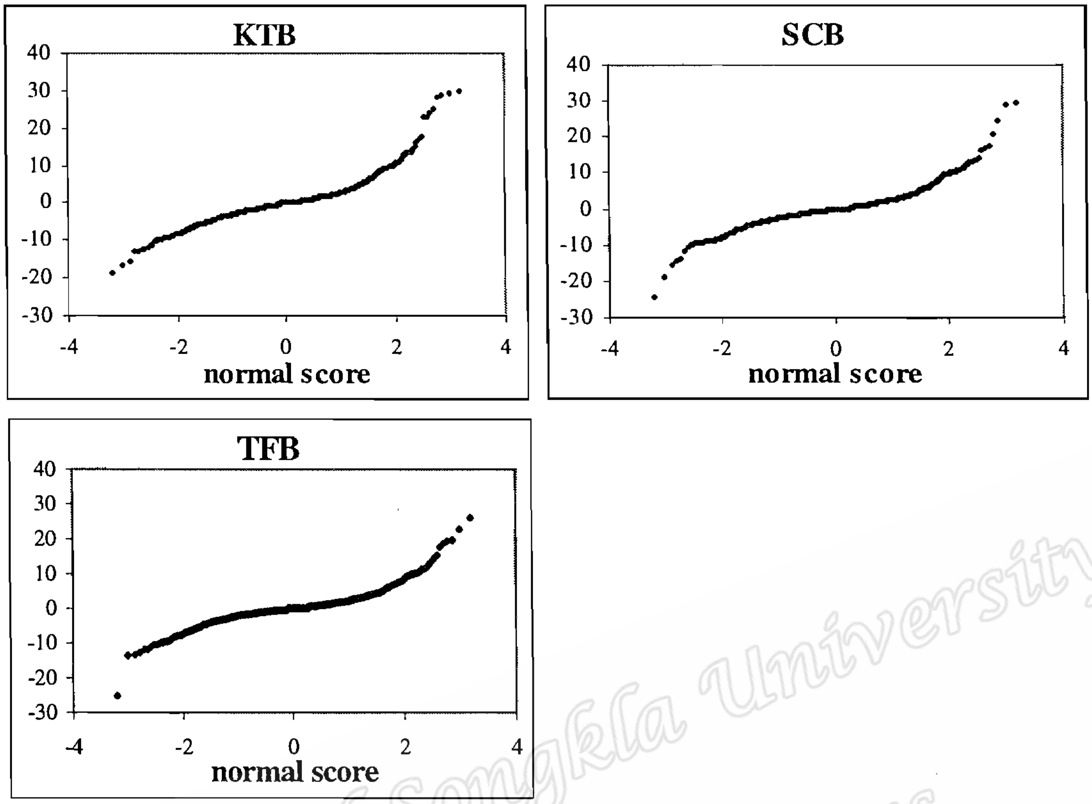


Figure 3.6b: Normal scores plots of KTB, SCB and TFB

Next, we examine in detail the annual trend and variability in the share price returns for each financial institution.

Table 3.7 gives the annual comparison of daily compounded returns for BAY shares. The means are positive in 1995 and 1999 and negative in 1996 to 1998, but these changes are small compared to the standard errors. The standard deviation increases substantially after 1996, and is 6.54 in 1998. This is more than three times larger than the average for 1994-1996. The means and 95% confidence intervals are shown in Figure 3.7.

	Banking shares: Compounded returns (%)			
year	***Size***	***Mean***	***SE***	***StDev***
94	244	-0.012	0.119	1.861
95	246	0.106	0.116	1.822
96	244	-0.311	0.169	2.636
97	247	-0.429	0.308	4.837
98	244	-0.242	0.419	6.542
99	243	0.119	0.279	4.344
BAY				

