The Day - of - the - Week Effect: Anomaly or Illusion? New Evidence from Sri Lanka

Nagaratnam Jeyasreedharan

Tasmanian School of Economics and Business (TSBE), University of Tasmania, Australia

Abstract

In this paper the Day-of-the-Week effect is studied by comparing the empirical cumulative distribution functions (ECDFs) of the close-to-close log-returns of one day-of-the-week to the remaining weekday log-returns amongst the stocks comprising the S&P Sri Lanka 20 Index for the period January 2006 to December 2012. The sample period for the study is sub-divided into two periods: the civil war period (1st January 2006 to 18th May 2009) and the post civil war period (19th May 2009 to 31st December 2012). A modified Kolmogorov-Smirnov statistic, called the DoW-statistic, was then used to define the degree of DoW efficiency. The DoW-statistic for each stock is subsequently used to rank the S&P Sri Lanka 20 Index stocks according to their DoW efficiencies. The classical Kolmogorov-Smirnov test is then used to ascertain the statistical significance of these DoW statistics. With no adjustments for ARCH effects, the results indicate that DoW effects were weak during the war period but strong during the post-war period. However, when potential ARCH effects were taken into account, both periods showed evidence of strong DoW effects, indicating the Day-of-the-Week effect to be an anomaly rather than an illusion.

Keywords: *day-of-the-week effect, market anomaly, Kolmogorov-Smirnov statistic and test.*

1. Introduction

The Day-of-the-Week (DoW) effect in stock markets has been extensively studied. If returns are generated on trading and not calendar basis, then there should be no difference in daily return distributions across business days. This implies that a DoW efficient market or stock should have no significant differences between their conditional distributions over trading or business days (weekdays). Analogously, significant differences between conditional distributions over trading days indicate DoW dependent inefficiencies (Aggarwal & Tandon, 1994; Bayar & Kan, 2002; Brooks & Pesarnd, 2001; Cross, 1973; Davidson & Faff, 1999; Dubois & Louvet, 1996; Flannery & Protopapadakis, 1988; French, 1980; M. R. Gibbons & Hess, 1981; Jaffe & Westerfield, 1985; Kamath & Chusanachoti, 2002; Keim & Stambaugh, 1984; G. Kohers,

Kohers, Pandey, & Kohers, 2004; Lakonishok & Levi, 1982; Lin & Lee, 2001; Miller, 1988; Pena, 1995; Poshakwale, 1996; Rogalski, 1984a; Smirlock & Starks, 1986; Steeley, 2001; Wang, Li, & Erickson, 1997; Wilson & Jones, 1993).

In this paper the empirical cumulative distribution functions (ECDFs) of the closing log-returns of one day-of-the-week are compared to the conditional closing log-returns of the other days-of-the-week to detect the existence of any DoW effect in the Sri Lankan stockmarket. Any significant deviations between the conditional ECDFs is taken as an indicator of the presence of DoW effect. The Kolmogorov-Smirnov (KS) test is then used to ascertain the statistical significance of the DoW effects. We utilize a statistic measure, as defined by Jeyasreedharan (2007), known as the DoW-statistic, to compute the degree of DoW efficiency in the sampled stocks.

The DoW-statistic is subsequently used to rank the Sri Lanka All Share Price Index (SL.ASP) and the S&P Sri Lanka 20 Index's component stocks according to their DoW-statistics. In particular, the DoW-statistic enables the ranking of stocks and markets without making any parametric assumptions as to the distributional shape of the asset returns. It is distribution-free statistic and can be used on stocks and market indices.

In Section 2 the background to empirical cumulative distribution functions (ECDFs) is presented. This is followed in Section 3 with further details on the KS-statistic and KS-test. In Section 4 we define the DoW-statistic. The dataset used in this paper is described in Section 5. The methodology adopted and the hypothesis to be tested is described and discussed in Section 6. In Section 7 we present our summarised results and discuss the findings and finally, in Section 8 we conclude and present areas for further investigation.

2. Empirical Distribution Functions (ECDFs)

The empirical cumulative distribution function (ECDF) of a sample, $F_d(x)$, is a step function defined as:

$$F_d(x) = \begin{cases} 0; & x < x_{(1)} \\ i/n; & x_{(i)} \le x < x_{(i+1)};\ i = 1,\ldots,n-1 \\ 1; & x_{(n)} \le x \end{cases} \qquad (2.1)$$

where n is the sample size and $F_d(x)$ is the proportion of observations with a value less or equal to x, with increasing steps of $1/n$ at each observation. Figure 2-1 depicts the ECDFs for the Sri Lanka Telecom PLC over each of the five days-of-the-week. The conditional ECDFs for the stock can be seen as distinct entities. The challenge is to determine whether the ECDFs are significantly different from each other.

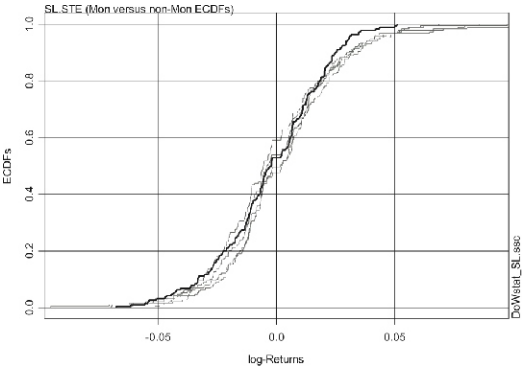

Figure 2.1. Empirical Cumulative Distribution Functions (ECDFs)

There are several statistical tests available for comparing $F_1(x)$ to $F_2(x)$, essentially differing in the ECDF-statistic defined for comparison. The Kolmogorov-Smirnov test or the KS-test is the most commonly used of these tests, and the KS-statistic is defined as the maximum difference between the two empirical distribution functions (ECDFs), $F_1(x)$ and $F_2(x)$. The Wilcoxon ranksum test is appropriate to detect differences in location and the Siegel-Turkey test is especially appropriate to detect differences in dispersion, both of which are not of concern here.

