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THE IRISH ACCOUNTING AND FINANCE ASSOCIATION

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All enquiries regarding membership should be addressed to:

Eoin Langan
Department of Accounting, Financial Services and Business Computing
Athlone Institute of Technology
Co. Westmeath
Ireland
Telephone: +353 (0)90 64 24521
e-mail: elangan@ait.ie

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Noel Hyndman
School of Management and Economics
Queen's University Belfast
Belfast BT7 1NN
Northern Ireland

Email: n.hyndman@qub.ac.uk

or

Ciarán Ó hÓgartaigh
UCD School of Business
University College Dublin
Belfield
Dublin 4
Ireland

Email: ciaran.ohogartaigh@ucd.ie

Notes for Contributors are contained on pages 103–104.

PREDICTABILITY REVISITED: UK EQUITY RETURNS 1965–2007[1]

David A. Bowen, Mark C. Hutchinson and Niall O'Sullivan
University College Cork

ABSTRACT

This study tests a large sample of UK equity returns from 1965 to 2007 for predictability. Returns are tested using the Lo and MacKinlay (1988) variance ratio test and the Chow and Denning (1993) multiple variance ratio tests. Overall, the results show strong signs of predictability. There is a size effect, in which small equities appear more predictable in the first half of the sample (1965–1985), and mid- to large size equities appear more predictable in the second half of the sample (1986–2007).

INTRODUCTION

Predictability-based trading strategies have become increasingly popular over the last decade. Equity market neutral, a strategy generally formulated from statistical analysis of past price movements (Patton, 2009), has assets under management globally increasing from $14 billion to $70 billion from 2001 to 2007.[2] However, the recent credit crisis has cast a shadow over these strategies with many funds delivering poor returns (Khandani and Lo, 2011), and it is now timely to question whether these strategies are based upon a false premise, i.e. are equity returns truly predictable? Our paper addresses this question by employing a range of tests for a large database of United Kingdom (UK) equities.

Our paper can also be considered a test of the Random Walk Theory (RWT) and also a limited test of the weak form of the Efficient Market Hypothesis (EMH). The RWT states that price changes must be unforecastable if they are properly anticipated (Samuelson, 1965), meaning returns are not predictable. Alternately, the weak form of the EMH states that abnormal profits (net of transaction costs) cannot be achieved based on analysis of past price movements. Comprehensive evidence of return predictability would naturally lead to a rejection of the RWT, whereas without a consideration of transaction costs we can draw fewer conclusions about EMH. On the other hand, evidence of no return predictability would provide evidence in support of both RWT and weak form EMH.

Researchers attempting to evaluate the predictability of equity returns are faced with several challenges. Firstly, it is necessary to specify a long sample period in order to provide a robust test. Specifying a shorter time period means you are less likely to capture a wide range of market conditions. Secondly, it is necessary to specify a large sample of equities. It is likely that there is significant cross-sectional variation in return predictability and some evidence suggests that return predictability is a small stock phenomenon. Thirdly, we need to allow for time variation in predictability. This is particularly relevant for trading strategies based upon predictability as profitability depends upon it being independent of time. Fourthly, there are several implementation issues associated with statistical tests of predictability.

In this paper we address each of these difficulties. We specify a 42-year sample period of UK equities. Within the sample we specify over 6,700 UK equities. This is the largest and longest sample period that we are aware of in a study of this nature using UK data. To allow for time variation we repeat tests in several sub-sample periods. We further divide our sample into deciles based upon market capitalisation, controlling for cross-sectional variation in results. The statistical tests we carry out are (1) simple Autocorrelation Functions (ACF) with Ljung-Box tests for serial correlation, (2) Lo and MacKinlay (1988) (hereafter LM) homoscedastic and heteroscedastic Variance Ratio tests, and (3) Chow and Denning (1993) (hereafter CD) Multiple Variance Ratio Tests.

The LM variance ratio test is a simple specification model based on variance estimators that can be used to test whether a series follows a random walk. The variance ratio test exploits the fact that intervals of a random walk are linear. For example, a five-day period variance of a time series should be five times as large as a daily variance of the same time series. Chow and Denning (1993) make a modification to the standard variance ratio test to allow for the joint testing of multiple variance ratios. They argue that instead of examining several variance ratios at different aggregate intervals against the standard statistical critical value, it is appropriate to consider an overall critical value that takes into account the number of variance ratios being tested.

When we specify these different tests, our empirical results generally find evidence of predictability. While we do provide evidence that stock price movement contains predictable components, there is considerable cross-sectional and time variation in our results. Consistent with prior research (see, for example, Lo and MacKinlay, 1988; Poterba and Summers, 1988; Lovatt et al., 2007), we find strong signs of serial dependence throughout the sample. When measured by variance ratios, signs of predictability are also present across all time periods and throughout the full sample. The mid- to large sized deciles of the full sample, notably the sixth to ninth deciles, report the highest number of significant variance ratios. The smaller deciles, second to fourth, have a number of insignificant variance ratios. When we specify the CD tests, joint variance test results suggest evidence of predictability in the mid- to large sized deciles. However, in the smaller deciles, a number of variance ratios that would be reported as significant with a conventional LM variance ratio test are found to be insignificant. When the sample is divided into the four sub-samples, these incorrect LM significant variance ratios are only present in the third time period, 1986–1996.

Taken in aggregate, these results challenge the classical finance view that financial markets follow a random walk and suggest that there are opportunities to follow statistical arbitrage strategies, based on past price movements, in the UK equity market. In this paper we build on several related themes. There is a considerable body of research that focuses on the predictability of UK equity data with mixed findings (see, for example, Malliaropulos, 1996; Belaire-Franch and Opong, 2005; Lovatt et al., 2007). These studies have generally focused on UK equity indices (Malliaropulos, 1996; Patro and Wu, 2004; Belaire-Franch and Opong, 2005) or relatively short sample periods (Lovatt et al., 2007). We build on each of these studies, providing more evidence on return predictability for a larger sample over a longer sample period, using a range of statistical tests.

A growing body of research is focused on the profitability of statistical trading strategies. Several authors, including Conrad and Kaul (1998) and Jegadeesh and Titman (1993, 1995, 2001), provide evidence from the United States (US) on momentum and contrarian investment strategy profitability. Likewise, in the UK, Antoniou et al. (2006) and Galariotis et al. (2007) report similar findings. With a very extensive test of predictability in UK equities, we present evidence supporting these studies, demonstrating that stock prices do not follow a random walk.

The rest of the paper is structured as follows. The next section describes the data, while the following section presents the predictability testing methodology. Then we report the empirical results, including variance ratio and multiple variance ratio predictability tests. The final section concludes.

DATA

We test for predictability in UK equities using a database of over 20 million daily equity returns over a sample period from 1965 to 2007, a time period that covers several market upturns and downturns, as well as relatively calm and volatile periods.[3] All data come from Datastream. We include failed firms in the dataset up to the date they are delisted from the London Stock Exchange, which helps to alleviate survival bias in the sample. Acquired firms' returns are included in the dataset up to the date they are delisted from the London Stock Exchange. We also omit all non-common equities from the sample. In addition, we manually scan the database for extremely high returns which are then reversed in the following month as this indicates a data entry error. We remove these returns.[4,5]

In our final sample we have a total of 6,729 equity securities, ranging from large to small capitalisation stocks. On average, in any one year, there are 1,872 securities in the sample. The year with the smallest (largest) samples is 1965 (2007), with a total number of 786 (2,225) securities.

To ensure our results are independent of firm size, at the beginning of each year we sort stocks into portfolio deciles based upon end-of-prior-year market capitalisation. The first portfolio represents the smallest stocks by market capitalisation and the tenth the largest. Within each portfolio stocks are equally weighted.[6]

To investigate whether predictability is consistent across time periods we also divide our sample into four sub-samples: from 1 January 1965 to 31 December 1974; from 1 January 1975 to 31 December 1985; from 1 January 1986 to 31 December 1996; and from 1 January 1997 to 31 December 2007.

Table 1, Panel A displays the summary statistics for the equally weighted portfolios for the entire sample period. The mean returns for the sample are 6.3 per cent. As size increases across the deciles, the standard deviation levels correspondingly increase. As liquidity is directly related to firm size, it is likely that the small stocks may trade less frequently than large stocks, with a consequent downward effect on standard deviation (Scholes and Williams, 1977). Each decile displays low levels of negative skewness; however, this is higher in the smaller deciles. The kurtosis levels also appear to be size dependent: as size increases across each decile, the kurtosis levels decrease. The minimum values (-12.24 per cent) for the full sample occurs on 20 October 1987. The maximum value of 6.57 per cent for the equally weighted portfolio occurs on 27 October 1975.

The summary statistics for the full sample over the four separate sample subperiods are reported in Table 1, Panel B. The period 1975–1985 has the highest mean returns, 21.71 per cent. The lowest returns occur in the fourth time period, 1997–2007, with annual mean returns of -6.06 per cent. Based on the summary statistics, it is evident that the returns vary quite considerably across the time periods investigated in this study.

TABLE 1: SUMMARY STATISTICS

Panel A contains 10 equally weighted portfolios of daily returns for all equities listed in the UK from 31 December 1965 to 31 December 2007, Decile 1 being the smallest and Decile 10 being the largest. Panel B looks at all equities over four time periods: 1965–1974, 1975–1985, 1986–1997 and 1998–2007.

Panel A	**Annual Mean**	**Annual Median**	**Annual Standard Deviation**	**Skewness**	**Kurtosis**	**Minimum**	**Maximum**
Decile 1	10.32	6.19	8.27	-2.04	48.13	-10.47	5.18
Decile 2	4.97	5.63	8.65	-3.10	74.63	-11.82	6.64
Decile 3	3.42	5.69	8.96	-2.62	62.77	-12.80	7.54
Decile 4	4.14	6.20	9.26	-2.45	50.88	-11.88	6.68
Decile 5	3.42	6.01	9.46	-2.14	41.50	-10.95	7.26
Decile 6	4.90	6.15	9.74	-1.90	39.47	-11.12	8.64
Decile 7	5.81	6.63	10.48	-1.61	32.41	-10.61	8.22
Decile 8	6.20	5.99	11.40	-1.31	28.55	-11.19	7.89
Decile 9	8.69	5.37	13.38	-0.60	20.10	-13.27	8.62
Decile 10	7.95	5.10	14.46	-0.64	19.62	-15.14	8.94
Full Sample	*6.30*	*7.17*	*8.91*	*-2.46*	*52.26*	*-12.24*	*6.57*

(*Continued*)

TABLE 1: (*CONTINUED*)

Panel B	Annual Mean	Annual Median	Annual Standard Deviation	Skewness	Kurtosis	Minimum	Maximum
1965–1974	3.73	5.45	9.06	-1.60	24.25	-6.95	3.77
1975–1985	21.71	24.07	8.82	0.83	22.38	-4.74	6.57
1986–1996	5.60	10.24	9.58	-6.01	110.95	-12.24	4.90
1997–2007	-6.06	10.41	8.03	-1.98	14.44	-4.65	2.40

METHODOLOGY

In this paper, to test for predictability we specify two variations of the variance ratio test, the standard LM variance ratio test and the CD multiple variance ratio test. Below we review the details of these tests.

The random walk theory in financial literature states that future stock returns cannot be predicted by previous stock prices. If equities follow RWT, the variance should be uncorrelated and should follow a linear pattern over time. Therefore, the variance ratio at time k should be k times the variance of its first difference. The LM variance ratio is defined as

$$VR(q) = \frac{\sigma_b^2(q)}{\sigma_a^2(q)} \tag{1}$$

where $\sigma_b^2(q)$ and $\sigma_a^2(q)$ are the maximum likelihood estimators of $1/q$ of the variance of the qth difference and the first difference of X_t, the return time series. Below, the formulas for $\sigma_b^2(q)$ and $\sigma_a^2(q)$ are defined in (2) and (4).

$$\sigma_b^2(q) = \frac{1}{m}\sum_{t=q}^{nq}(X_t - X_{t-q} - q\hat{\mu})^2 \tag{2}$$

where:

$$m = q(nq - q + 1)\left(1 - \frac{q}{nq}\right) \tag{3}$$

$$\sigma_a^2(q) = \frac{1}{nq-1}\sum_{t=1}^{nq}(X_t - X_{t-1} - \hat{\mu})^2 \tag{4}$$

where:

$$\hat{\mu} = \frac{1}{nq-1}(X_{nq} - X_0) \tag{5}$$

The asymptotic variance of the variance-ratio under homoscedasticity is shown below in (6).

$$\phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)} \tag{6}$$

$Z(q)$, the standard normal test statistic under homoscedasticity, is shown below.

$$Z(q) = \frac{VR(q)-1}{[\phi(q)]^{\frac{1}{2}}} \overset{a}{\sim} N(0,1) \tag{7}$$

$\varphi^*(q)$ represents the heteroscedasticity consistent asymptotic variance of the variance ratio and is defined as:

$$\phi^*(q) = \sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q} \right]^2 \hat{\delta}(j) \tag{8}$$

where:

$$\hat{\delta}(j) = \frac{\sum_{t=j+1}^{nq} (X_t - X_{t-1} - \hat{\mu})^2 (X_{t-j} - X_{t-j-1} - \hat{\mu})^2}{\left[\sum_{k=1}^{nq} (X_t - X_{t-1} - \hat{\mu})^2 \right]^2} \tag{9}$$

As stock returns are often non-normally distributed and heteroscedastic, Lo and MacKinlay (1988) define $Z^*(q)$ as:

$$Z^*(q) = \frac{VR(q)-1}{[\phi^*(q)]^{\frac{1}{2}}} \overset{a}{\sim} N(0,1) \tag{10}$$

In this study we estimate variance ratios at two-, three-, four-, five-, ten- and twenty-day frequencies.