Table 3.7: Annual comparison of compounded returns of BAY shares

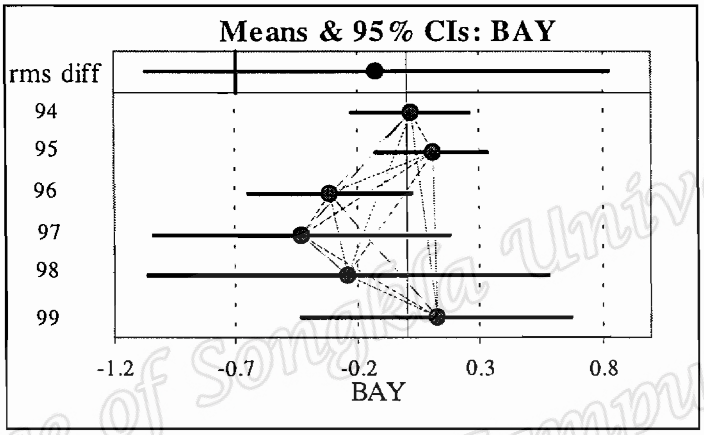


Figure 3.7: Annual means and 95% confidence intervals of BAY daily returns

Table 3.8 gives the annual comparison of daily compounded returns for BBL shares. The means are positive in 1995 and 1999 and negative in 1996 to 1998, but these changes are small compared to the standard errors. The standard deviation increases substantially after 1996, and is 5.47 in 1998. This is three times larger than the average for 1994-1996. The means and 95% confidence intervals are shown in Figure 3.8.

Comparison:	**Banking shares: Compounded returns (%)**			
year	***Size***	***Mean***	***SE***	***StDev***
94	244	-0.075	0.137	2.136
95	246	0.024	0.098	1.530
96	244	-0.066	0.109	1.703
97	247	-0.336	0.244	3.841
98	244	-0.180	0.350	5.473
99	243	0.095	0.219	3.418
BBL				

Table 3.8: Annual comparison of compounded returns of BBL shares

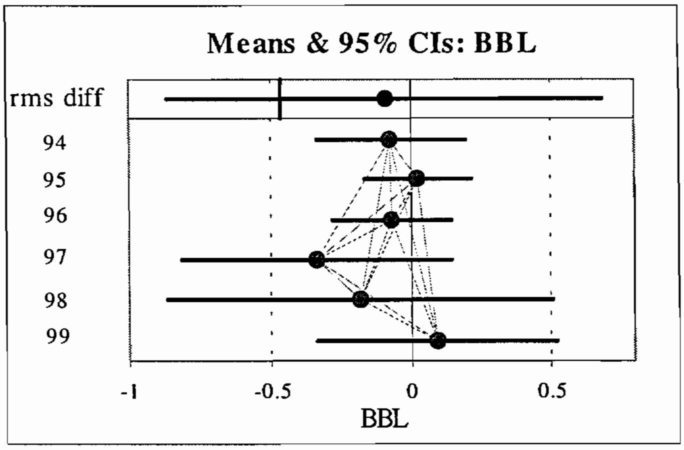


Figure 3.8: Annual means and 95% confidence intervals of BBL daily returns

Table 3.9 gives the annual comparison of daily compounded returns for BOA shares. The means are positive in 1998 and negative in 1996 to 1997 and 1999, but these changes are small compared to the standard errors. The standard deviation increases substantially after 1996, and is 7.15 in 1998. This is more than three times larger than the average for 1994-1996. The means and 95% confidence intervals are shown in Figure 3.9.

Comparison:	**Banking shares: Compounded returns (%)**			
year	***Size***	***Mean***	***SE***	***StDev***
94	244	-0.074	0.165	2.570
95	246	-0.024	0.167	2.614
96	244	-0.193	0.126	1.967
97	247	-0.502	0.318	5.002
98	244	0.365	0.457	7.146
99	243	-0.119	0.261	4.061
BOA				