3. The KS-statistic and KS-test

As mentioned in Section 2, the statistic measuring the difference between $F_1(x)$ and $F_2(x)$ are called ECDF statistics, D^+ and D^- , which are respectively the largest vertical difference when $F_1(x) > F_2(x)$ and the largest vertical difference when $F_1(x) < F_2(x)$. Formally,

$$D^+ = \sup_x \{F_1(x) - F_2(x)\} \quad (3.1)$$

$$D^- = \sup_x \{F_1(x) - F_2(x)\} \quad (3.2)$$

The more commonly used ECDF statistic by however is:

$$D = \sup_x \left|F_1(x) - F_2(x)\right| = \max(D^+, D^-) \quad (3.3)$$

where D is known as the Kolmogorov-Smirnov (KS) statistic (Kolmogorov, 1933), (Chakravart, Laha, & Roy, 1967)). The Kolmogorov-Smirnov test detects differences in the shapes of the distributions. Substantial differences in the mean, spread, skewness and kurtosis of the distribution will result in a small KS p-value. Hence, 'any difference in any of these moments between two distributions can lead to a rejection of the null hypothesis'.The test is also fairly robust to outliers(Kalidas, Mbululu, & Chipeta, 2013; Lehmann, 2006).

Although this test was primarily designed for continuous distributions, it can also be applied to discrete distributions where the critical values tend to be over-conservative, i.e. a tabulated 5% critical value might in fact represent an actual 4% significance level (Neave & Worthington, 1988). However, there are modified KS-tests which are distribution free (J. D. Gibbons & Chakraborti, 1992). In this paper, the value of the KS statistic for two samples is based on the procedure given by Hollander &Wolfe (1999). In addition, the p-value of the KS-statistic is determined using the algorithm given by Kim & Jennrich (1970) which corrects for the over-conservative nature of the KS-test.

4. The Dow-statistic

We use Day-of-the-Week statistic (DoW-statistic) introduced by Jeyasreedharan (2007)for measuring the DoW efficiency of stockmarkets. The DoW-statistic is defined as:

$$DoW = 1 - \max \begin{bmatrix} \max(D_{Mon-\overline{Mon}}), \\ \max(D_{Tue-\overline{Tue}}), \\ \max(D_{Wed-\overline{Wed}}), \\ \max(D_{Thu-\overline{Thu}}), \\ \max(D_{Fri-\overline{Fri}}) \end{bmatrix} \quad (4.1)$$

where $D_{Day-\overline{Day}} = \sup_x \left|F_{Day}(x) - F_{\overline{Day}}(x)\right|$ and $\overline{Day}$ means all other weekdays except Day, the current day. Suppose we are computing $D_{Mon-\overline{Mon}}$, then $\overline{Mon}$ ("not-Mondays") means Tuesdays, Wednesdays, Thursdays and Fridays.

This formulation ensures that the largest KS-statistic for the day in question is selected. The DoW-statistic is defined as 1 minus the maxim KS-statistic across all the weekdays. The DoW-statistic, by definition, will be bounded between 0 to 1. The DoW-statistic can then be used to rank to DoW efficiency of stocks and markets, a value of '1' indicating perfect DoW efficiency. A DoW-statistic of say, 0.729, indicates 72.29% DoW efficiency.

The DoW efficiencies can subsequently be classified according to the significant level, α , of rejection of the underlying KS-statistic. If the maximum KS-statistic chosen was rejected at the 1% level, then the stock in question can be classified as DoW inefficient at the 1% level. Rejection at the 5% level indicates DoW

inefficiency at the 5% level. Rejection at the 10% level is DoW in efficient at the 10% level and no significance rejections depict DoW efficiencies.

5. Date

The S&P Sri Lanka 20 index covers the 20 largest and most liquid stocks from the Sri Lankan equity market emphasizing investability and tradability. To ensure investability, a minimum six-month average daily value traded (ADVT) of SLR 1 million is required. All the component stocks must also be profitable, as measured by positive net income over the latest 12-month period, as of the rebalancing reference date. Consequently the component stocks are expected to be relatively DoW efficient.

The closing daily prices for the All Price Share Index (SL.APS) and the S&P Sri Lanka 20 component stocks were downloaded from Datastream, a division of Thomson Reuters. The sample period is from 1st January 2006 to 31st December, 2012. The sample period for the study is further sub-divided into two periods: the civil war period (1st January 2006 to 18th May 2009) and the post civil war period (19th may 2009 to 31st December 2012). The daily close-to-close log-returns were computed for all trading days. Since we are considering only trading day or weekday anomalies, we could opt for close-to-open log-returns. However, for the sake of consistency we have stuck to the traditional close-to-close log-returns. The results of alternative approaches do not significantly differ in their empirical DoW measures.

Table 5.1 lists the S&P Sri Lanka 20 component stock descriptions and their corresponding stock codes.

Table 5.1. S&P Sri Lanka 20 component stocks

Stock Description	Stock Code
Asian Hotels and Properties	SL.AHC
Aitken Spence Hotel Holdings PLC	SL.AHU
Aitken Spence and Co PLC	SL.ASE
Bukit Darah Col. Ltd.	SL.BTD
Carsons Cumberbatch and Co PLC	SL.CAR
Commercial Bank of Ceylon PLC	SL.CBL
Cargills Ceylon PLC	SL.CGC
CT Holdings PLC	SL.CTE
DFCC Bank	SL.DEF
Distilleries Co of Sri Lanka PLC	SL.DSC
Dialog Axiata PLC	SL.DTT
Hayleys PLC	SL.HLY
Hatton National Bank PLC	SL.HNN
John Keells Holdings PLC	SL.KEL
Chevron Lubricants Lanka PLC	SL.LUB
Nestle Lanka	SL.MLK
National Development Bank PLC	SL.NDB
Sampath Bank PLC	SL.SPB
Sri Lanka Telecom PLC	SL.STE
Ceylon Tobacco Co Ltd	SL.TOB

We included the All Price Share Index (SL.APS) in our study for comparison with other academic studies on Sri Lanka, in particular the paper by Deyshappriya (2014) on the Colombo Stock Exchange and the war and post war periods.