Chow and Denning (1993) argue that the RWT requires that all variance ratios across all aggregate observations should be equal to one. Therefore, they develop a joint variance ratio test of the null hypothesis of the RWT with multiple comparisons of all selected variance ratio estimates that are equal to one. The CD multiple variance ratio test is a modification of the standard variance ratio test designed by Lo and MacKinlay (1988). Chow and Denning (1993) demonstrate that it is only necessary to consider the largest absolute value of the test statistic. The maximum heteroscedasticity consistent test statistic is defined as:

$$Z_2^*(q) = \max_{1 \le i \le m} \left| Z^*(q_i) \right| \tag{11}$$

where the confidence interval of at least 100(1-α) per cent for the extreme statistic is:

$$Z_2^*(q) \pm SMM(\alpha; m; \infty) \tag{12}$$

SMM$(\alpha; m; \infty)$ is the asymptotic critical value of the α-point of Studentized Maximum Modulus (SMM) distribution with m (number of variance ratios) and ∞ (sample size) degrees of freedom. The SMM can also be calculated from the conventional standard normal distribution as displayed in Equation 15. Chow and Denning (1993) also note that the SMM table can be found in Hahn and Hendrickson (1971) and Stolin and Ury (1979).

$$SMM(\alpha; m; \infty) = Z_{\alpha+/2} \tag{13}$$

where:

$$\alpha^+ = 1 - (1 - \alpha)^{1/m} \tag{14}$$

The multiple variance ratio test statistic at the 5 per cent significance level for six variance ratios and ∞ degrees of freedom is calculated to ± 2.632.[7] Therefore, the CD maximum test statistic can be compared to results from the LM conventional variance ratio tests. If the value for $Z^*(q)$ is greater than the SMM critical value of 2.632, then the RWT is rejected.

RESULTS

As discussed in the previous section, in order to test for predictability we specify three separate tests: ACFs, the LM variance ratio test, and the CD multiple variance ratio test. In this section of the paper we report results for each of these tests for equally weighted size decile portfolios across four eleven-year time periods.

ACF Tests

Table 2 displays the ACFs as well as the corresponding Q-statistics for the equally weighted deciles for the entire sample period. The autocorrelation coefficients and Q-statistics are reported at various lags ranging from one to twenty. Studies such as Lo and MacKinlay (1988), Poterba and Summers (1988) and Lovatt et al. (2007) have shown that equity data may display significant positive autocorrelation in the short term. The deciles show strong signs of autocorrelation, as evidenced by their Q-statistics, which are significant at the 1 per cent level across all deciles and over all lags. The fifth to eighth deciles report the highest autocorrelation coefficients and Q-statistics. For example, in the seventh equally weighted decile, 33.8 per cent of returns are explained by the previous day's returns. The highly significant

TABLE 2: AUTOCORRELATIONS OF CONTINUOUSLY COMPOUNDED DAILY RETURNS FROM 1 JANUARY 1965 TO 31 DECEMBER 2007 (Q-STATISTICS)

Panel A	**Autocorrelations of Continuously Compounded Equally Weighted Daily Returns**						
Lags	*1*	*2*	*3*	*4*	*5*	*10*	*20*
Decile 1	0.212	0.145	0.133	0.151	0.126	0.144	0.100
	(503.5)***	(738.4)***	(937.7)***	(1192)***	(1369.4)***	(2155)***	(2910.8)***
Decile 2	0.249	0.196	0.150	0.168	0.145	0.158	0.117
	(694.9)***	(1126.1)***	(1377.9)***	(1694.4)***	(1929.9)***	(2866.1)***	(3816.3)***
Decile 3	0.258	0.180	0.137	0.154	0.132	0.137	0.102
	(748.2)***	(1112.3)***	(1323.4)***	(1587.8)***	(1782.2)***	(2509.5)***	(3288.8)***
Decile 4	0.294	0.190	0.143	0.151	0.132	0.134	0.096
	(968.5)***	(1372.6)***	(1601.3)***	(1856.1)***	(2051)***	(2813.7)***	(3461.1)***
Decile 5	0.331	0.202	0.160	0.155	0.141	0.124	0.075
	(1227.6)***	(1685.2)***	(1973.9)***	(2244.2)***	(2466.6)***	(3193.5)***	(3814.5)***
Decile 6	0.332	0.203	0.157	0.149	0.139	0.133	0.064
	(1234.7)***	(1697.7)***	(1975.2)***	(2224.2)***	(2439.9)***	(3119.6)***	(3629)***
Decile 7	0.338	0.191	0.143	0.132	0.122	0.122	0.064
	(1281.5)***	(1692.4)***	(1922.1)***	(2119.1)***	(2285.6)***	(2832.9)***	(3243.7)***
Decile 8	0.320	0.164	0.139	0.126	0.112	0.114	0.050
	(1146.7)***	(1448.2)***	(1664)***	(1842.2)***	(1982.2)***	(2384.1)***	(2660)***
Decile 9	0.242	0.091	0.079	0.081	0.063	0.085	0.045
	(659.3)***	(753.2)***	(822.9)***	(897.1)***	(942.1)***	(1115.1)***	(1226.6)***
Decile 10	0.085	0.018	0.023	0.039	0.002	0.047	0.049
	(80.3)***	(84)***	(89.8)***	(107)***	(107)***	(148.3)***	(204.1)***
Full Sample	*0.321*	*0.178*	*0.145*	*0.153*	*0.126*	*0.138*	*0.079*
	*(1154.8)****	*(1512.3)****	*(1749.3)****	*(2011.6)****	*(2189.8)****	*(2870.6)****	*(3414.7)****

Note: *** indicates significance at the 1% level

Q-statistics support rejection of the null hypothesis that UK stocks follow a random walk over the sample period.

Separating the sample into four sub-samples helps to determine if autocorrelation coefficients are consistent across all time periods. The equally weighted decile ACF and Q-statistics for the period 1965–1974 are reported in Table 3, Panel A. Panel B contains the 1975–1985 period results, while Panels C and D display the results for 1986–1996 and 1997–2007 respectively.

In Table 3, Panel A, all Q-statistics reported across all deciles and lags are significant at the 1 per cent level. The deciles that report the highest Q-statistics for the first four lags are the fifth to eighth deciles. This suggests that mid- to large sized equities have the highest level of autocorrelation. Comparing deciles, the sixth decile reports the highest level of autocorrelation at 34.1 per cent. However, examining the tenth and twentieth lags, it appears that smaller securities have higher autocorrelations and Q-statistics. For the second time period, 1975–1985, the autocorrelation coefficients are all shown to be positive and significant. The fourth decile reports the highest first order autocorrelation coefficient of 44.8 per cent. Compared to Panel A in the second period, it appears that the autocorrelation coefficients are higher in the lower lags. In Panel C, the tenth decile has negative autocorrelations of -3.6 per cent and -2.1 per cent in the first two lags. These are both significant at the 10 per cent level. For the fourth and final time period, 1997–2007, the equally weighted portfolio's autocorrelations are positive and significant at the 1 per cent level across all lags and all deciles, with the exception of the tenth decile. The tenth decile reports insignificant autocorrelations in the first two lags and significant negative autocorrelation coefficients for lags 3 and 5, 10 and 20.

The results in Table 3 provide evidence that a considerable proportion of the variation of current day returns is predictable from past returns, supporting findings in the literature (see Lovatt et al., 2007). For example, for the full sample portfolios between 25 per cent (1986–1996) and 42 per cent (1975–1996) of the variation of current day returns is predictable from prior day returns. At longer lags, between 4 per cent (1997–2007) and 11 per cent (1965–1974) of the variation in current day returns is predictable from the returns from twenty days previously. These results provide early evidence that UK equity returns do not appear to follow a random walk.

Variance Ratio Tests

The homoscedasticity and heteroscedasticity consistent variance ratios for the equally weighted portfolios within the entire sample period are reported in Panels A and B of Table 4 respectively. Examining the homoscedastic consistent variance ratios, the results suggest that predictability is evident across all deciles at every number of q base observations. The deciles with the highest homoscedasticity consistent test statistics are generally the sixth to the eight deciles. The tenth decile reports significant variance ratios; however, unlike the rest of the deciles, the variance ratios are negative, indicating mean reversion. The highly significant $Z(q)$ values for all deciles and for the full sample supports a rejection of the null hypothesis that UK equity returns follow a random walk.

Table 4, Panel B reports the results using the heteroscedasticity consistent test statistics for the equally weighted portfolios. The results are weaker than the results

TABLE 3: AUTOCORRELATIONS OF CONTINUOUSLY COMPOUNDED DAILY RETURNS FOR SUB-SAMPLE PERIODS (Q-STATISTICS)

	Panel A							Panel B						
	Autocorrelations of Equally Weighted Continuously Compounded Daily Returns 1965–1974							Autocorrelations of Equally Weighted Continuously Compounded Daily Returns 1975–1985						
Lags	*1*	*2*	*3*	*4*	*5*	*10*	*20*	*1*	*2*	*3*	*4*	*5*	*10*	*20*
Decile 1	0.167	0.118	0.103	0.089	0.205	0.246	0.179	0.331	0.234	0.184	0.127	0.123	0.098	0.085
	(72.9)***	(109.2)***	(137.1)***	(157.8)***	(267.4)***	(510.2)***	(763.5)***	(314)***	(471)***	(568.9)***	(615.2)***	(658.7)***	(753.1)***	(843.6)***
Decile 2	0.238	0.168	0.132	0.121	0.261	0.212	0.231	0.376	0.241	0.163	0.074	0.089	0.132	0.089
	(147.4)***	(221.3)***	(266.8)***	(305)***	(482.9)***	(701.9)***	(1005.6)***	(406.7)***	(573.1)***	(649.7)***	(665.3)***	(687.9)***	(788.3)***	(905.4)***
Decile 3	0.272	0.179	0.140	0.118	0.245	0.240	0.179	0.429	0.254	0.180	0.098	0.079	0.104	0.086
	(193.1)***	(276.6)***	(327.9)***	(364.3)***	(521.4)***	(766.8)***	(1105.2)***	(528.3)***	(714.4)***	(807.9)***	(835.3)***	(853.5)***	(905.9)***	(991.9)***
Decile 4	0.303	0.188	0.123	0.130	0.242	0.198	0.140	0.448	0.228	0.165	0.086	0.060	0.099	0.071
	(240.3)***	(332.4)***	(371.7)***	(415.6)***	(568.7)***	(791.5)***	(1025.8)***	(577.7)***	(727.7)***	(806.2)***	(827.4)***	(837.8)***	(887)***	(940.6)***
Decile 5	0.328	0.185	0.120	0.102	0.230	0.168	0.089	0.433	0.233	0.184	0.091	0.067	0.075	0.063
	(281.5)***	(371.1)***	(408.6)***	(436)***	(574)***	(740.2)***	(913.4)***	(537.4)***	(693.6)***	(791)***	(814.6)***	(827.5)***	(868.7)***	(924.2)***
Decile 6	0.341	0.192	0.106	0.098	0.218	0.165	0.075	0.401	0.203	0.184	0.084	0.070	0.097	0.053
	(303)***	(399.6)***	(428.7)***	(453.8)***	(577.7)***	(730.7)***	(909.7)***	(463)***	(581.2)***	(678.4)***	(698.6)***	(712.8)***	(752)***	(799.9)***
Decile 7	0.339	0.176	0.094	0.093	0.180	0.156	0.080	0.389	0.157	0.141	0.055	0.058	0.103	0.083
	(300.7)***	(381.2)***	(404.5)***	(426.9)***	(511.8)***	(637.7)***	(791.2)***	(434.7)***	(505.5)***	(562.5)***	(571.3)***	(580.9)***	(627.5)***	(680)***
Decile 8	0.318	0.152	0.095	0.087	0.172	0.127	0.048	0.352	0.121	0.134	0.073	0.044	0.117	0.074
	(264.3)***	(324.8)***	(348.3)***	(367.9)***	(445.7)***	(544)***	(664.5)***	(355.5)***	(397.9)***	(449.4)***	(464.5)***	(470.1)***	(520.5)***	(574.3)***
Decile 9	0.277	0.115	0.068	0.056	0.141	0.104	0.051	0.289	0.061	0.097	0.052	0.030	0.115	0.081
	(200.9)***	(235.7)***	(247.9)***	(255.9)***	(307.7)***	(366.2)***	(429.1)***	(240.5)***	(251.3)***	(278.3)***	(286)***	(288.7)***	(338.2)***	(389.6)***
Decile 10	0.200	0.055	0.006	0.029	0.045	0.075	0.054	0.189	0.034	0.078	0.038	0.000	0.094	0.050
	(104.9)***	(112.8)***	(112.9)***	(115.1)***	(120.3)***	(146.4)***	(182.5)***	(102.4)***	(105.8)***	(123.1)***	(127.3)***	(127.3)***	(162.9)***	(182.2)***
Full	*0.313*	*0.169*	*0.107*	*0.106*	*0.226*	*0.195*	*0.110*	*0.419*	*0.185*	*0.173*	*0.091*	*0.059*	*0.122*	*0.082*
Sample	*(255)****	*(329.9)****	*(359.6)****	*(388.7)****	*(522.3)****	*(701.4)****	*(908.6)****	*(503.5)****	*(602.2)****	*(688.3)****	*(712.2)****	*(722.2)****	*(789.9)****	*(862.3)****