Table 3.9: Annual comparison of compounded returns of BOA shares

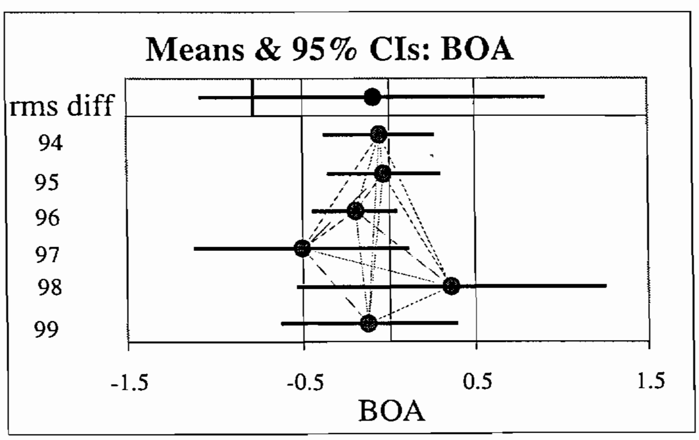


Figure 3.9: Annual means and 95% confidence intervals of BOA daily returns

Table 3.10 gives the annual comparison of daily compounded returns for SCB shares. The means are positive in 1995 and 1999 and negative in 1996 to 1998, but these changes are small compared to the standard errors. The standard deviation increases substantially after 1996, and is 6.36 in 1998. This is more than three times larger than the average for 1994-1996. The means and 95% confidence intervals are shown in Figure 3.10.

Comparison:	Banking shares: Compounded returns (%)			
year	*Size*	*Mean*	*SE*	*StDev*
94	244	-0.049	0.136	2.117
95	246	0.069	0.125	1.963
96	244	-0.160	0.131	2.044
97	247	-0.474	0.259	4.065
98	244	-0.402	0.407	6.357
99	243	0.416	0.274	4.274
SCB				

Table 3.10: Annual comparison of compounded returns of SCB shares

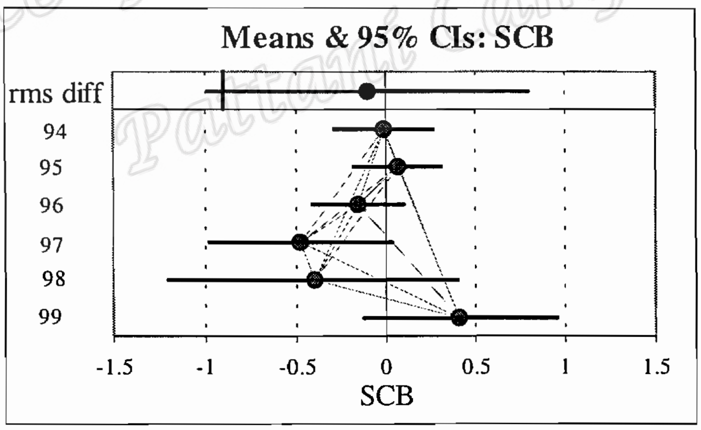


Figure 3.10: Annual means and 95% confidence intervals of SCB daily returns

Table 3.11 gives the annual comparison of daily compounded returns for IFCT shares. The means are positive in 1995 and 1998 and negative in 1996 to 1997 and 1999, but these changes are small compared to the standard errors. The standard deviation increases substantially after 1995, and is 8.44 in 1998. This is more than three times larger than the average for 1994-1996. The means and 95% confidence intervals are shown in Figure 3.11.

Comparison:	Banking shares: Compounded returns (%)			
Year	*Size*	*Mean*	*SE*	*StDev*
94	244	-0.086	0.183	2.852
95	246	0.232	0.157	2.463
96	244	-0.119	0.174	2.715
97	247	-0.980	0.361	5.680
98	244	0.316	0.541	8.443
99	243	0.074	0.285	4.447
IFCT				