Table 5.2 lists the first four moments for the S&P Sri Lanka 20 stocks and the Sri Lankan All Share price Index (SL.ASP) for the two sub-periods under study. Many of the stocks displayvarying skewness and kurtosis, thus making the choice of a suitable analytical distribution to depict observed returns a yet unresolved problem (Los, 2003; Officer, 1972). We circumvent this problem in this paper by using the empirical distribution function to depict the distribution of the stock and market log-returns. The ASPI Index had a smaller mean and larger standard deviation during the war period

compared to the post-war period as expected and reported by Deyshappriya (2014). Further, all the means of the log-returns

periods may be masked or appear illusionary by the heteroskedasti city in the time series. To address the ARCH effect, in this paper we also

Table 5.2. First Four Moments of S&P Sri Lanka 20 stocks and All Share Price Index

	War Period				Post War Period			
Code	Mean	Stdev	Skew	Kurtosis	Mean	Stdev	Skew	Kurtosis
SL.AHC	-0.0003	0.0259	0.305	5.2716	0.0016	0.0221	0.4928	6.6664
SL.AHU	0.0006	0.026	-0.152	7.041	0.0016	0.0237	1.1911	10.2087
SL.ASE	0.0002	0.0173	0.2009	26.8788	0.0017	0.0208	1.6121	11.5227
SL.ASP	0.0001	0.0105	0.3911	10.85	0.0011	0.0098	0.3162	5.9792
SL.BTD	-0.0001	0.0363	0.5667	9.9091	0.0021	0.0308	2.0154	17.0861
SL.CAR	0.0001	0.0455	4.0099	57.1627	0.0018	0.0248	2.0505	16.4568
SL.CBL	0.0002	0.0165	1.7192	17.1164	0.0012	0.0141	1.0293	8.6042
SL.CGC	0.0012	0.0343	1.7364	53.9778	0.0015	0.0214	0.7388	8.3106
SL.CTE	-0.0005	0.0614	0.2296	98.3768	0.0013	0.0265	0.967	7.5024
SL.DEF	-0.0002	0.0221	0.5562	11.8028	0.0009	0.0173	1.6008	12.4133
SL.DSC	0.001	0.0224	0.7113	7.8335	0.0007	0.0185	-0.0286	18.8713
SL.DTT	-0.0012	0.0225	-0.8812	12.8739	0.0004	0.0219	0.7882	9.7733
SL.HLY	0.0002	0.0187	0.9659	9.2574	0.0011	0.0161	0.7407	7.4314
SL.HNN	0.0009	0.0232	1.5857	12.6718	0.001	0.0228	-4.9979	100.563
SL.KEL	0	0.0175	1.7485	18.4348	0.0012	0.0147	1.5844	13.5126
SL.LUB	0.0008	0.0135	-0.4102	10.7928	0.0013	0.0143	2.0276	17.961
SL.MLK	0.0012	0.0202	1.1654	19.3169	0.0017	0.0268	1.7347	62.0267
SL.NDB	-0.0004	0.0172	1.1815	17.7034	0.0011	0.0169	1.5689	12.8882
SL.SPB	0	0.0175	0.2024	6.7072	0.0017	0.0177	1.8772	11.8266
SL.STE	0.0011	0.0202	0.9515	8.9207	0	0.0228	0.5407	6.4067
SL.TOB	0.0008	0.021	0.208	14.8367	0.0021	0.0189	2.5303	24.8366

for the 20 stocks were positive during the post war period, whereas during the war periods the signs of the mean log-returns were mixed.

Figure 5.1 displays the price and log-return time series for three stocks and the All Price Share Index for the period 19th May 2009 to 31st December 2012. The log-returns for all the four time series exhibit volatility clustering or ARCH effects. Thus, DoW effects, if any, in the sample

apply a GARCH model to the log-returns and compare the adjusted DoW statistics results with the original DoW statistics of the raw log-return series.