(*Continued*)

TABLE 3: (*CONTINUED*)

	Panel C							Panel D						
	Autocorrelations of Equally Weighted Continuously Compounded Daily Returns 1986–1996							Autocorrelations of Equally Weighted Continuously Compounded Daily Returns 1997–2007						
Lags	*1*	*2*	*3*	*4*	*5*	*10*	*20*	*1*	*2*	*3*	*4*	*5*	*10*	*20*
Decile 1	0.201	0.126	0.121	0.185	0.079	0.133	0.084	0.164	0.111	0.112	0.122	0.120	0.099	0.058
	(115.6)***	(161.3)***	(203.3)***	(301.9)***	(319.8)***	(565.4)***	(804)***	(77.5)***	(112.7)***	(148.8)***	(191.7)***	(233.3)***	(361)***	(468.2)***
Decile 2	0.171	0.161	0.109	0.200	0.078	0.142	0.080	0.271	0.212	0.186	0.179	0.163	0.123	0.071
	(83.7)***	(158.3)***	(192.3)***	(307.3)***	(324.7)***	(593)***	(840.7)***	(210.3)***	(339.4)***	(438.4)***	(530.5)***	(606.9)***	(836.8)***	(1057.4)***
Decile 3	0.167	0.136	0.090	0.199	0.061	0.102	0.066	0.216	0.157	0.136	0.133	0.141	0.091	0.063
	(80.1)***	(133)***	(156.5)***	(270.3)***	(281)***	(536.8)***	(745.5)***	(134)***	(204.5)***	(258)***	(308.5)***	(366)***	(508.1)***	(653.9)***
Decile 4	0.209	0.163	0.109	0.205	0.080	0.133	0.082	0.239	0.171	0.163	0.132	0.135	0.082	0.069
	(125.1)***	(201.9)***	(236.1)***	(357.5)***	(376)***	(677.4)***	(882.8)***	(164.6)***	(248.6)***	(325)***	(375.2)***	(427.9)***	(609.1)***	(756)***
Decile 5	0.245	0.187	0.146	0.217	0.107	0.126	0.063	0.310	0.185	0.175	0.186	0.149	0.108	0.063
	(172)***	(272.4)***	(333.9)***	(469.3)***	(502.4)***	(825.6)***	(1058)***	(276.7)***	(375.3)***	(463)***	(562)***	(625.6)***	(864.4)***	(1052.1)***
Decile 6	0.250	0.209	0.158	0.229	0.107	0.147	0.062	0.315	0.194	0.165	0.173	0.156	0.105	0.052
	(179.5)***	(305.1)***	(377.2)***	(528.6)***	(561.5)***	(905.7)***	(1130.4)***	(285.6)***	(393.8)***	(472.4)***	(558)***	(628)***	(879.4)***	(1013.9)***
Decile 7	0.275	0.227	0.163	0.232	0.122	0.134	0.045	0.320	0.210	0.171	0.169	0.127	0.083	0.012
	(217.3)***	(365.2)***	(441.4)***	(596.4)***	(639)***	(956.3)***	(1158.1)***	(293.4)***	(420.1)***	(504.4)***	(586.3)***	(632.7)***	(821.1)***	(914.6)***
Decile 8	0.299	0.192	0.154	0.217	0.110	0.125	0.030	0.283	0.201	0.172	0.152	0.124	0.066	0.011
	(256.5)***	(362.6)***	(430.8)***	(566.5)***	(601.4)***	(810.3)***	(925)***	(230)***	(346)***	(430.8)***	(497.4)***	(541.9)***	(670.7)***	(722.6)***
Decile 9	0.217	0.098	0.084	0.138	0.063	0.088	0.013	0.165	0.096	0.055	0.087	0.028	0.022	0.009
	(134.9)***	(162.6)***	(182.7)***	(237.1)***	(248.5)***	(316.7)***	(354.2)***	(78.3)***	(104.8)***	(113.5)***	(135.1)***	(137.4)***	(172)***	(194)***
Decile 10	-0.036	-0.021	0.053	0.055	0.002	0.043	0.086	0.020	0.010	-0.047	0.029	-0.037	-0.019	-0.004
	(3.7)*	(5)*	(13)***	(21.6)***	(21.6)***	(31.9)***	(81.2)***	(1.1)	(1.4)	(7.7)*	(10.2)**	(14.1)**	(23.4)***	(42.7)***
Full	*0.242*	*0.152*	*0.124*	*0.210*	*0.084*	*0.126*	*0.057*	*0.309*	*0.200*	*0.168*	*0.181*	*0.130*	*0.089*	*0.044*
Sample	*(167.9)****	*(234)****	*(277.8)****	*(404.2)****	*(424.4)****	*(675.7)****	*(855.2)****	*(273.9)****	*(388.3)****	*(469.3)****	*(563.2)****	*(611.7)****	*(835.1)****	*(975.7)****

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively from Panel A but still support a rejection of the RWT. Deciles 1 and 4–9 and the full sample are statistically significant across all aggregate observations. Deciles 6–9 report the highest associated test statistic across all aggregate observations. The variance ratio of Decile 10 is negative and statistically insignificant for all values of q, suggesting that the largest of the UK equities do not show signs of predictability over the sample period. Lo and MacKinlay (1988) report similar results for large capitalisation stocks in the US. Deciles 2–4 do not show signs of significance until the lagged observations are at least four days.

TABLE 4: VARIANCE RATIOS FOR CONTINUOUSLY COMPOUNDED DAILY RETURNS FOR UK EQUITIES RETURNS AT VARIOUS AGGREGATIONS, 1 JANUARY 1965 TO 31 DECEMBER 2007 FOR 10 EQUALLY WEIGHED PORTFOLIOS

Panel A	**Variance Ratio Test Under Homoscedastic Conditions Time Series Equally Weighted**					
	Number (q) of base observations aggregated to form variance ratio					
	2	*3*	*4*	*5*	*10*	*20*
Decile 1	1.18	1.32	1.44	1.59	2.14	3.14
	(19.03)***	(22.54)***	(25.16)***	(28.56)***	(35.83)***	(45.57)***
Decile 2	1.15	1.29	1.40	1.55	2.05	2.99
	(16.00)***	(20.92)***	(22.77)***	(26.4)***	(33.03)***	(42.47)***
Decile 3	1.14	1.26	1.36	1.50	1.99	2.84
	(15.01)***	(18.75)***	(20.4)***	(24.00)***	(30.98)***	(39.28)***
Decile 4	1.19	1.35	1.47	1.62	2.18	3.11
	(20.32)***	(24.55)***	(26.49)***	(29.74)***	(36.94)***	(44.95)***
Decile 5	1.23	1.42	1.57	1.74	2.41	3.42
	(24.69)***	(29.73)***	(32.24)***	(35.96)***	(44.22)***	(51.60)***
Decile 6	1.24	1.44	1.61	1.79	2.50	3.55
	(25.58)***	(31.37)***	(34.51)***	(38.29)***	(47.08)***	(54.25)***
Decile 7	1.28	1.51	1.71	1.90	2.63	3.67
	(29.66)***	(36.48)***	(39.95)***	(43.49)***	(51.26)***	(56.98)***
Decile 8	1.28	1.50	1.69	1.87	2.54	3.39
	(29.90)***	(35.56)***	(38.90)***	(41.98)***	(48.32)***	(51.01)***
Decile 9	1.14	1.24	1.31	1.38	1.62	1.93
	(14.58)***	(16.77)***	(17.47)***	(18.4)***	(19.30)***	(19.80)***
Decile 10	0.95	0.93	0.91	0.90	0.87	0.90
	(-5.27)***	(-5.29)***	(-5.29)***	(-4.62)***	(-3.98)***	(-2.14)**
Full Sample	*1.25*	*1.44*	*1.59*	*1.76*	*2.40*	*3.38*
	*(26.67)****	*(31.01)****	*(33.44)****	*(36.75)****	*(43.97)****	*(50.68)****

(*Continued*)

TABLE 4: (*CONTINUED*)

Panel B	**Variance Ratio Test Under Heteroscedastic Conditions Time Series Equally Weighted**					
Decile 1	1.18	1.32	1.44	1.59	2.14	3.14
	(2.38)**	(3.03)***	(3.60)***	(4.23)***	(5.86)***	(8.51)***
Decile 2	1.15	1.29	1.40	1.55	2.05	2.99
	(1.06)	(1.49)	(1.72)*	(2.06)**	(2.82)***	(4.21)***
Decile 3	1.14	1.26	1.36	1.50	1.99	2.84
	(0.97)	(1.30)	(1.50)	(1.84)*	(2.7)***	(4.01)***
Decile 4	1.19	1.35	1.47	1.62	2.18	3.11
	(1.73)*	(2.24)**	(2.56)**	(2.96)***	(4.01)***	(5.65)***
Decile 5	1.23	1.42	1.57	1.74	2.41	3.42
	(2.23)**	(2.87)***	(3.30)***	(3.78)***	(5.00)***	(6.63)***
Decile 6	1.24	1.44	1.61	1.79	2.50	3.55
	(3.12)***	(4.04)***	(4.69)***	(5.31)***	(6.9)***	(9.06)***
Decile 7	1.28	1.51	1.71	1.90	2.63	3.67
	(4.57)***	(5.85)***	(6.67)***	(7.41)***	(9.27)***	(11.69)***
Decile 8	1.28	1.50	1.69	1.87	2.54	3.39
	(5.75)***	(7.27)***	(8.43)***	(9.36)***	(11.48)***	(13.68)***
Decile 9	1.14	1.24	1.31	1.38	1.62	1.93
	(4.77)***	(5.66)***	(6.06)***	(6.5)***	(7.18)***	(7.87)***
Decile 10	0.95	0.93	0.91	0.90	0.87	0.90
	(-1.37)	(-1.48)	(-1.57)	(-1.44)	(-1.44)	(-0.86)
Full Sample	*1.25*	*1.44*	*1.59*	*1.76*	*2.40*	*3.38*
	*(2.73)****	*(3.42)****	*(3.95)****	*(4.51)****	*(5.98)****	*(8.03)****

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively

Multiple Variance Ratio Test

In this section, we provide results from the CD multiple variance ratio test, which is a sterner test of predictability. Below we also outline instances where, according to the CD test, the results for the LM variance ratio test would be due to inference errors.

Results under heteroscedastic conditions are reported in Table 5. It appears that only the mid- to large sized equities have signs of predictability in their returns. The sixth to ninth deciles and the full sample are significant across all aggregated observations. The smaller portfolios, first to fifth deciles, all report insignificant variance ratios, as well as variance ratios that are incorrectly reported as significant under the LM variance ratio tests.

Separation of the sample into four sub-samples is performed in order to determine if the results from the joint variance ratio test are consistent across all sample time periods. The results for each time period are reported in Table 6, Panels A to D. Applying the joint variance ratio test to the first two time periods, 1965–1974 (Panel A) and 1975–1986 (Panel B), there is almost no deviation from the results using an LM variance ratio test. In each time period, all portfolios at levels of aggregated observations are significant according to the SMM critical value. Predictability is evident across all portfolios during the first two time periods.