Table 3.11: Annual comparison of compounded returns of IFCT shares

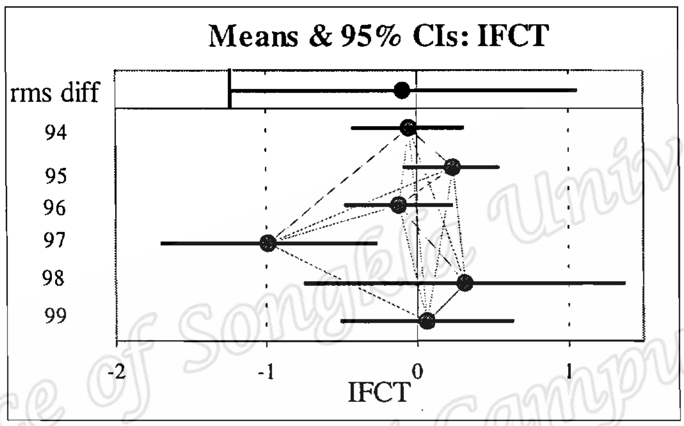


Figure 3.11: Annual means and 95% confidence intervals of IFCT daily returns

Table 3.12 gives the annual comparison of daily compounded returns for TFB shares. The means are negative in 1995 to 1999, but these changes are small compared to the standard errors. The standard deviation increases substantially after 1996, and is 5.88 in 1998. This is more than three times larger than the average for 1994-1996. The means and 95% confidence intervals are shown in Figure 3.12.

Comparison:	Banking shares: Compounded returns (%)			
year	*Size*	*Mean*	*SE*	*StDev*
94	244	0.082	0.133	2.083
95	246	-0.033	0.084	1.321
96	244	-0.148	0.111	1.741
97	247	-0.320	0.259	4.065
98	244	-0.025	0.376	5.878
99	243	-0.103	0.221	3.450
TFB				

Table 3.12: Annual comparison of compounded returns of TFB shares

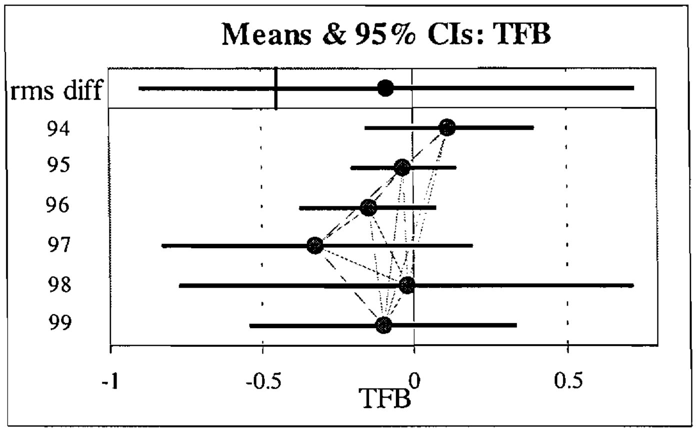


Figure 3.12: Annual means and 95% confidence intervals of TFB daily returns

Table 3.13 gives the annual comparison of daily compounded returns for KTB shares. The means are positive in 1995 and 1998 and negative in 1996 to 1997 and 1998, but these changes are small compared to the standard errors. The standard deviation increases substantially after 1996, and is 6.81 in 1998. This is more than three times larger than the average for 1994-1996. The means and 95% confidence intervals are shown in Figure 3.13.

Comparison:	**Banking shares: Compounded returns (%)**			
year	***Size***	***Mean***	***SE***	***StDev***
94	244	0.029	0.145	2.271
95	246	0.057	0.116	1.817
96	244	-0.283	0.169	2.634
97	247	-0.684	0.291	4.577
98	244	0.307	0.436	6.813
99	243	-0.037	0.333	5.191
KTB				