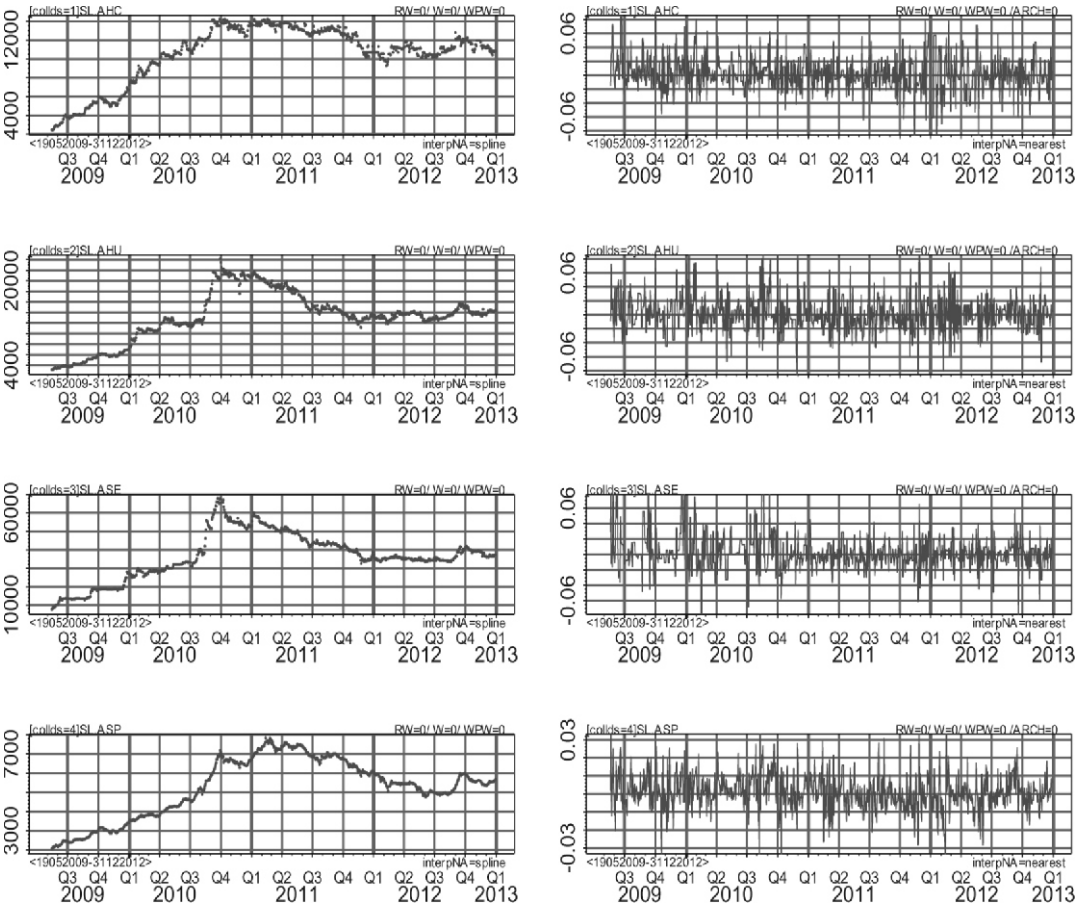

Figure 5-1 Price and log-return series for SL.AHC, SL.AHU, SL.ASE and SL.ASP (Post War period)

Note: The left panel plots depict the raw price series and the right panel plots depict the log-returns series. The volatility clustering (ARCH effects) in the log-return series is visually observable.

6. Methodology

The statistical methodology adopted in most of the studies mentioned earlier utilizes t-tests of the differences between means and F-tests of the differences between variances. The classic t-tests and F-tests are biased (Connolly, 1989) as they assume that the underlying log-returns are normally distributed.

The methodology adopted here is a pairwise comparison of all daily ECDFs as suggested by Galai & Levy (2003). In this study however, we do not utilize the multiple comparisons procedure (MCP), also mentioned in Galai & Levy (2003), as we do not seek the joint rejection of a particular day's distribution over all the other days. Thus our alternate hypothesis does not require all weekday pairs to be rejected, just any one of the combinations (Alt, Fortin, & Weinberger, 2002; Connolly, 1989; Galai & Levy, 2003).

Consequently, the following null hypothesis is tested:

$$H_0 : \{ECDF_{Mon} = ECDF_{Tue} = ECDF_{Wed} = ECDF_{Thu} = ECDF_{Fri}\} \quad (6.1)$$

$$H_{Mon} : \begin{Bmatrix} ECDF_{Mon} = ECDF_{Tue} \,|\, ECDF_{Mon} = ECDF_{Wed} \,| \\ ECDF_{Mon} = ECDF_{Thu} \,|\, ECDF_{Mon} = ECDF_{Fri} \end{Bmatrix}$$

$$| H_{Tue} : \begin{Bmatrix} ECDF_{Tue} = ECDF_{Mon} \,|\, ECDF_{Tue} = ECDF_{Wed} \,| \\ ECDF_{Tue} = ECDF_{Thu} \,|\, ECDF_{Tue} = ECDF_{Fri} \end{Bmatrix}$$

$$| H_{Wed} : \begin{Bmatrix} ECDF_{Wed} = ECDF_{Mon} \,|\, ECDF_{Wed} = ECDF_{Tues} \,| \\ ECDF_{Wed} = ECDF_{Thu} \,|\, ECDF_{Wed} = ECDF_{Fri} \end{Bmatrix} \quad (6.2)$$

$$| H_{Thu} : \begin{Bmatrix} ECDF_{Thu} = ECDF_{Mon} \,|\, ECDF_{Thu} = ECDF_{Tue} \,| \\ ECDF_{Thu} = ECDF_{Wed} \,|\, ECDF_{Thu} = ECDF_{Fri} \end{Bmatrix}$$

$$| H_{Fri} : \begin{Bmatrix} ECDF_{Fri} = ECDF_{Mon} \,|\, ECDF_{Fri} = ECDF_{Tue} \,| \\ ECDF_{Fri} = ECDF_{Wed} \,|\, ECDF_{Fri} = ECDF_{Thu} \end{Bmatrix}$$

Rejection of the null hypothesis implies that at least log-returns of one the five weekdays is not distributed equally as any one of the others.

The conditional daily ECDFs are pairwise differenced and the relevant KS-statistic and level of statistical significance determined. The largest KS-statistic or the lowest DoW-statistic across all possible combinations of weekdays is selected. For each stock and weekday the maximum KS-statistic realized is chosen and the maximum for all weekdays is used to compute the DoW-statistic. The Dow-statistic is then the weakest pairwise combination in the sample dataset.

7. Results

We report the summarized results across each and all weekdays. For clarity we illustrate the detailed Friday results for the Colombo All Share Price Index for the post-war period in Figure 7-1. The top-left panel depicts the Fri-Mon ECDFs and the top-right depicts Fri-Tue ECDFs. The middle-left