TABLE 5: MULTIPLE VARIANCE RATIOS FOR CONTINUOUSLY COMPOUNDED DAILY RETURNS FOR UK EQUITIES RETURNS AT VARIOUS AGGREGATIONS FOR 10 EQUALLY WEIGHTED DECILES FROM 1 JANUARY 1965 TO 31 DECEMBER 2007 UNDER HETEROSCEDASTIC CONDITIONS

Panel A	**Variance Ratio Test Equally Weighted Time Series**					
	Number (q) of base observations aggregated to form variance ratio					
	2	*3*	*4*	*5*	*10*	*20*
Decile 1	1.18	1.32	1.44	1.59	2.14	3.14
	(2.38)[b]	(3.03)[a]	(3.60)[a]	(4.23)[a]	(5.86)[a]	(8.51)[a]
Decile 2	1.15	1.29	1.40	1.55	2.05	2.99
	(1.06)	(1.49)	(1.72)	(2.06)[b]	(2.82)[a]	(4.21)[a]
Decile 3	1.14	1.26	1.36	1.50	1.99	2.84
	(0.97)	(1.30)	(1.50)	(1.84)	(2.7)[a]	(4.01)[a]
Decile 4	1.19	1.35	1.47	1.62	2.18	3.11
	(1.73)	(2.24)[b]	(2.56)[b]	(2.96)[a]	(4.01)[a]	(5.65)[a]
Decile 5	1.23	1.42	1.57	1.74	2.41	3.42
	(2.23)[b]	(2.87)[a]	(3.3)[a]	(3.78)[a]	(5)[a]	(6.63)[a]
Decile 6	1.24	1.44	1.61	1.79	2.5	3.55
	(3.12)[a]	(4.04)[a]	(4.69)[a]	(5.31)[a]	(6.9)[a]	(9.06)[a]
Decile 7	1.28	1.51	1.71	1.9	2.63	3.67
	(4.57)[a]	(5.85)[a]	(6.67)[a]	(7.41)[a]	(9.27)[a]	(11.69)[a]
Decile 8	1.28	1.5	1.69	1.87	2.54	3.39
	(5.75)[a]	(7.27)[a]	(8.43)[a]	(9.36)[a]	(11.48)[a]	(13.68)[a]
Decile 9	1.14	1.24	1.31	1.38	1.62	1.93
	(4.77)[a]	(5.66)[a]	(6.06)[a]	(6.5)[a]	(7.18)[a]	(7.87)[a]
Decile 10	0.95	0.93	0.91	0.9	0.87	0.9
	(-1.37)	(-1.48)	(-1.57)	(-1.44)	(-1.44)	(-0.86)
Full Sample	*1.25*	*1.44*	*1.59*	*1.76*	*2.4*	*3.38*
	(2.73)[a]	*(3.42)*[a]	*(3.95)*[a]	*(4.51)*[a]	*(5.98)*[a]	*(8.03)*[a]

Notes: [a] The corresponding variance ratios are statistically different from 1 at the 5 per cent level when compared with the SMM critical value of 2.632

[b] Inference error in which the test statistics are significant according to the standard normal critical value but are jointly insignificant

TABLE 6: MULTIPLE VARIANCE RATIOS FOR CONTINUOUSLY COMPOUNDED DAILY RETURNS FOR UK EQUITY RETURNS AT VARIOUS AGGREGATIONS FOR 10 EQUALLY AND VALUE-WEIGHTED DECILES UNDER HETEROSCEDASTIC CONDITIONS

	Panel A						Panel B					
	Variance Ratio Test under Heteroscedastic Conditions from 1 January 1965 to 31 December 1974 Time Series Equally Weighted						**Variance Ratio Test under Heteroscedastic Conditions from 1 January 1975 to 31 December 1985 Time Series Equally Weighted**					
	Number (q) of base observations aggregated to form variance ratio						*Number (q) of base observations aggregated to form variance ratio*					
	2	*3*	*4*	*5*	*10*	*20*	*2*	*3*	*4*	*5*	*10*	*20*
Decile 1	1.37	1.7	1.97	2.2	3.35	5.18	1.21	1.38	1.51	1.61	1.92	2.59
	(7.66)[a]	(9.77)[a]	(11.22)[a]	(12.37)[a]	(17.5)[a]	(22.79)[a]	(5.2)[a]	(6.62)[a]	(7.16)[a]	(7.42)[a]	(7.76)[a]	(9.82)[a]
Decile 2	1.46	1.83	2.13	2.4	3.59	5.32	1.35	1.6	1.77	1.87	2.15	2.87
	(6.69)[a]	(8.62)[a]	(10.04)[a]	(11.29)[a]	(15.52)[a]	(19.3)[a]	(8.27)[a]	(9.25)[a]	(9.4)[a]	(9.19)[a]	(8.66)[a]	(10.78)[a]
Decile 3	1.44	1.77	2.04	2.28	3.26	4.86	1.36	1.63	1.81	1.92	2.16	2.67
	(7.96)[a]	(9.58)[a]	(10.65)[a]	(11.56)[a]	(14.57)[a]	(18.27)[a]	(9.04)[a]	(10.1)[a]	(10.24)[a]	(10.06)[a]	(9.15)[a]	(9.96)[a]
Decile 4	1.43	1.74	1.97	2.17	3.11	4.51	1.41	1.68	1.86	1.97	2.23	2.64
	(6.71)[a]	(8.17)[a]	(9.05)[a]	(9.89)[a]	(13.04)[a]	(15.95)[a]	(8.98)[a]	(9.75)[a]	(9.83)[a]	(9.65)[a]	(8.83)[a]	(9.32)[a]
Decile 5	1.42	1.71	1.92	2.1	2.86	3.96	1.38	1.64	1.84	1.97	2.34	2.8
	(7.48)[a]	(8.78)[a]	(9.54)[a]	(10.15)[a]	(12.44)[a]	(14.62)[a]	(8.83)[a]	(9.87)[a]	(10.17)[a]	(10.17)[a]	(10.13)[a]	(10.77)[a]
Decile 6	1.42	1.71	1.91	2.07	2.8	3.91	1.37	1.62	1.81	1.95	2.34	2.82
	(7.63)[a]	(8.92)[a]	(9.5)[a]	(9.99)[a]	(12.2)[a]	(14.59)[a]	(8.42)[a]	(9.17)[a]	(9.44)[a]	(9.53)[a]	(9.86)[a]	(10.75)[a]
Decile 7	1.4	1.67	1.85	1.99	2.64	3.64	1.36	1.58	1.75	1.85	2.15	2.54
	(7.4)[a]	(8.59)[a]	(9.12)[a]	(9.56)[a]	(11.36)[a]	(13.45)[a]	(8.87)[a]	(9.56)[a]	(9.7)[a]	(9.57)[a]	(9.27)[a]	(9.63)[a]
Decile 8	1.39	1.65	1.83	1.98	2.64	3.64	1.31	1.5	1.65	1.74	2	2.31
	(7.37)[a]	(8.43)[a]	(8.99)[a]	(9.47)[a]	(11.42)[a]	(13.51)[a]	(7.61)[a]	(8.31)[a]	(8.57)[a]	(8.51)[a]	(8.26)[a]	(8.31)[a]
Decile 9	1.34	1.55	1.68	1.8	2.31	3.05	1.24	1.35	1.43	1.48	1.61	1.79
	(7.23)[a]	(8.04)[a]	(8.37)[a]	(8.7)[a]	(10.12)[a]	(11.47)[a]	(7.66)[a]	(7.73)[a]	(7.7)[a]	(7.4)[a]	(6.37)[a]	(5.96)[a]
Decile 10	1.25	1.37	1.43	1.48	1.7	2.11	1.14	1.2	1.25	1.3	1.37	1.45
	(7.41)[a]	(7.55)[a]	(7.15)[a]	(7.02)[a]	(6.96)[a]	(7.8)[a]	(5.51)[a]	(5.52)[a]	(5.69)[a]	(5.68)[a]	(4.74)[a]	(3.91)[a]
Full Sample	*1.43*	*1.72*	*1.92*	*2.11*	*2.91*	*4.12*	*1.38*	*1.63*	*1.8*	*1.92*	*2.25*	*2.72*
	(7.15)[a]	*(8.39)[a]*	*(9.08)[a]*	*(9.72)[a]*	*(12.17)[a]*	*(14.64)[a]*	*(8.92)[a]*	*(9.8)[a]*	*(10.09)[a]*	*(10.06)[a]*	*(9.81)[a]*	*(10.51)[a]*

(*Continued*)

TABLE 6: (*CONTINUED*)

	Panel C						Panel D					
	Variance Ratio Test under Heteroscedastic Conditions from 1 January 1986 to 31 December 1996 Time Series Equally Weighted						**Variance Ratio Test under Heteroscedastic Conditions from 1 January 1997 to 31 December 2007 Time Series Equally Weighted**					
	Number (q) of base observations aggregated to form variance ratio						*Number (q) of base observations aggregated to form variance ratio*					
	2	*3*	*4*	*5*	*10*	*20*	*2*	*3*	*4*	*5*	*10*	*20*
Decile 1	1.17	1.29	1.40	1.54	2.06	3.04	1.2	1.37	1.53	1.68	2.32	3.35
	(1.53)	(1.90)	(2.23)[b]	(2.67)[a]	(3.72)[a]	(5.59)[a]	(5.1)[a]	(6.52)[a]	(7.7)[a]	(8.73)[a]	(11.68)[a]	(14.93)[a]
Decile 2	1.14	1.27	1.37	1.51	2.01	2.95	1.25	1.46	1.64	1.81	2.46	3.54
	(0.87)	(1.23)	(1.42)	(1.74)	(2.43)[b]	(3.69)[a]	(4.41)[a]	(5.53)[a]	(6.19)[a]	(6.82)[a]	(8.81)[a]	(11.04)[a]
Decile 3	1.13	1.24	1.33	1.47	1.96	2.84	1.17	1.32	1.45	1.57	2.11	2.93
	(0.75)	(1.02)	(1.18)	(1.48)	(2.23)[b]	(3.4)[a]	(3.96)[a]	(5.08)[a]	(5.89)[a]	(6.57)[a]	(9.2)[a]	(11.31)[a]
Decile 4	1.18	1.33	1.44	1.59	2.17	3.15	1.2	1.35	1.5	1.63	2.18	3.03
	(1.27)	(1.65)	(1.88)	(2.22)[b]	(3.1)[a]	(4.47)[a]	(4.21)[a]	(5.15)[a]	(6.01)[a]	(6.65)[a]	(9)[a]	(11.42)[a]
Decile 5	1.21	1.38	1.53	1.71	2.4	3.47	1.28	1.47	1.63	1.79	2.44	3.43
	(1.49)	(1.98)[b]	(2.30)[b]	(2.70)[a]	(3.73)[a]	(5.07)[a]	(5.5)[a]	(6.36)[a]	(7)[a]	(7.7)[a]	(9.91)[a]	(12.2)[a]
Decile 6	1.22	1.42	1.59	1.79	2.54	3.7	1.26	1.45	1.62	1.77	2.43	3.32
	(1.88)	(2.52)[b]	(2.98)[a]	(3.46)[a]	(4.65)[a]	(6.32)[a]	(5.61)[a]	(6.84)[a]	(7.71)[a]	(8.56)[a]	(11.47)[a]	(13.65)[a]
Decile 7	1.26	1.49	1.69	1.9	2.73	3.93	1.3	1.53	1.72	1.9	2.56	3.48
	(2.27)[b]	(3.04)[a]	(3.54)[a]	(4.05)[a]	(5.34)[a]	(7.04)[a]	(7.31)[a]	(8.84)[a]	(9.76)[a]	(10.59)[a]	(12.83)[a]	(14.59)[a]
Decile 8	1.3	1.52	1.71	1.92	2.67	3.67	1.26	1.48	1.66	1.83	2.45	3.2
	(3.03)[a]	(3.82)[a]	(4.42)[a]	(5)[a]	(6.25)[a]	(7.74)[a]	(6.9)[a]	(8.64)[a]	(9.88)[a]	(10.86)[a]	(13.59)[a]	(15.14)[a]
Decile 9	1.14	1.24	1.32	1.41	1.74	2.17	1.13	1.23	1.3	1.37	1.57	1.85
	(2.13)[b]	(2.64)[a]	(3.07)[a]	(3.48)[a]	(4.52)[a]	(5.64)[a]	(4.15)[a]	(4.85)[a]	(5.04)[a]	(5.29)[a]	(5.5)[a]	(5.83)[a]
Decile 10	0.8	0.71	0.69	0.7	0.7	0.75	1.02	1.02	1.00	1	0.95	0.97
	(-2.07)[b]	(-2.21)[b]	(-2.04)[b]	(-1.85)	(-1.51)	(-1.08)	(0.69)	(0.59)	(0.07)	(-0.04)	(-0.6)	(-0.25)
Full Sample	*1.22*	*1.38*	*1.52*	*1.69*	*2.32*	*3.3*	*1.3*	*1.52*	*1.7*	*1.88*	*2.56*	*3.56*
	(1.55)	*(1.93)*	*(2.24)*[b]	*(2.64)*[a]	*(3.64)*[a]	*(5.05)*[a]	*(6.15)*[a]	*(7.45)*[a]	*(8.3)*[a]	*(9.11)*[a]	*(11.59)*[a]	*(13.83)*[a]

Notes: [a] The corresponding variance ratios are statistically different from 1 at the 5 per cent level when compared with the SMM critical value of 2.632
[b] Inference error in which the test statistics are significant according to the standard normal critical value but are jointly insignificant

Only the third time period fails to provide convincing evidence of predictability in UK equities. This period, 1986–1997, reports dramatically different results to those of the first two time periods. The results show that every portfolio, with the exception of the eight decile, has incorrectly significant LM variance ratios when utilising the SMM critical value. The seventh and ninth deciles report significant observations for a number of variance ratios; however, only the eighth decile has significant variance ratios across all aggregated observations. Evidence of predictability significantly decreases in this third time period.

Finally, in the most recent time period (1997–2007), reported in Panel D, all portfolios, with the exception of Decile 10, exhibit statistically significant signs of predictability. As with the LM variance ratio tests, Decile 10 variance ratios are statistically insignificant from zero using the CD multiple variance ratio test.

That the returns of different decile portfolios in different periods have statistically insignificant variance ratios is not surprising. Lo and MacKinlay (1988) report similar findings when their sample is disaggregated. As individual returns contain company-specific noise, this makes it difficult to detect the presence of predictable components. Aggregating the stock returns into portfolios filters much of the noise, evidenced by the consistent results for the full sample portfolio across time periods. However, at the decile level of aggregation some noise is likely to remain.

Overall, the evidence we present in this section of the paper suggests that equity returns do appear to be predictable. The evidence is strongest when predictability is measured using simple autocorrelation tests and LM variance ratios. When we estimate the more stringent CD multiple variance ratios, the evidence is weaker, but further analysis shows that this is driven by the 1986–1996 period, where for all tests there is considerably less evidence of predictability.