Table 3.13: Annual comparison of compounded returns of KTB shares

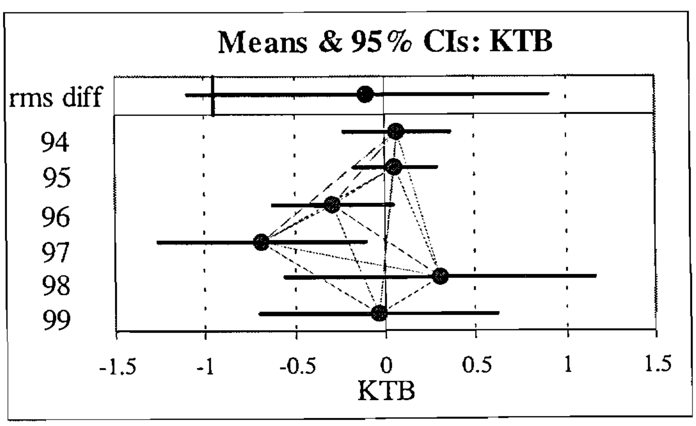


Figure 3.13: Annual means and 95% confidence intervals of KTB daily returns

3.3 Correlations Between Share Price Returns

Table 3.14 shows the correlations between the share price returns for the seven banking institutions. These correlations are all positive and range from 0.49 (between BOA and SCB) to 0.80 (between BBL and TFB).

Bank	*BAY*	*BBL*	*BOA*	*IFCT*	*KTB*	*SCB*	*TFB*
BAY	1						
BBL	0.617	1					
BOA	0.513	0.501	1				
IFCT	0.608	0.646	0.514	1			
KTB	0.664	0.669	0.567	0.671	1		
SCB	0.648	0.681	0.490	0.638	0.708	1	
TFB	0.618	0.797	0.485	0.640	0.647	0.668	1

Table 3.14: Correlation matrix of banking share daily returns, 1994-1999

When market variables are highly correlated, a set of uncorrelated variables can be created by taking linear combinations using principal components analysis, as described, for example, by Hull (2000, page 357). The advantage of this approach is that risks and volatilities can be controlled more effectively. The coefficients in the linear combinations (that is, the principal components) are obtained by extracting the eigenvectors of the correlation matrix, and these components are ordered according to the magnitudes of the eigenvalues. These eigenvalues jointly sum to the total variance in the market variables. Each eigenvector is scaled so that its sum of squares is 1.

Table 3.15 shows the eigenvalues of the correlation matrix and the percentages of the scaled sum of squares accounted for by each eigenvector. The first component accounts for just over 67% of the variation, and the remaining components are of approximately the same size.

Component	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Eigenvalue	4.730	0.607	0.447	0.388	0.348	0.278	0.201
Percentage	67.571	8.676	6.391	5.543	4.971	3.970	2.877

Table 3.15: Eigenvalues of correlation matrix of banking share returns, 1994-1999

Table 3.16 shows the eigenvectors of the correlation matrix, which constitute the coefficients in the linear combinations of the banking share returns (that is, the principal components).

Bank	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
BAY	0.373	-0.038	-0.558	0.496	0.545	-0.045	0.047
BBL	0.395	0.301	0.449	0.131	0.037	0.103	0.723
BOA	0.318	-0.873	0.328	0.090	-0.036	-0.138	-0.009
IFCT	0.378	0.019	-0.122	-0.827	0.355	-0.177	0.018
KTB	0.395	-0.076	-0.276	-0.113	-0.386	0.770	-0.083
SCB	0.389	0.170	-0.261	0.072	-0.635	-0.586	-0.018
TFB	0.391	0.332	0.469	0.161	0.150	0.025	-0.684

Table 3.16: Principal components based on eigenvectors of correlation matrix of banking share daily returns, 1994-1999

The first component is close to the average of the share returns from the seven financial institutions. The coefficients are scaled so that their sum of squares is 1 (rather than their sum), so each coefficient in the first principal component is approximately $1/\sqrt{7} = 0.378$ rather than $1/7 = 0.143$. Note that the average coefficient in the **PC1** column in Table 3.16 is 0.377.

Thus the first component corresponds to an investment portfolio containing the same number of shares in each of the seven banks.

The other components have both positive and negative coefficients. For example **PC7**, the component with the smallest variation, is approximately equal to the combination 0.7×**BBL**–0.7×**TFB**. This would correspond to an investment portfolio containing purchased **BBL** shares and an equal number of borrowed **TFB** shares.

A portfolio corresponding to **PC1** has the highest risk (and thus the greatest potential for profit or loss) because it has the maximum variance possible based on a combination of shares owned or borrowed in the seven banking institutions. Such a portfolio would appeal to a market speculator. In contrast, a portfolio corresponding to **PC7** has the lowest risk, and would appeal to a risk-averse investor.