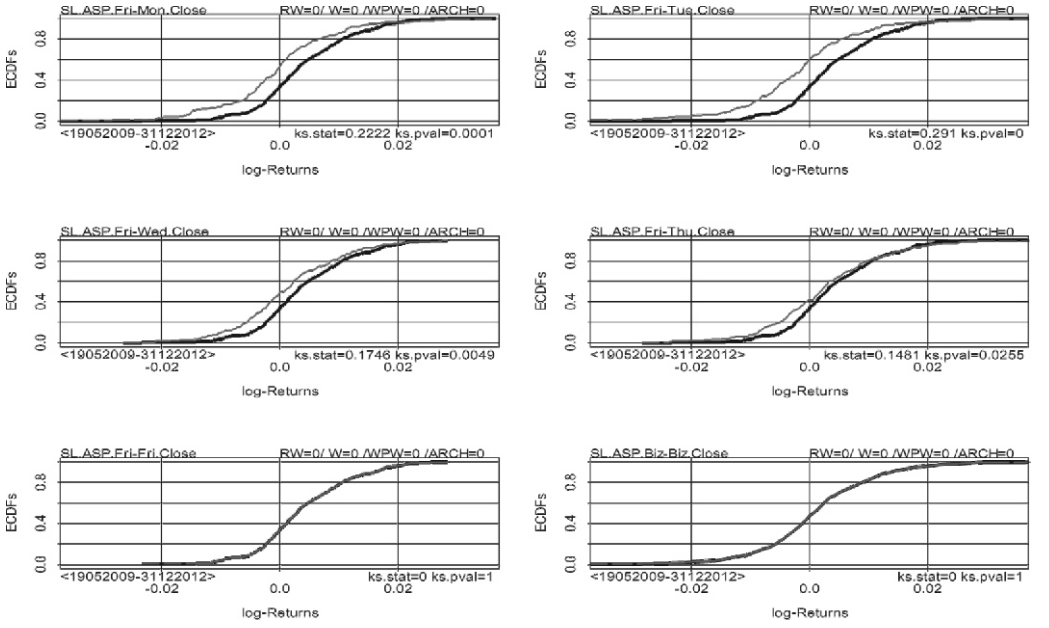

Figure 7.1 Fridays ECDFs for the All Share Price Index (Post War period)

Note: The top-left panel depicts the Fri-Mon ECDFs and the top-right depicts Fri-Tue ECDFs. The middle-left depict Fri-Wed ECDFs whilst the middle-right depicts Fri-Thu ECDFs. The bottom-left and bottom-right are self-matches (Fri-Fri, Biz-Biz) and are check plots. Biz ~ averaged daily log-returns over all days-of-the-week (Mon to Fri). Black lines depict the day-of-the-week; grey lines depict the 'paired' days.

depict Fri-Wed ECDFs whilst the middle-right depicts Fri-Thu ECDFs. The bottom-left and bottom-right panel plots are self-matches (Mon-Mon, Biz-Biz) and act as visual checks.

In the top-right panel in Figure 7-1 one can observe the large vertical separation (ks.stat=0.291) in the middle of the ECDFs for the Fri-Tues pair, indicating Fri-Tues returns to be the most DoW inefficient. For the Fri-Mon, Fri-Tues and Fri-Wed combinations, the null hypothesis is rejected at the 1% significance level. The Fri-Thu combination is rejected at the 5% level.

The summarized results for the post-war period are listed in Table 7.2. In addition the stocks that are ranked from 1 to 3 do not exhibit DoW effects. Stocks ranked from 4 to 5.5 have DoW effects at the 10% significance level. Stocks ranked from 7.5 to 10 have DoW effects at the 5% significance level and stocks ranked from 11 to 20 have DoW effects at the 1% significance level. The ASPI is ranked 21 for the post-war period, indicating the market as a whole was strongly DoW inefficient.

The most DoW efficient S & P Sri Lanka 20 stock for the post-war period is Dialog Axiata PLC (SL.DTT) and the most DoW inefficient stock is Aitken Spence Hotel Holdings PLC (SL.AXU) for the same period considered. The ASPI index exhibits significant DoW effects and is ranked 21 or is at the bottom of the table. Consequently, when we use market indices to test for DoW effects, we should not assume market-based DoW efficiencies to make inferences regarding the DoW efficiencies of individual stocks in the market. Individually the stocks in

Table 7.1KS and DoW statistics with ARCH effects (War period)

Symbol	Monday	Tuesday	Wednesday	Thursday	Friday	KS.max	DoW	Rank
SL.MLK	0.0465	0.0511	0.0465	0.0455	0.0511	0.0511	0.9489	1
SL.CGC	0.0521	0.0511	0.0398	0.0521	0.0455	0.0521	0.9479	2
SL.ASE	0.0663	0.0739	0.0625	0.0663	0.0739	0.0739	0.9261	3
SL.SPB	0.0577	0.0852	0.0625	0.0852	0.0625	0.0852	0.9148	4.5
SL.TOB	0.0716	0.0682	0.0852	0.0852	0.0682	0.0852	0.9148	4.5
SL.CAR	0.0883	0.0852	0.0909	0.077	0.0909	0.0909	0.9091	6
SL.AHU	0.0821	0.0966	0.0682	0.0966	0.0795	0.0966	0.9034	7
SL.CTE	0.0986	0.1023	0.1023	0.0966	0.1023	0.1023	0.8977	8
SL.DTT	0.1042	0.1023	0.0795	0.1042	0.0869	0.1042	0.8958	9
SL.HLY	0.1045	0.1023	0.0852	0.0816	0.1045	0.1045	0.8955	10
SL.BTD	0.118	0.0795	0.1064	0.118	0.0896	0.118	0.882	11
SL.LUB	0.0931	0.1193	0.108	0.0909	0.1193	0.1193	0.8807	12.5
SL.NDB	0.1048	0.1193	0.0852	0.1023	0.1193	0.1193	0.8807	12.5
SL.AHC	0.1232	0.1136	0.0948	0.1119	0.1232	0.1232	0.8768	14
SL.CBL	0.1614**	0.1193	0.1614**	0.1047	0.1388*	0.1614**	0.8386	15
SL.ASP	0.1621**	0.1648**	0.1451**	0.1648**	0.1621**	0.1648**	0.8352	16
SL.DEF	0.1383*	0.142**	0.1648**	0.1136	0.1648**	0.1648**	0.8352	17
SL.STE	0.1729***	0.1193	0.1157	0.133*	0.1729***	0.1729***	0.8271	18
SL.DSC	0.1733***	0.108	0.1335*	0.1221	0.1733***	0.1733***	0.8267	19
SL.KEL	0.1844***	0.1761***	0.142**	0.1271*	0.1844***	0.1844***	0.8156	20
SL.HNN	0.1952***	0.1534**	0.1364*	0.1136	0.1952***	0.1952***	0.8048	21

Note: "*" depicts 10% (low) significance; "**" depicts 5% (medium) significance; "***" depicts 1% (high) significance.

the market might, as is the case here, exhibit varying degrees of DoW efficiencies even though the at the index level the market may be inefficient.