We also find considerable cross-sectional and cross-longitudinal variance in the results of our predictability measures. Evidence of predictability is strongest in the 1965–1985 and 1997–2007 periods. In the 1986–1996 period, the results are less clear. Cross-sectional evidence also shows that in some time periods the variance ratios are larger for small capitalisation stocks, whereas in others, it is the largest capitalisation stocks which appear most predictable.

Our evidence of predictability in UK equity returns is consistent with prior evidence for UK equities (Lovatt et al., 2007) and UK indices (Belaire-Franch and Opong, 2005). However, it is worth highlighting that the evidence for UK indices is mixed, with both Malliaropulos (1996) and Patro and Wu (2004) finding evidence supporting RWT in the UK, though both studies are less comprehensive than Belaire-Franch and Opong (2005).

These results raise implications for both researchers and practitioners. Though recent financial market events, such as the dot-com and housing bubbles, have cast doubt on RWT and EMH, they remain a cornerstone of finance theory. Our results provide evidence that would suggest a rejection of RWT. However, we do not consider transaction costs as part of our analysis so we can draw fewer conclusions relating to EMH.

From the perspective of a practitioner, the results should provide a guide to highlight the pitfalls of statistics-based trading strategies. By focusing on one group, such as large capitalisation stocks, in isolation, a practitioner will likely encounter periods of low profitability, perhaps due to unsystematic risks. Alternatively, taking a more diversified approach with a portfolio constructed across both small and large capitalisation stocks will likely insulate against these cross-sectional variations in predictability, taking advantage of systematic predictability. Another concern for the practitioner should be the longitudinal variation in predictability. In our analysis, the sub-sample from 1986 to 1996 was a period of relatively weak return predictability. Put simply, performance is likely to vary considerably over time.

CONCLUSION

This paper has clear practical implications for investors in equity market neutral hedge funds and managers pursuing statistical arbitrage strategies in equity markets. Despite the large losses reported for this group in 2007 and 2008, the strategies are based upon a sound premise – equity returns are, to a degree, predictable. Irrespective of measure, our results show strong evidence of return predictability.

The evidence reported in this paper, using the CD multiple variance ratio, our most stringent test, shows that in the early time periods, 1965–1974 and 1975–1985, all firm size deciles exhibit return predictability. It is reasonable to postulate that statistical arbitrage profitability in such an environment would be relatively high. However, in the 1986–1996 time period the results are quite different. Only in the large stock deciles (specifically Deciles 7–9) is return predictability evident. Again, we can deduce that this environment would be difficult for fund managers. Finally, in the 1997–2007 period, the environment becomes more favourable, and returns are predictable for the majority of stocks.

Because return predictability is both cross-sectionally and time variable, practitioners must be very flexible. These results demonstrate the challenges for a manager who bases a strategy on return predictability.

ENDNOTES

1 The financial support of the Irish Research Council for the Humanities and Social Sciences (IRCHSS) is gratefully acknowledged. We are also grateful to two anonymous referees for comments which have greatly improved the paper.

2 Barclay Group estimates: <http://www.barclaygrp.com/indices/ghs/mum/Equity_Market_Neutral.html>.

3 We calculate the stock returns adjusted for dividends from the stock return index, *RI*, provided by Datastream. Returns are calculated as:

$$\ln\left(\frac{RI_t}{RI_{t-1}}\right)$$

4 The concerns which have been raised by Ince and Porter (2006) amongst others about data errors in Datastream are mainly concentrated amongst small stocks and/or low price stocks. Dividing our sample into deciles provides a natural control for any remaining errors as these stocks will be mainly grouped in Decile 1. Readers concerned about the effect of these errors should focus their attention on the results for Deciles 2 to 10.

5 Holidays are omitted from the sample. If a stock return is missing for a particular day it is omitted from the aggregate and decile portfolio for that day.

6 As an additional robustness test, we also form value-weighted portfolios. The results for these portfolios are in line with the equally weighted results and are available from the authors on request.

7 SMM critical values can be taken from the standard normal *z* table; the 5 per cent SMM critical value is the *z*-value leaving an upper tail area of $0.5[1 - (1 - 0.05)^{1/k}]$ where *k* is the number of sampling intervals.
Upper Tail: 05 * (1 – (1 – 0.05) ^ (1/6)) = 0.004256
Lower Tail: 1 – 0.004256 = 0.99574
$\alpha^{+} = \pm 2.632$

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OPTIMAL STATISTICAL ARBITRAGE: A MODEL SPECIFICATION ANALYSIS ON ISEQ EQUITY DATA

Mark Cummins[1]
University of Limerick

ABSTRACT

A comprehensive empirical analysis of the novel optimal statistical arbitrage trading model of Bertram (2010) is performed on a dataset of stocks quoted on the Irish Stock Exchange. Evidence of significant errors on average in the key measures underlying the trading model is presented, reflecting the mis-specification of the underlying Gaussian Ornstein–Uhlenbeck (OU) process. Overestimation of the expected return per unit time measure and underestimation of the expected trade cycle time measure are most notable. It is further shown that the Bertram (2010) trading model is more robust to high mean reversion and/or volatility parameter estimates compared to two benchmark models based on the exact and approximate first-hitting time densities of Linetsky (2004) for an OU process.

INTRODUCTION

Statistical arbitrage trading strategies are commonly applied in industry to exploit the long-term statistical relationships that often exist between assets, with *pairs trading* being one of the most well-known applications. Cointegration techniques are generally used to formally establish the statistical relationships upon which various trading strategies may be designed. One of the key considerations in such strategies is the optimal choice of entry and exit levels for the trades. A directly related risk is the stochastic nature of the trade cycle time (i.e. the time between entering, exiting and subsequently re-entering a trade) for such trades.

A number of alternative studies in the area of statistical arbitrage trading have been conducted to date. Many of the papers focus on the design of statistical arbitrage trading rules and the resulting performance when applied to empirical data. These include Burgess (1999, 2000), Trapletti, Geyer and Leisch (2002), Vidyamurthy (2004), Whistler (2004), Elliott,Van Der Hoek and Malcolm (2005), Gatev, Goetzmann and Rouwenhorst (2006) and Do, Faff and Hamza (2006). Andrade, di Petro and Seasholes (2005), Papadakis and Wysocki (2007) and Do and Faff (2009) contribute to the literature by means of providing independent verification of the trading rule proposed by Gatev et al. (2006) and examining the sustainability of profits. Aldridge (2009), Bowen, Hutchinson and O'Sullivan (2010) and Dunis, Giorgini, Laws and Rudy (2010) consider the application of statistical arbitrage trading on high-frequency data. Kanamura, Rachev and Fabozzi (2010) use the approximate first-time hitting density formulation of Linetsky (2004) to develop a total profit model for pairs trading. Other papers of interest include Shleifer and Vishny (1997), Hogan, Jarrow, Teo and Warachka (2004) and Lin, McRae and Gulati (2006).

However, few of these papers deal directly with the issue of optimal entry and exit trading levels in the presence of stochastic trade cycle times. Vidyamurthy (2004) proposes an optimal entry level given by the maximum point on a profitability profile constructed as the product of probability estimates – obtained from counting the number of times each candidate entry level is exceeded – and the associated absolute profit levels. Vidyamurthy (2004) further proposes an exit level that lies through the long-run equilibrium level and of equal distance away as the entry level; this is to account for any potential trade *slippage*. Elliott et al. (2005) use first-passage time theory on the standard Ornstein–Uhlenbeck (OU) process to develop a framework for calculating the expected trade cycle time of a statistical arbitrage strategy, along with symmetric entry and exit boundaries. Do et al. (2006) similarly consider statistical arbitrage trading under an OU framework, drawing on asset pricing theory to inform the underlying statistical applications.

In contrast to the above papers, Bertram (2010) presents a novel approach to the issue of optimal statistical arbitrage trading. Specifically, modelling a given spread series as a mean-reverting OU process, analytic solutions are derived that allow for the optimal entry and exit levels to be determined through maximising either (i) the expected return *per unit time* or (ii) the associated *per unit time* Sharpe ratio. Considering the expected return and Sharpe ratio on a per unit time basis is a very important innovation of Bertram (2010). Statistical arbitrage trading strategies with defined entry and exit levels offer deterministic (log-) returns. However, uncertainty lies in the stochastic trade cycle times associated with such trades. The expected return per unit time is defined as the ratio of the deterministic return to the expected trade cycle time, with the definition of the Sharpe ratio following in a similar way. This normalisation explicitly accounts for the different deterministic returns and expected trade cycle times associated with alternative statistical arbitrage trading strategies defined by alternative entry and exit levels. Hence, the normalisation allows for consistent cross-comparison of alternative statistical arbitrage trading strategies.

The analytic solutions provide significant computational efficiencies, which are of particular advantage for the implementation of statistical arbitrage trading at a high frequency level. However, the underlying OU process being Gaussian only allows for a normal distribution for changes in the spread series. Whereas this allows for analytic solutions to determining optimal entry and exit levels, empirical data does not conform with the assumption of normality. This study contributes to the literature by means of performing a comprehensive model specification analysis of the optimal statistical arbitrage trading model of Bertram (2010) – herein referred to as the Bertram trading model – on a set of cointegrated pairs identified from the current (July 2010) listing of ISEQ stocks on the Irish Stock Exchange. The empirical analysis allows for the identification and quantification of model mis-specification errors in the Bertram trading model. That is, it looks to investigate the mis-specification error introduced in using a Gaussian OU process to describe non-Gaussian empirical cointegration spread series.

The paper further contributes by means of unifying the optimal statistical arbitrage trading criteria set out in the Bertram trading model with the first-hitting time density framework of Linetsky (2004) in order to develop two alternative trading models for benchmark purposes. The benchmark trading models are based on the *exact* and *approximate* first-hitting time density formulations of Linetsky (2004), defined under the OU model specification. The benchmark trading models provide insight into the superior stability of the Bertram trading model for cases where the speed of mean reversion and/or volatility parameters of the OU process are particularly high. The analysis, in presenting results for individual pairs, also helps to understand the sensitivity of the Bertram trading model to variations in the key parameters of the OU process. Furthermore, in implementing the benchmark trading model based on the approximate first-hitting time density of Linetsky (2004), the error introduced as a result of the approximation is investigated and quantified in the context of a trading application.

The remainder of the paper is organised as follows. The next section provides an overview of the optimal statistical arbitrage trading model of Bertram (2010) and discusses the benchmark models based on the first-hitting time density approach of Linetsky (2004). The following section discusses the ISEQ stock data and presents the cointegration and OU fitting results for the set of stock pairings used. The fourth and fifth sections respectively present the empirical analysis in the cases of maximising the expected return per unit time and maximising the Sharpe ratio. The final section concludes.

OPTIMAL STATISTICAL ARBITRAGE TRADING

Bertram (2010) approaches the issue of optimal statistical arbitrage trading by first assuming that the spread on two given asset log-prices, denoted s_t, is described by the following OU process:

$$ds_t = -\alpha s_t dt + \sigma dW_t \tag{1}$$

with $\alpha, \sigma < 0$ and W_t a Wiener process. This model by construction allows for mean reversion of the spread process s_t about a long-run mean level of zero, where the speed of the mean reversion is given by α.[2] The Wiener process, W_t, drives the randomness in the process, where, by definition, changes in the Wiener process,

dW_t, are normally distributed with mean zero and variance dt. The volatility parameter σ is a scaling parameter, which scales this variance to $\sigma^2 dt$. It is the normality of the Wiener that implies the normality of the spread process s_t.

Defining the entry and exit levels of the trading strategy by a and m respectively, a complete trade cycle is the time taken for the spread process to transition from the entry level a to the exit level m and then return back to the entry level a. Formally, the trade cycle time is defined as follows:

$$\mathrm{T} \equiv \mathrm{T}_{a\to m} + \mathrm{T}_{m\to a}$$

where $\mathrm{T}_{a\to m}$ is the time to transition from a to m and $\mathrm{T}_{m\to a}$ is the time to transition from m to a, and the independence of the two times follows from the Markovian property of the OU process. So, T is a random variable representing the complete trade cycle time for the statistical arbitrage trading strategy.

Given relative transaction costs c, the total log-return from one complete trade cycle is given by $r(a,m,c) \equiv m - a - c$. That is, the log-return is given as the difference between the exit level and entry level. Important to note is that this log-return is deterministic and known in advance, whereas the associated trade cycle time is stochastic, as already discussed. So, the time it takes to achieve this deterministic log-return is random and unknown in advance. In this context, Bertram (2010) proposes the concept of the expected return per unit time as follows:

$$\xi(a,m,c) \equiv \frac{r(a,m,c)}{E(\mathrm{T})}$$

where $E(\mathrm{T}) = E(\mathrm{T}_{a\to m}) + E(\mathrm{T}_{m\to a})$. That is, $\xi(a,m,c)$ is the ratio of the deterministic log-return to the expected trade cycle time. This normalisation explicitly accounts for the different deterministic log-returns and expected trade cycle times associated with alternative choices of the entry and exit levels. Therefore, the normalisation allows for consistent cross-comparison of the alternative statistical arbitrage trading strategies. Bertram (2010) further proposes a variance of return per unit time measure as follows:

$$\varsigma(a,m,c) \equiv \frac{r^2(a,m,c)V(\mathrm{T})}{E^3(\mathrm{T})}$$

where $V(\mathrm{T}) = V(\mathrm{T}_{a\to m}) + V(\mathrm{T}_{m\to a})$ is the variance of the trade cycle time.