Figure 3.14 shows the monthly averages of the returns from two banking share portfolios, with the same monetary value, corresponding to the largest and smallest principal components. The portfolio based on **PC1** is a weighted combination of shares bought, in which each bank has weight 1/7 = 14.3%, whereas the portfolio based on **PC7** is a combination of a share bought in **BBL** and a share borrowed in **TFB**, each having weight 0.5. These weights ensure that the two portfolios have the same monetary value. The overall average daily returns for the two portfolios are –0.102% and –0.003%, respectively.

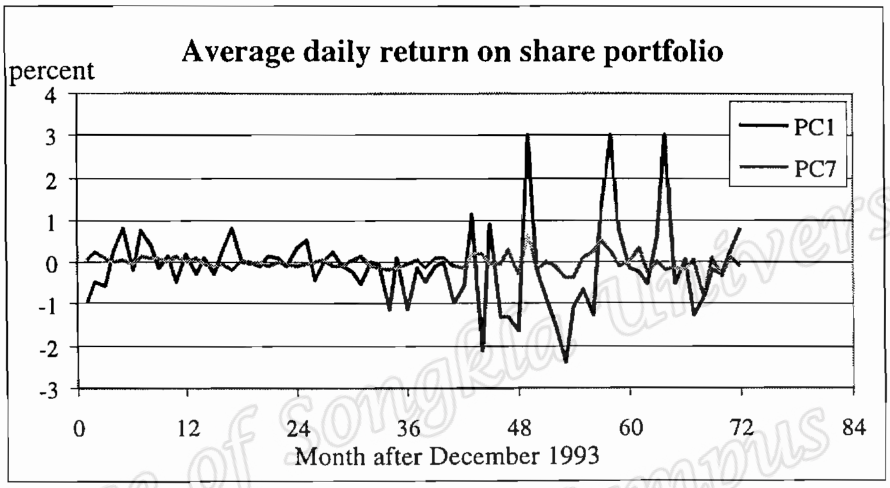


Figure 3.14: Mean daily returns on two portfolios

Figure 3.15 plots the volatilities (that is, the standard deviations) of the two portfolios computed monthly over the same six-year period. This plot clearly shows that the volatility increased substantially over the years 1997-1999. In the next chapter, a model for stochastic volatility is applied to these data.

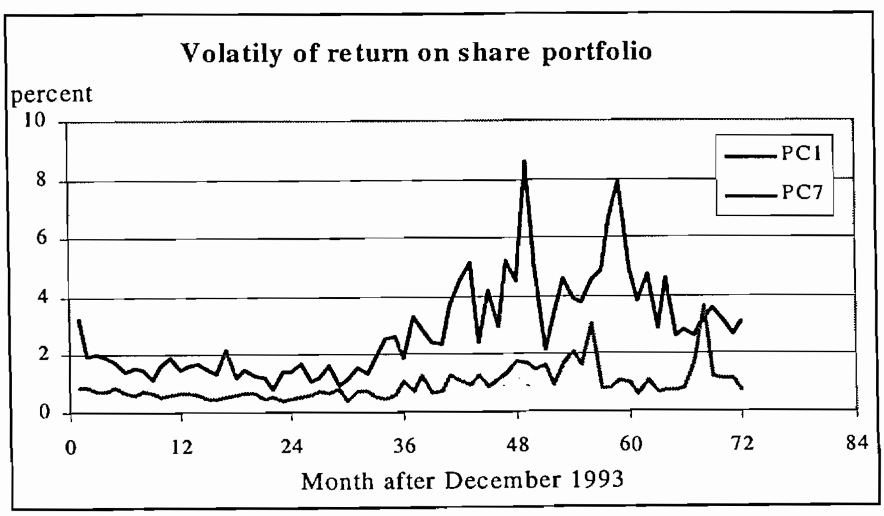


Figure 3.15: Volatility of daily returns on two portfolios