Table 7.1 lists the DoW statistics for the war period. Surprisingly very few stocks display DoW inefficiency for the aforesaid period. In fact more than two-thirds (14 out of 20) stocks are DoW efficient. On the other hand, the ASP Index is DoW inefficient at the significance 5% level.

This is contrary to the corresponding results for the post war period in Table 7.2. The DoW statistics as listed in Table 7.2 clearly shows the traditional Monday and Friday effects so often encountered reported in the day-of-the-week literature. In addition, there seems to be a Tuesday and Thursday effect as well. The ASPI index is the most DoW inefficient for the Post War period, indicating that stock DoW inefficiencies are not disaggregated but aggregated in a market index. Furthermore, there is high degree of variation in the DoW-statistics across stocks and across weekdays indicating a whole range of variation in the DoW anomalies across stocks and weekdays. The highest DoW-statistic scores occur on Mondays, Tuesdays and Fridays. Wednesdays and Thursdays appear to be the most efficient DoW days with the least DoW effects. These results are similar to the findings of (Barone, 1990; Damodaran, 1989; Deyshappriya, 2014; Harris, 1986; Pathirawasam, 2006; Peter & Fernando, 2010; Solnik & Bousquet, 1990;

Table 7.2. KS and DoW statistics with ARCH effects (Post War period)

Symbol	Monday	Tuesday	Wednesday	Thursday	Friday	KS.max	DoW	Rank
SL.DTT	0.0899	0.0741	0.0899	0.0688	0.0899	0.0899	0.9101	1
SL.MLK	0.0847	0.1005	0.0952	0.0582	0.1005	0.1005	0.8995	2
SL.TOB	0.1005	0.0741	0.0635	0.0899	0.1005	0.1005	0.8995	3
SL.STE	0.1005	0.127*	0.0899	0.1217	0.127*	0.127*	0.873	4
SL.ASE	0.1323*	0.1217	0.0952	0.1323*	0.1217	0.1323*	0.8677	5.5
SL.HLY	0.0899	0.1323*	0.0741	0.0952	0.1323*	0.1323*	0.8677	5.5
SL.CTE	0.1217	0.1429**	0.1164	0.1164	0.1429**	0.1429**	0.8571	7.5
SL.NDB	0.1217	0.1429**	0.0952	0.1005	0.1429**	0.1429**	0.8571	7.5
SL.CBL	0.1376**	0.1534**	0.127*	0.1111	0.1534**	0.1534**	0.8466	9
SL.AHC	0.1481**	0.1534**	0.1164	0.1164	0.1534**	0.1534**	0.8466	10
SL.DSC	0.164***	0.1429**	0.1164	0.127*	0.164***	0.164***	0.836	11
SL.CGC	0.164***	0.127*	0.1429**	0.1376**	0.164***	0.164***	0.836	12.5
SL.KEL	0.1164	0.164***	0.127*	0.164***	0.1587**	0.164***	0.836	12.5
SL.DEF	0.1429**	0.1693***	0.1058	0.1693***	0.1587**	0.1693***	0.8307	14
SL.HNN	0.1693***	0.1376**	0.1217	0.1217	0.1693***	0.1693***	0.8307	15.5
SL.LUB	0.1693***	0.1376**	0.1217	0.127*	0.1693***	0.1693***	0.8307	15.5
SL.SPB	0.1799***	0.1429**	0.1164	0.1376**	0.1799***	0.1799***	0.8201	17
SL.BTD	0.1693***	0.2011***	0.164***	0.1217	0.2011***	0.2011***	0.7989	18
SL.CAR	0.1429**	0.2169***	0.1587**	0.127*	0.2169***	0.2169***	0.7831	19
SL.AHU	0.2381***	0.2381***	0.1534**	0.1429**	0.2381***	0.2381***	0.7619	20
SL.ASP	0.2222***	0.291***	0.1746***	0.2169***	0.291***	0.291***	0.709	21

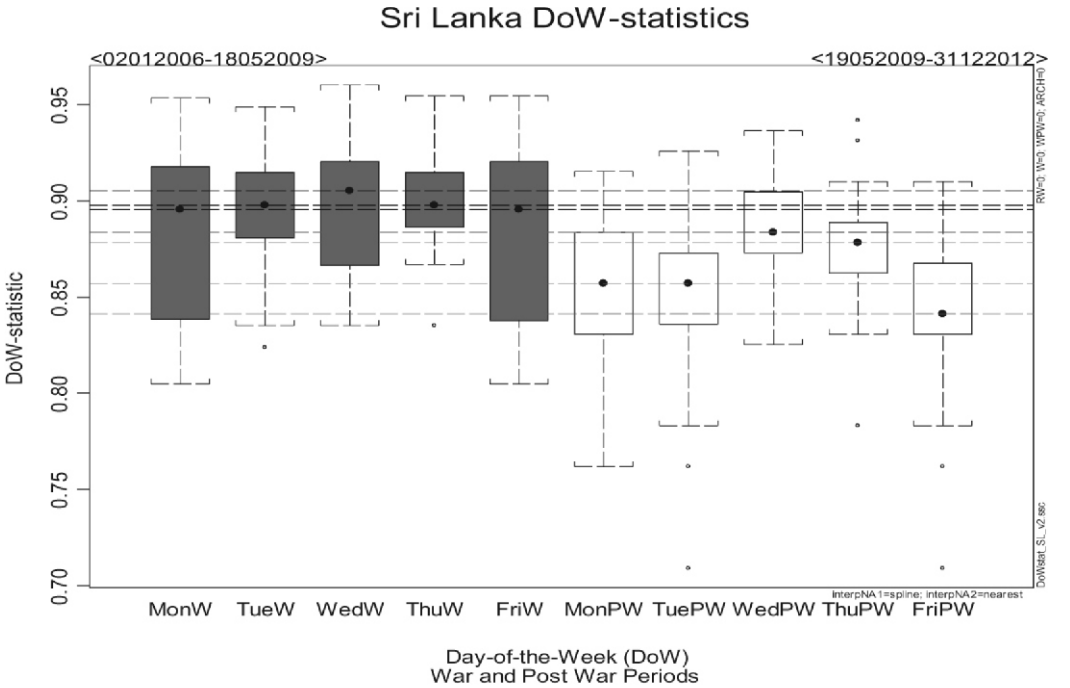

Figure 7.2. Boxplot of DoW-statistics (War and Post-War Periods with ARCH effects)