Following a transformation of the OU process in Equation 1 to a dimensionless system, and drawing on the first-passage time theory of Thomas (1975), Sato (1977) and Ricciardi and Sato (1988), Bertram (2010) derives analytic expressions for $E(\mathrm{T})$, $V(\mathrm{T})$, $\xi(a,m,c)$ and $\varsigma(a,m,c)$. These analytic expressions involve standard mathematical tools; namely the imaginary error function, the gamma function and the digamma function. With these analytic results in place, it is shown that the optimal entry and exit levels a^* and m^* may be derived by maximising the expected return per unit time, $\xi(a,m,c)$. Solving for the optimal entry and exit levels a^* and m^*

is straightforward and, furthermore, it is shown that they are symmetrically positioned about the long-run mean level.

Bertram (2010) further develops a second approach, whereby the optimal entry and exit levels are determined by means of maximising the associated per unit time Sharpe ratio. For this, the per unit time Sharpe ratio is defined as follows:

$$S(a,m,c,r_f) \equiv \frac{\xi(a,m,c) - \dfrac{r_f}{E(\mathrm{T})}}{\sigma}$$

where r_f is the risk-free rate of interest. Solving for the optimal entry and exit levels a^* and m^* is straightforward and again they are shown to be symmetric about the long-run mean level. For technical details on any of the above, the interested reader is directed to the paper of Bertram (2010).

Benchmark Models

This section presents a unification of the optimal trading criteria (i.e. maximisation of expected return per unit time, $\xi(a,m,c)$, or Sharpe ratio, $S(a,m,c,r_f)$) proposed by Bertram (2010) and the first-hitting time density approach of Linetsky (2004). In so doing, an alternative statistical arbitrage trading model is presented that serves as a benchmark for the Bertram trading model. Linetsky (2004) considers the more general OU process:

$$ds_t = \alpha(\mu - s_t)dt + \sigma dW_t \tag{2}$$

The only difference between this specification and that of Equation 1 is that the process s_t mean reverts around the long-run mean level μ, which is not necessarily zero. Under this process, Linetsky (2004) considers the associated first-hitting time density for the movement of the process from a given point to another defined point. The first-hitting time density describes the probability distribution for the stochastic time it takes to move between the two points and allows one to calculate, for instance, the expected time of this movement. In the context of this study, the two points may be considered to be the entry and exit levels of the statistical arbitrage trading model. Linetsky (2004) derives both exact and approximate solutions for the first-hitting time density. The exact formulation involves the Hermite function, which is a standard mathematical tool, whereas the approximate formulation involves nothing more complex than the cosine function. For technical details the interested reader is directed to the paper of Linetsky (2004).

Armed with these first-hitting time density formulations, calculation of $E(\mathrm{T})$, $V(\mathrm{T})$, $\xi(a,m,c)$ and $\varsigma(a,m,c)$ is straightforward. Whereas Bertram (2010) provides analytic expressions from which to determine the optimal entry and exit levels a^* and m^*, the approach here requires calculating either $\xi(a,m,c)$ or $S(a,m,c,r_f)$ as required over a grid of potential entry and exit levels and extracting the optimal levels from the results. For the purposes of the empirical analysis to follow, both the exact and approximate approaches will be implemented as benchmark models for the Bertram model. Further to this, implementation of the approximate approach provides an opportunity to investigate the effect of the error introduced by the approximation in the context of a trading application. For the exposition to follow, the benchmark models will be referred to as the Linetsky Exact and Linetsky Approximate models.

DATA AND PRELIMINARY STATISTICAL RESULTS

Drawing from the current (July 2010) ISEQ stock listing, 32 stocks in total are examined with end-of-day mid-quoted price data spanning the sample period 21 July 2000 to 23 July 2010.[3,4] The 32 stocks chosen are those for which time series are available over the full sample period, which is deemed a sufficiently long period to test for cointegration and, more importantly, to comprehensively test the Bertram trading model as described below. The ISEQ stocks not considered are those for which the date of first listing succeeds 21 July 2000. The majority of these stocks (all bar two) actually have listing dates from 2006 onwards and so the associated time series are not deemed sufficiently long for the empirical testing.

All price series are first tested for stationarity using the standard augmented Dickey–Fuller (Dickey and Fuller, 1981) test and, hence, one stock is dropped from the sample data set for failing to reject the null hypothesis of stationarity. From the remaining 31 stocks, the residual-based cointegration test of Engle and Granger (1987) is performed on the resulting 465 stock pairings, which assumes the following linear model:

$$s_{2,t} = \gamma + \beta s_{1,t} + e_t$$

where $s_{1,t}$ and $s_{2,t}$ are the log-prices of the two assets in the pair, and the resulting cointegration spread series is defined such that $s_t \equiv s_{2,t} - \beta s_{1,t}$. Using a 1 per cent significance level criterion, cointegration is established between 37 pairs of stocks in total, made up of the 22 stocks listed in Table 1. Use of the high 1 per cent significance level serves to reduce the number of pairings examined for this particular study, allowing for results for individual pairs to be more easily reported for the perusal of the reader. It is the individual results that provide insights into the sensitivity of the Bertram trading model to variations in the key parameters of the OU process. In practice, of course, a 5 per cent significance level may be deemed acceptable to establish cointegration in the price spread. Indeed, cointegration is recognised as a strong statistical test and so may not identify weaker forms of predictability that offer trading opportunities. Burgess (1999) discusses this point and proposes an alternative variance ratio test approach to establishing predictability. Table 2 presents the cointegration pairs, along with the associated *t*-statistics from the cointegration testing. Descriptive statistics for the resulting spread series are also presented.

With the cointegrated pairs identified, the next stage of analysis fits the general OU process in Equation 2 to each spread series. Table 2 presents the estimated parameters $\hat{\alpha}$, $\hat{\mu}$ and $\hat{\sigma}$ for each of the 37 pairings. These estimates will be used in

TABLE 1: ISEQ STOCKS IN PAIRINGS

Reuters Instrument Code	Name
ALBK	Allied Irish Banks
AMNX	Aminex
ARYN	Aryzta
BKIR	Bank of Ireland
DQ5	CPL Resources
CRH	CRH
DQ7	Donegal Creameries
DGO	Dragon Oil
FBD	FBD Holdings
GRF	Grafton Group
GNC	Greencore Group
INME	Independent News & Media
IPM	Irish Life & Permanent
JEV	Kenmare Resources
KYGa	Kerry Group 'A'
KSP	Kingspan Group
MCI	McInerney Holdings
ORM	Ormonde Mining
OVG	Ovoca Gold
PACC	Prime Actvie Capital
RDMX	Readymix
UDG	United Drug

the application of the Bertram, Linetsky Exact and Linetsky Approximate trading models in the forthcoming sections. From the descriptive statistics for the spread series reported in Table 2, it is clearly evident that the OU process, being Gaussian, is inadequate to capture the non-normal asymmetric and leptokurtic features of the spread series data. The next section investigates the error introduced as a result of this model mis-specification within the trading models.

TABLE 2: COINTEGRATION AND OU MODEL FITTING RESULTS

Pairing	*t*-stat	Standard Deviation	Skewness	Kurtosis	$\hat{\alpha}$	$\hat{\mu}$	$\hat{\sigma}$
ALBK–AMNX	-4.03	0.36	-0.35	2.97	4.18	-2.46	1.01
ALBK–BKIR	-4.32	0.17	0.65	6.12	4.62	0.64	0.53
ALBK–GNC	-4.51	0.16	0.14	3.07	3.64	-0.02	0.43
ALBK–INME	-5.13	0.28	-0.87	4.94	3.96	0.46	0.75

(*Continued*)

TABLE 2: (*CONTINUED*)

Pairing	*t*-stat	Standard Deviation	Skewness	Kurtosis	$\hat{\alpha}$	$\hat{\mu}$	$\hat{\sigma}$
ALBK–IPM	-5.20	0.26	0.48	6.21	4.04	-0.64	0.73
ALBK–OVG	-5.75	0.35	0.56	3.71	9.52	-1.70	1.49
ALBK–RDMX	-6.34	0.20	-0.38	6.31	7.48	-1.82	0.76
AMNX–BKIR	-4.14	0.35	-0.35	3.04	4.40	-2.18	1.02
AMNX–INME	-3.95	0.35	-0.54	3.02	4.16	-2.29	1.01
AMNX–IPM	-4.34	0.35	-0.39	2.85	4.75	-2.82	1.05
AMNX–OVG	-6.39	0.33	-0.18	2.67	12.86	0.58	1.66
ARYN–KYGa	-4.46	0.09	-0.01	3.11	4.27	1.18	0.26
BKIR–GNC	-4.62	0.16	0.68	3.19	4.34	0.26	0.46
BKIR–IPM	-6.97	0.19	0.10	5.07	7.32	-1.27	0.71
BKIR–OVG	-5.95	0.34	0.79	4.08	10.15	-1.41	1.50
BKIR–RDMX	-4.81	0.25	-0.12	7.94	5.09	-1.25	0.78
DQ5–CRH	-4.44	0.13	0.25	3.22	3.92	2.82	0.37
CRH–JEV	-4.58	0.14	0.09	3.61	4.76	3.36	0.41
CRH–KSP	-5.22	0.10	0.09	2.85	5.26	2.33	0.33
CRH–ORM	-3.88	0.17	0.19	2.76	3.23	3.57	0.43
DQ7–UDG	-4.40	0.18	0.29	2.66	4.25	-0.03	0.51
DGO–KYGa	-3.94	0.10	-0.43	2.77	3.07	2.81	0.25
FBD–OVG	-4.81	0.40	-0.05	2.63	7.13	-2.13	1.48
GRF–INME	-3.98	0.48	-0.29	3.15	5.16	2.49	1.55
GRF–OVG	-5.39	0.38	0.13	3.04	9.49	-0.24	1.64
GNC–IMP	-5.10	0.15	0.83	3.71	5.04	-0.36	0.48
GNC–OVG	-4.32	0.29	-0.31	2.13	5.56	1.35	0.94
INME–IMP	-4.21	0.31	-1.22	5.75	2.76	1.01	0.70
INME–OVG	-5.88	0.32	-0.21	3.20	10.80	-1.56	1.48
INME–PACC	-4.73	0.36	-0.01	2.26	6.93	-1.78	1.34
INME–RDMX	-4.37	0.25	-0.90	3.48	4.16	-1.46	0.70
IPM–OVG	-5.82	0.35	0.73	3.52	9.65	-2.06	1.50
IPM–RDMX	-4.91	0.29	-0.82	6.91	4.61	-2.38	0.88
MCI–OVG	-4.07	0.49	0.37	2.90	4.87	-0.49	1.48
ORM–UDG	-5.26	0.33	0.17	3.64	5.86	-4.28	1.07
OVG–PACC	-5.39	0.38	0.13	3.04	9.49	-0.24	1.64
OVG–RDMX	-3.99	0.55	-0.23	1.96	4.93	0.82	1.70

Note: The reported *t*-stats result from the residual-based cointegration test of Engle and Granger (1987). $\hat{\alpha}$, $\hat{\mu}$ and $\hat{\sigma}$ are the estimated speed of mean reversion, long-run mean and volatility parameter estimates for the general OU process.

EMPIRICAL ANALYSIS: MAXIMISING EXPECTED RETURN

This section presents an empirical analysis of the optimal Bertram trading model, along with the optimal benchmark Linetsky Exact and Linetsky Approximate models, where the expected return per unit time is maximised.[5] For each stock pairing under each trading model, the optimal entry and exit levels a^* and m^* are determined. Using the empirical spread series, sample counterparts to $E(\mathrm{T})$, $V(\mathrm{T})$, $\xi(a,m,c)$ and $\varsigma(a,m,c)$ are calculated, herein denoted $\overline{\mathrm{T}}$, $\hat{V}$, $\hat{\xi}$, and $\hat{\varsigma}$ respectively. Complete trade cycles $a^* \rightarrow m^* \rightarrow a^*$ are identified and the associated trade cycle times recorded. For this, and given the discrete daily frequency structure of the data, each occurrence of the spread series crossing over either the optimal a^* or m^* level is first identified and then interpolation is used as required to assign an associated time (as a fraction of a year). For each spread series $j = 1,\ldots 37$, and given the sampled trade cycle times $\{\mathrm{T}_i^j\}$, $i = 1,\ldots,n_j$,[6] the sample measures are defined as follows:

$$\overline{\mathrm{T}}^j = \frac{1}{n_j}\sum_{i=1}^{n_j}\mathrm{T}_i^j$$

$$\hat{V}^j = \frac{1}{n}\sum_{i=1}^{n_j}(\mathrm{T}_i^j - \overline{\mathrm{T}})^2$$

$$\hat{\xi}^j = (m_j^* - a_j^* - c)\big/\overline{\mathrm{T}}^j$$

$$\hat{\varsigma}^j = (m_j^* - a_j^* - c)^2\,\hat{V}^j\big/(\overline{\mathrm{T}}^j)^3$$

Table 3 presents the optimal entry and exit levels relative to the estimated long-run mean parameters. The errors between the model and corresponding empirical expected return per unit time and expected trade cycle time measures are also presented for each model. Table 4 provides the actual expected return per unit time and expected trade cycle time measures under each model. To conserve space, the variance of return per unit time and variance of trade cycle time measures are not reported, but are available upon request.