The only discrepancy in our findings so far is that the Sri Lankan stockmarket was more DoW efficient during the war period compared to the post-war period. This is further illustrated in Figure 7.2 where the box-plot of the DoW-statistics over the two periods is presented. The shaded boxes represent the war period and the un-shaded boxes the post-war period. The post-war period clearly displays the Monday and Friday DoW effects, whilst during the war period the corresponding DoW effects are unclear. This is contrary to common expectations and, in particular, the findings by Deyshappriya (2014) where, using a GARCH (1,1) model, he found the day-of-the-week effect to be more 'common in the war period than the post war period' for Sri Lanka.

One possibility in our results would be that ARCH (conditional heteroskedasticity) effects might be masking the DoW results. So in addition to the standard methodology, we augment our work by fitting an ARMA (4,4) + GARCH(4,4) model to all the 20 stocks and the ASPI index prior to re-testing for DoW effects over both the periods. The ARMA (4,4) - GARCH (4,4) formulation was chosen as there were 5 days to a week, and hence 4-lags were required to remove any mean and volatility dependencies in the log-return series. The results are listed in Table 7.3 and Table 7.4 and displayed in Figure 7.3.

Table 7.3. KS and DoW statistics without ARCH effects (War period)

Symbol	Monday	Tuesday	Wednesday	Thursday	Friday	KS.max	DoW	Rank
SL.SPB	0.1013	0.1023	0.1023	0.0966	0.0852	0.1023	0.8977	1
SL.CGC	0.1118	0.1118	0.0778	0.0739	0.1002	0.1118	0.8882	2
SL.TOB	0.1168	0.0997	0.0718	0.1168	0.0841	0.1168	0.8832	3
SL.LUB	0.1177	0.125	0.1193	0.108	0.125	0.125	0.875	4
SL.ASE	0.1297*	0.1297*	0.1193	0.1193	0.1238	0.1297*	0.8703	5
SL.NDB	0.1158	0.1307*	0.0987	0.108	0.1307*	0.1307*	0.8693	6
SL.DEF	0.1351*	0.142**	0.142**	0.1136	0.142**	0.142**	0.858	7
SL.BTD	0.1513**	0.1185	0.1289*	0.1513**	0.1343*	0.1513**	0.8487	8
SL.MLK	0.1517**	0.1517**	0.084	0.1014	0.1122	0.1517**	0.8483	9
SL.AHC	0.1571**	0.0966	0.122	0.1065	0.1571**	0.1571**	0.8429	10
SL.CAR	0.1579**	0.1339*	0.1295*	0.1509**	0.1579**	0.1579**	0.8421	11
SL.CBL	0.1616**	0.1567**	0.1616**	0.1281*	0.151**	0.1616**	0.8384	12
SL.DTT	0.1683**	0.1683**	0.1347*	0.142**	0.1228	0.1683**	0.8317	13
SL.HLY	0.1687**	0.1687**	0.1289*	0.146**	0.1005	0.1687**	0.8313	14
SL.ASP	0.1688**	0.142**	0.157**	0.1688**	0.1671**	0.1688**	0.8312	15
SL.CTE	0.1793***	0.1341*	0.1193	0.1793***	0.1167	0.1793***	0.8207	16
SL.AHU	0.1804***	0.1804***	0.1684**	0.152**	0.169**	0.1804***	0.8196	17
SL.HNN	0.1838***	0.1648**	0.142**	0.142**	0.1838***	0.1838***	0.8162	18
SL.STE	0.1845***	0.1705***	0.1534**	0.1441**	0.1845***	0.1845***	0.8155	19
SL.DSC	0.2194***	0.1461**	0.1505**	0.1448**	0.2194***	0.2194***	0.7806	20.5
SL.KEL	0.2194***	0.1989***	0.142**	0.1574**	0.2194***	0.2194***	0.7806	20.5

The DoW statistics as listed in Table 7-3 is remarkably different from those found in Table 7-1. Now the Monday and Friday effects are still prevalent during the war period. Taking into consideration the ARCH effects seems to have removed the illusion of DoW efficiency during the war period. This change in outcomes is clearly illustrated in Figure 7-3 where the now familiar 'DoW frown', with Mondays and Fridays being more DoW inefficient and Wednesdays being more DoW efficient, is apparent for both periods.

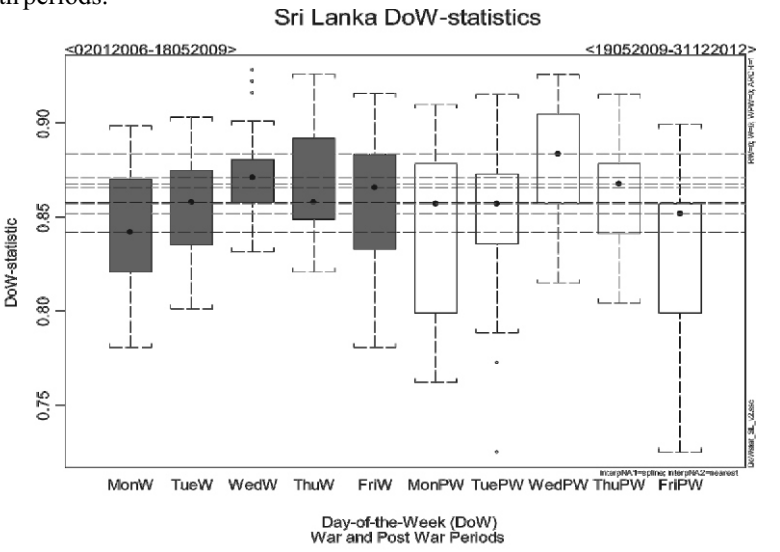

Figure 7.3. Boxplot of DoW-statistics (War and Post-War Periods without ARCH effects)

Hence the DoW effect is a persistent anomaly in the case of Sri Lanka for the period investigated, and probably in many other equity markets. We do not attempt to explain why these DoW anomalies or effects occur as there are already a number of competing hypotheses offering conflicting explanations (Condoyanni, O'Hanlon, & Ward, 1987; Damodaran, 1989; Edward, 1988; T. Kohers & Kohers, 1995; Rogalski, 1984b; investigated (Hsiao & Solt, 2004; G. Kohers, et al., 2004).

The ARCH effect adjusted DoW results for the post-war period as displayed in Table 7-4 does not seem to be significantly different from the unadjusted DoW results for the same. The overall DoW rejection levels (at 1%, 5% and 10% significance levels) of the stock and index remain unaffected significantly.

Table 7.4 KS and DoW statistics without ARCH effects (Post War period)

Symbol	Monday	Tuesday	Wednesday	Thursday	Friday	KS.max	DoW	Rank
SL.MLK	0.1005	0.0847	0.0847	0.0847	0.1005	0.1005	0.8995	1
SL.TOB	0.1164	0.0847	0.0741	0.1005	0.1164	0.1164	0.8836	2
SL.AHC	0.1217	0.1164	0.0847	0.1217	0.1217	0.1217	0.8783	3
SL.HLY	0.1164	0.127*	0.0952	0.127*	0.127*	0.127*	0.873	4
SL.CBL	0.1376**	0.1323*	0.1111	0.1323*	0.1376**	0.1376**	0.8624	5
SL.DEF	0.1429**	0.127*	0.0952	0.1323*	0.1429**	0.1429**	0.8571	6.5
SL.NDB	0.1429**	0.1164	0.1005	0.1323*	0.1429**	0.1429**	0.8571	6.5
SL.CTE	0.1111	0.1429**	0.1164	0.0952	0.1429**	0.1429**	0.8571	8.5
SL.HNN	0.1429**	0.1111	0.1005	0.1058	0.1429**	0.1429**	0.8571	8.5
SL.STE	0.0899	0.1534**	0.0847	0.1217	0.1534**	0.1534**	0.8466	10
SL.DTT	0.164***	0.164***	0.127*	0.1005	0.164***	0.164***	0.836	11
SL.KEL	0.1481**	0.164***	0.1111	0.164***	0.1481**	0.164***	0.836	12
SL.CAR	0.1429**	0.1534**	0.1852***	0.127*	0.1852***	0.1852***	0.8148	13
SL.ASE	0.1958***	0.1429**	0.1429**	0.1958***	0.1481**	0.1958***	0.8042	14
SL.LUB	0.1958***	0.1534**	0.1323*	0.1429**	0.1958***	0.1958***	0.8042	15
SL.DSC	0.2011***	0.1693***	0.1217	0.1534**	0.2011***	0.2011***	0.7989	16
SL.CGC	0.2011***	0.1429**	0.1429**	0.1587**	0.2011***	0.2011***	0.7989	17.5
SL.SPB	0.2011***	0.1376**	0.1429**	0.1799***	0.2011***	0.2011***	0.7989	17.5
SL.BTD	0.2011***	0.2275***	0.1852***	0.1481**	0.2275***	0.2275***	0.7725	19
SL.AHU	0.2328***	0.2116***	0.1587**	0.1587**	0.2328***	0.2328***	0.7672	20
SL.ASP	0.2381***	0.2751***	0.1746***	0.1852***	0.2751***	0.2751***	0.7249	21

Rystrom & Benson, 1989; Ziemba, 1993) and many others. In addition, the question of whether abnormal gains can be realized by trading in DoW inefficient stocks or whether transaction costs and time varying risk-premium will prevent these gains from being realized is also not

8. Conclusions

The DoW-statistic is shown to be a simple and yet all encompassing measure of DoW efficiency. It is a comparative measure based on the conditional ECDFs of sample log-returns and is thus unit and scale invariant. We are able to classify the DoW inefficiencies using the level of

significant rejections of 10%, 5% and 1%. A DoW inefficient stock is one in which the null hypothesis is rejected at the 10% or less significant level. Analogously, a DoW efficient stock is one that cannot be rejected even at the 10% level.

Although we used the S&P Sri Lanka 20 stocks to illustrate the effectiveness of the DoW-statistic, it can be applied to any markets or stocks. Of the twentyS&P Sri Lanka 20 stocks investigated, it was found that the stock of Sampath Bank PLC (SL.SPB) was the most DoW efficient for the war period and Nestle Lanka (SL.MLK) for the post-war period correspondingly (adjusted for ARCH effects). Of the 20 stocks tested, only 3-4stocks were DoW efficient over both periods. However, it must be stressed at this juncture that DoW inefficiency is only one aspect of stockmarket inefficiency. A DoW efficient stock or market might be inefficient is a different sense, i.e. there might be other dependency structures in the timeseries of log-returns (Bessembinder & Hertzel, 1993).

All we can conclude, based on the DoW-statistic cum test, is whether a market or stock is DoW efficient. In doing so we able to rank stocks and markets accordingly to provide us with a DoW-ordered list for potential investment and trading decisions. The presence of a significant DoW inefficiency is evidence against the random walk and efficient market hypothesis for the affected stocks and markets. One might be seen to be prudent 'investing' in a DoW efficient market to avoid this DoW anomaly but also might be seen to be equally prudent 'trading' in a DoW inefficient market to exploit the DoW anomaly.

However, in this paper we have not attempted to explain why these DoW anomalies or effects occur as there are already a number of competing hypotheses offering conflicting explanations. Further, the question of whether any abnormal gains can be realized by trading in DoW inefficient stocks or transaction costs and time varying risk-premium will erode the gains, if any,is also not investigated. Both the theoretical explanations and practical applications are left open for further investigation.

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