An important first observation to make is that for the Linetsky models, no results are reported for a number of pairings (highlighted with the symbol x). In these cases, the Linetsky models are found to exhibit an instability that is not experienced by the Bertram model. Specifically, the Linetsky models are found to generate implausible expected return values, resulting directly from the excessively small (i.e. close to zero) expected trade cycle time estimates. From the fitted OU model parameters, these pairings can be seen to correspond to speed of mean reversion and/or volatility parameter estimates that are particularly high relative to the other pairings.

For the Bertram trading model, the optimal entry and exit levels are, by construction, symmetric about the long-run mean level. The results of the Linetsky Exact and Linetsky Approximate models support this, showing symmetry for all pairings for which valid results are achieved. The trading models generally overestimate the expected return per unit time relative to the empirical data. The mean error for the Bertram model across all 37 pairings is significant at 46.19 per cent. Across only the valid pairings for the Linetsky models, mean errors for the Bertram, Linetsky Exact and Linetsky Approximate models are again significant at 28.39 per cent, 27.65 per cent and 28.11 per cent respectively. Underlying these errors is the underestimation of expected trade cycle times relative to the empirical data. Across all 37 pairings, the mean error in the trade cycle time for the Bertram model is approximately four and a half months, at -0.3813 years. For the valid pairings

TABLE 3: MODEL-EMPIRICAL MEASURE ERRORS: MAXIMISED EXPECTED RETURN

	$a^*/\hat{\mu}$			$m^*/\hat{\mu}$			$\xi^j - \hat{\xi}^j$			$E(\mathrm{T}^j) - \overline{\mathrm{T}}^j$		
Pairing	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**
ALBK–AMNX	1.023	1.029	1.044	0.977	0.971	0.956	0.29	0.29	0.25	-0.20	-0.25	-0.27
ALBK–BKIR	0.945	0.948	0.922	1.055	1.052	1.078	0.28	0.28	0.29	-1.97	-1.80	-3.39
ALBK–GNC	3.247	3.075	4.113	-1.247	-1.075	-2.113	0.13	0.13	0.15	-0.39	-0.37	-0.65
ALBK–INME	0.898	0.881	0.821	1.103	1.120	1.179	0.33	0.31	0.30	-0.86	-0.84	-0.89
ALBK–IPM	1.073	1.082	1.122	0.927	0.918	0.878	0.29	0.29	0.21	-0.55	-0.59	-0.38
ALBK–OVG	1.033	×	×	0.967	×	×	1.00	×	×	-0.31	×	×
ALBK–RDMX	1.021	×	×	0.979	×	×	0.36	×	×	-0.23	×	×
AMNX–BKIR	1.026	1.033	1.049	0.974	0.967	0.951	0.34	0.33	0.27	-0.25	-0.30	-0.27
AMNX–INME	1.025	1.031	1.046	0.975	0.969	0.954	0.40	0.40	0.38	-0.45	-0.58	-0.66
AMNX–IPM	1.020	1.025	1.038	0.980	0.975	0.963	0.47	0.44	0.39	-0.47	-0.48	-0.46
AMNX–OVG	0.907	×	×	1.093	×	×	1.20	×	×	-0.17	×	×
ARYN–KYGa	0.981	0.978	0.978	1.019	1.022	1.022	0.03	0.05	0.06	-0.07	-0.19	-0.20
BKIR–GNC	0.872	0.880	0.820	1.128	1.120	1.180	0.15	0.16	0.18	-0.31	-0.36	-0.73
BKIR–IPM	1.030	×	×	0.970	×	×	0.36	×	×	-0.30	×	×
BKIR–OVG	1.039	×	×	0.961	×	×	1.08	×	×	-0.36	×	×
BKIR–RDMX	1.036	1.039	1.059	0.964	0.961	0.941	0.40	0.38	0.40	-0.79	-0.75	-1.11
DQ5–CRH	0.990	0.991	0.986	1.011	1.009	1.014	0.07	0.04	0.04	-0.15	-0.07	-0.10
CRH–JEV	0.991	0.992	0.988	1.009	1.008	1.012	0.15	0.15	0.17	-0.33	-0.34	-0.57
CRH–KSP	0.989	0.987	0.987	1.011	1.013	1.013	0.11	0.08	0.09	-0.28	-0.20	-0.21
CRH–ORM	0.990	0.991	0.986	1.010	1.010	1.014	0.09	0.10	0.09	-0.23	-0.26	-0.32

(Continued)

TABLE 3: (*CONTINUED*)

	$a^*/\hat{\mu}$			$m^*/\hat{\mu}$			$\xi^j - \hat{\xi}^j$			$E(\mathrm{T}^j) - \overline{\mathrm{T}}^j$		
Pairing	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**
DQ7–UDG	2.106	2.133	2.700	-0.106	-0.133	-0.700	0.18	0.18	0.17	-0.41	-0.42	-0.50
DGO–KYGa	0.991	0.990	0.990	1.009	1.010	1.010	0.01	0.00	0.00	-0.03	0.00	-0.02
FBD–OVG	1.029	×	×	0.971	×	×	0.91	×	×	-0.52	×	×
GRF–INME	0.972	0.962	0.962	1.028	1.039	1.039	0.61	0.61	0.64	-0.24	-0.32	-0.32
GRF–OVG	1.247	×	×	0.753	×	×	0.99	×	×	-0.20	×	×
GNC–IMP	1.090	1.082	1.123	0.910	0.918	0.877	0.15	0.17	0.18	-0.23	-0.25	-0.43
GNC–OVG	0.964	×	×	1.037	×	×	0.31	×	×	-0.16	×	×
INME–IMP	0.949	0.939	0.908	1.051	1.061	1.092	0.19	0.20	0.20	-0.42	-0.61	-0.78
INME–OVG	1.034	×	×	0.966	×	×	1.00	×	×	-0.22	×	×
INME–PACC	1.033	×	×	0.967	×	×	0.79	×	×	-0.48	×	×
INME–RDMX	1.031	1.034	1.051	0.969	0.966	0.949	0.21	0.20	0.26	-0.26	-0.24	-0.63
IPM–OVG	1.027	×	×	0.973	×	×	0.97	×	×	-0.26	×	×
IPM–RDMX	1.021	1.025	1.037	0.979	0.976	0.963	0.37	0.37	0.47	-0.45	-0.55	-2.03
MCI–OVG	1.142	1.099	1.199	0.858	0.901	0.801	0.69	0.72	0.70	-0.47	-0.42	-0.62
ORM–UDG	1.012	×	×	0.988	×	×	0.31	×	×	-0.11	×	×
OVG–PACC	1.247	×	×	0.753	×	×	0.99	×	×	-0.20	×	×
OVG–RDMX	0.907	0.934	0.867	1.093	1.066	1.133	0.89	0.74	0.85	-0.79	-0.24	-0.73

Note: $a^*/\hat{\mu}$ is the ratio of the optimal entry level a^* to the estimated long-run mean level $\hat{\mu}$. $m^*/\hat{\mu}$ is the ratio of the optimal exit level m^* to the estimated long-run mean level $\hat{\mu}$. The error $\xi^j - \hat{\xi}^j$ is the difference between the expected return per unit time calculated under a given trading model and estimated from the empirical data. The error $E(\mathrm{T}^j) - \overline{\mathrm{T}}^j$ is the difference between the expected trade cycle time calculated under a given trading model and estimated from the empirical data. B, LE and LA denote the Bertram, Linetsky Exact and Linetsky Approximate trading models respectively.

TABLE 4: TRADING MODEL MEASURES

	Maximising Expected Return						Maximising Sharpe Ratio								
	ξ^j			$E(T^j)$			S^j			ξ^j			$E(T^j)$		
Pairing	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**
ALBK–AMNX	0.57	0.57	0.59	0.20	0.25	0.36	1.50	1.49	1.49	0.56	0.58	0.59	0.58	0.61	0.48
ALBK–BKIR	0.31	0.31	0.32	0.23	0.21	0.31	1.43	1.43	1.42	0.30	0.32	0.32	0.69	0.64	0.64
ALBK–GNC	0.23	0.23	0.24	0.29	0.27	0.40	1.25	1.25	1.25	0.22	0.23	0.23	0.90	0.81	0.81
ALBK–INME	0.41	0.41	0.42	0.23	0.27	0.39	1.41	1.41	1.41	0.40	0.42	0.42	0.68	0.66	0.66
ALBK–IPM	0.41	0.41	0.42	0.23	0.25	0.37	1.42	1.42	1.41	0.40	0.42	0.42	0.67	0.62	0.62
ALBK–OVG	1.28	×	×	0.09	×	×	2.25	2.25	2.24	1.24	1.29	1.31	0.26	0.27	0.21
ALBK–RDMX	0.57	×	×	0.13	×	×	1.86	1.86	1.85	0.55	0.57	0.57	0.41	0.41	0.41
AMNX–BKIR	0.60	0.60	0.61	0.19	0.24	0.35	1.53	1.53	1.53	0.58	0.60	0.61	0.55	0.59	0.46
AMNX–INME	0.57	0.57	0.59	0.20	0.24	0.36	1.49	1.49	1.49	0.56	0.58	0.59	0.58	0.60	0.48
AMNX–IPM	0.64	0.64	0.66	0.17	0.22	0.32	1.59	1.59	1.58	0.62	0.65	0.65	0.51	0.54	0.43
AMNX–OVG	1.65	×	×	0.07	×	×	2.61	2.60	2.59	1.61	1.68	1.68	0.19	0.20	0.20
ARYN–KYGa	0.14	0.14	0.15	0.31	0.35	0.34	1.18	1.18	1.17	0.13	0.14	0.14	1.01	0.97	0.97
BKIR–GNC	0.26	0.26	0.27	0.25	0.23	0.34	1.36	1.36	1.35	0.25	0.26	0.26	0.77	0.70	0.70
BKIR–IPM	0.53	×	×	0.14	×	×	1.83	1.83	1.81	0.51	0.54	0.54	0.42	0.41	0.41
BKIR–OVG	1.33	×	×	0.08	×	×	2.32	2.32	2.31	1.29	1.34	1.36	0.24	0.25	0.20
BKIR–RDMX	0.49	0.49	0.50	0.18	0.20	0.29	1.58	1.58	1.58	0.47	0.50	0.50	0.54	0.50	0.50
DQ5–CRH	0.20	0.20	0.21	0.29	0.26	0.37	1.25	1.25	1.24	0.19	0.20	0.20	0.91	0.92	0.84
CRH–JEV	0.25	0.25	0.26	0.24	0.21	0.31	1.39	1.38	1.37	0.24	0.25	0.25	0.75	0.76	0.64
CRH–KSP	0.20	0.20	0.21	0.24	0.29	0.28	1.36	1.36	1.35	0.19	0.20	0.20	0.77	0.69	0.69
CRH–ORM	0.21	0.21	0.22	0.32	0.31	0.46	1.19	1.19	1.18	0.20	0.21	0.21	1.00	0.94	0.94

(*Continued*)

TABLE 4: (*CONTINUED*)

	Maximising Expected Return						Maximising Sharpe Ratio								
	ξ^j			$E(T^j)$			S^j			ξ^j			$E(T^j)$		
Pairing	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**
DQ7–UDG	0.29	0.29	0.30	0.24	0.25	0.36	1.38	1.38	1.37	0.28	0.29	0.29	0.74	0.75	0.75
DGO–KYGa	0.12	0.12	0.12	0.41	0.49	0.47	1.04	1.04	1.03	0.11	0.12	0.12	1.32	1.34	1.14
FBD–OVG	1.10	×	×	0.11	×	×	1.98	1.97	1.97	1.07	1.12	1.12	0.32	0.28	0.28
GRF–INME	0.98	0.98	1.01	0.14	0.19	0.19	1.71	1.71	1.71	0.96	1.01	1.01	0.41	0.38	0.38
GRF–OVG	1.41	×	×	0.08	×	×	2.27	2.27	2.26	1.37	1.44	1.44	0.25	0.21	0.21
GNC–IMP	0.30	0.30	0.31	0.22	0.20	0.29	1.46	1.46	1.45	0.28	0.30	0.30	0.67	0.59	0.59
GNC–OVG	0.61	×	×	0.16	×	×	1.68	1.68	1.68	0.60	0.62	0.62	0.47	0.46	0.46
INME–IMP	0.32	0.32	0.33	0.31	0.38	0.55	1.20	1.20	1.19	0.31	0.33	0.33	0.93	0.94	0.94
INME–OVG	1.36	×	×	0.08	×	×	2.38	2.38	2.37	1.32	1.38	1.38	0.23	0.24	0.24
INME–PACC	0.98	×	×	0.12	×	×	1.93	1.93	1.92	0.96	1.00	1.00	0.34	0.36	0.29
INME–RDMX	0.40	0.40	0.41	0.22	0.25	0.36	1.43	1.43	1.42	0.38	0.40	0.40	0.67	0.61	0.61
IPM–OVG	1.30	×	×	0.09	×	×	2.27	2.26	2.26	1.26	1.31	1.33	0.25	0.27	0.21
IPM–RDMX	0.53	0.53	0.54	0.19	0.22	0.32	1.54	1.54	1.53	0.51	0.53	0.53	0.56	0.54	0.54
MCI–OVG	0.91	0.91	0.93	0.15	0.11	0.21	1.66	1.66	1.66	0.89	0.93	0.93	0.44	0.42	0.42
ORM–UDG	0.72	×	×	0.15	×	×	1.75	1.75	1.74	0.70	0.73	0.73	0.43	0.46	0.36
OVG–PACC	1.41	×	×	0.08	×	×	2.27	2.27	2.26	1.37	1.44	1.44	0.25	0.21	0.21
OVG–RDMX	1.05	1.05	1.08	0.14	0.10	0.20	1.69	1.69	1.69	1.03	1.08	1.08	0.41	0.40	0.40

Note: ξ^j is the expected return per unit time calculated under a given trading model. $E(T^j)$ is the expected trade cycle time calculated under a given trading model. S^j is the per unit time Sharpe ratio calculated under a given trading model. B, LE and LA denote the Bertram, Linetsky Exact and Linetsky Approximate trading models respectively.

under the Linetsky models, the mean trade cycle time errors show underestimation of almost six months for both the Bertram and Linetsky Exact models, at -0.4414 and -0.4337 respectively, and in excess of six months for the Linetsky Approximate model, at -0.6788. On a case-by-case basis, the lowest errors generally correspond to those pairings with spread series that are close to Gaussian, in particular those that exhibit kurtosis close to 3. As expected, the closer the spread series is described by a Gaussian distribution, the smaller the model mis-specification error that is introduced.

To conclude, it is worth making some final comments on the variance of return per unit time and the variance of trade cycle time, where we focus on only those pairings with valid results under the Linetsky models. The mean variance of return per unit time is 0.0771, 0.0772 and 0.0831, for the Bertram, Linetsky Exact and Linetsky Approximate models respectively, with corresponding mean errors of 0.0584, 0.0543 and 0.0611. For the Bertram model, the mean variance of trade cycle time is 0.0813, with a mean error of -0.5875. For the Linetsky Exact and Approximate models, the mean variances of trade cycle time are higher relative to the Bertram model at 0.0878 and 0.3415 respectively, with errors of -0.5037 and -0.6838.

In summary, the trading models examined show the following common attributes: overestimation of the expected return per unit time; underestimation of the expected trade cycle time; overestimation of the variance of return per unit time; and underestimation of the variance of trade cycle time.

EMPIRICAL ANALYSIS: MAXIMISING SHARPE RATIO

Similar to the previous section, an empirical analysis of the statistical arbitrage trading models is performed whereby the optimal entry and exit levels are determined this time by means of maximising the Sharpe ratio. The empirical counterparts to the expected trade cycle time, variance of trade cycle time, expected return per unit time and variance of return per unit time measures are calculated as outlined previously. In addition to these, an empirical counterpart to the Sharpe ratio is defined as follows:

$$\hat{S}^j \equiv (m_j^* - a_j^* - c - r_f)\sqrt{\frac{\bar{\bar{\mathrm{T}}}^j}{(m_j^* - a_j^* - c)^2\,\hat{V}^j}}$$

For ease of the analysis to follow, the risk-free rate of interest r_f is set equal to the average three-month composite EURIBOR over the full sample period of 2.9966 per cent. Table 5 presents the optimal entry and exit levels, along with the model-empirical measure errors. Table 4 again provides the actual expected return per unit time and expected trade cycle time measures under each model. The variance of return per unit time and variance of trade cycle time measures are again not reported in order to conserve on space.

In contrast to the previous section, the Linetsky models do not show instability for any of the 37 pairings. This likely reflects the fact that, overall, the reported

TABLE 5: MODEL-EMPIRICAL MEASURE ERRORS: MAXIMISED SHARPE RATIO

	$a^*/\hat{\mu}$			$m^*/\hat{\mu}$			$S^j - \hat{S}^j$			$\xi^j - \hat{\xi}^j$			$E(T^j) - \overline{T}^j$		
Pairing	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**
ALBK–AMNX	1.066	1.073	1.058	0.934	0.927	0.942	-0.17	-0.11	-0.44	0.20	0.17	0.27	-0.31	-0.26	-0.42
ALBK–BKIR	0.839	0.843	0.843	1.161	1.157	1.157	-3.35	-3.41	-3.42	0.27	0.29	0.29	-6.61	-6.79	-6.79
ALBK–GNC	7.540	7.226	7.226	-5.540	-5.226	-5.226	0.14	0.15	0.15	0.10	0.12	0.12	-0.73	-0.95	-0.95
ALBK–INME	0.706	0.701	0.701	1.294	1.299	1.299	0.31	0.23	0.22	0.17	0.16	0.16	-0.48	-0.40	-0.40
ALBK–IPM	1.209	1.204	1.204	0.791	0.796	0.796	-0.04	0.01	0.01	0.22	0.24	0.24	-0.86	-0.84	-0.84
ALBK–OVG	1.094	1.103	1.083	0.906	0.897	0.917	1.34	1.33	1.36	1.04	1.07	1.13	-1.31	-1.31	-1.38
ALBK–RDMX	1.061	1.064	1.064	0.939	0.936	0.936	1.19	1.20	1.19	0.47	0.48	0.48	-2.31	-2.18	-2.18
AMNX–BKIR	1.074	1.081	1.065	0.926	0.919	0.935	-0.05	-0.23	0.03	0.23	0.24	0.25	-0.35	-0.39	-0.32
AMNX–INME	1.071	1.077	1.062	0.929	0.923	0.938	-0.62	-0.50	-0.56	0.28	0.29	0.35	-0.58	-0.62	-0.69
AMNX–IPM	1.057	1.062	1.050	0.943	0.938	0.950	0.06	-0.02	0.05	0.28	0.29	0.37	-0.42	-0.43	-0.55
AMNX–OVG	0.734	0.715	0.715	1.266	1.285	1.285	0.78	0.78	0.77	1.03	1.09	1.09	-0.34	-0.36	-0.36
ARYN–KYGa	0.943	0.942	0.942	1.058	1.058	1.058	0.21	0.21	0.19	0.04	0.05	0.05	-0.41	-0.46	-0.46
BKIR–GNC	0.628	0.640	0.640	1.373	1.361	1.361	0.38	0.38	0.37	0.14	0.16	0.16	-1.02	-1.06	-1.06
BKIR–IPM	1.086	1.088	1.088	0.914	0.912	0.912	0.74	0.55	0.54	0.37	0.41	0.41	-1.07	-1.34	-1.34
BKIR–OVG	1.111	1.122	1.098	0.889	0.878	0.902	1.47	1.41	1.48	1.09	1.14	1.16	-1.33	-1.46	-1.21
BKIR–RDMX	1.103	1.099	1.099	0.897	0.902	0.902	0.72	0.72	0.71	0.41	0.44	0.44	-3.54	-3.60	-3.60
DQ5–CRH	0.969	0.968	0.972	1.031	1.033	1.033	0.05	-0.24	0.06	0.02	0.02	0.04	-0.12	-0.09	-0.18
CRH–JEV	0.974	0.972	0.976	1.026	1.028	1.024	0.01	-0.05	-0.11	0.12	0.13	0.13	-0.73	-0.78	-0.74
CRH–KSP	0.968	0.970	0.970	1.032	1.030	1.030	0.41	0.49	0.47	0.11	0.12	0.12	-0.99	-1.00	-1.00
CRH–ORM	0.972	0.972	0.972	1.029	1.028	1.028	0.26	0.26	0.25	0.10	0.11	0.11	-1.00	-1.05	-1.05

(*Continued*)

TABLE 5: (*CONTINUED*)

	$a^*/\hat{\mu}$			$m^*/\hat{\mu}$			$S^j - \hat{S}^j$			$\xi^j - \hat{\xi}^j$			$E(\mathrm{T}^j) - \overline{\mathrm{T}}^j$		
Pairing	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**	**B**	**LE**	**LA**
DQ7–UDG	4.208	4.400	4.400	-2.208	-2.400	-2.400	0.31	-0.22	-0.23	0.18	0.21	0.21	-1.32	-2.02	-2.02
DGO–KYGa	0.974	0.972	0.976	1.026	1.028	1.024	-0.38	-0.26	-0.26	-0.02	-0.01	0.01	0.19	0.15	-0.06
FBD–OVG	1.082	1.075	1.075	0.918	0.925	0.925	0.93	0.98	0.98	0.95	1.01	1.01	-2.49	-2.50	-2.50
GRF–INME	0.920	0.923	0.923	1.080	1.077	1.077	0.53	0.52	0.52	0.57	0.63	0.63	-0.61	-0.62	-0.62
GRF–OVG	1.701	1.630	1.630	0.299	0.370	0.370	1.22	1.23	1.22	0.93	1.03	1.03	-0.51	-0.53	-0.53
GNC–IMP	1.262	1.246	1.246	0.738	0.754	0.754	0.29	0.28	0.27	0.17	0.19	0.19	-1.01	-0.97	-0.97
GNC–OVG	0.896	0.894	0.894	1.104	1.106	1.106	0.89	0.86	0.85	0.53	0.56	0.56	-3.90	-4.05	-4.05
INME–IMP	0.855	0.847	0.847	1.145	1.153	1.153	0.06	0.02	0.01	0.15	0.17	0.17	-0.88	-0.98	-0.98
INME–OVG	1.098	1.104	1.104	0.902	0.896	0.896	1.44	1.43	1.42	1.19	1.25	1.25	-2.11	-2.26	-2.26
INME–PACC	1.093	1.102	1.082	0.907	0.898	0.918	0.81	0.73	0.83	0.68	0.73	0.75	-0.85	-1.01	-0.86
INME–RDMX	1.088	1.085	1.085	0.912	0.915	0.915	0.88	0.89	0.88	0.25	0.28	0.28	-1.26	-1.40	-1.40
IPM–OVG	1.077	1.086	1.068	0.923	0.915	0.932	1.37	1.34	1.40	1.11	1.16	1.10	-1.82	-1.97	-1.05
IPM–RDMX	1.060	1.061	1.061	0.940	0.939	0.939	0.52	0.50	0.50	0.41	0.43	0.43	-2.22	-2.27	-2.27
MCI–OVG	1.400	1.398	1.398	0.600	0.602	0.602	0.42	0.43	0.42	0.74	0.78	0.78	-2.20	-2.26	-2.26
ORM–UDG	1.035	1.039	1.031	0.965	0.961	0.969	0.41	0.29	0.43	0.25	0.27	0.33	-0.24	-0.27	-0.30
OVG–PACC	1.701	1.630	1.630	0.299	0.370	0.370	1.22	1.23	1.22	0.93	1.03	1.03	-0.51	-0.53	-0.53
OVG–RDMX	0.739	0.734	0.734	1.261	1.266	1.266	0.83	0.84	0.84	0.93	0.97	0.97	-3.63	-3.60	-3.60

Note: $a^*/\hat{\mu}$ is the ratio of optimal entry level a^* to the estimated long-run mean level $\hat{\mu}$. $m^*/\hat{\mu}$ is the ratio of optimal exit level m^* to the estimated long-run mean level $\hat{\mu}$. The error $S^j - \hat{S}^j$ is the difference between the per unit time Sharpe ratio calculated under a given trading model and estimated from the empirical data. The error $\xi^j - \hat{\xi}^j$ is the difference between the expected return per unit time calculated under a given trading model and estimated from the empirical data. The error $E(\mathrm{T}^j) - \overline{\mathrm{T}}^j$ is the difference between the expected trade cycle time calculated under a given trading model and estimated from the empirical data. B denotes the Bertram trading model, LE denotes the Linetsky Exact trading model and LA denotes the Linetsky Approximate trading model.

optimal entry and exit levels for each pairing represent a wider range around the long-run mean level compared to maximisation of expected return per unit time and, hence, the associated expected trade cycle time is much longer. Indeed, the mean expected trade cycle times for the Bertram, Linetsky Exact and Linetsky Approximate models respectively are 0.5709, 0.5553 and 0.5226 years. Despite the greater absolute returns on offer from the wider optimal entry and exit levels, it is particularly interesting to note that the longer expected trade cycle times lead to expected return per unit time measures that are quite comparable to the previous section. So on a per unit time basis, there appears to be marginal difference between the trading strategy based on either maximisation of expected return per unit time or Sharpe ratio. Further to this, the mean error in the expected return per unit time relative to the empirical data is 44.92 per cent, 47.80 per cent and 48.89 per cent for the Bertram, Linetsky Exact and Linetsky Approximate models respectively. Again, the trading models significantly overestimate the expected return relative to the empirical data, reflecting significant underestimation of the expected trade cycle time with mean errors of -1.3474, -1.4175 and -1.3994 years.

On the associated Sharpe ratio measures, the trading models show evidence of both overestimation and underestimation relative to the empirical data, with varying degrees of magnitude. Overall, the mean error is positive at 0.4214, 0.3848 and 0.3952 for the Bertram, Linetsky Exact and Linetsky Approximate models respectively. The mean variance of return per unit time is 0.1258, 0.1389 and 0.1375 for the Bertram, Linetsky Exact and Linetsky Approximate models respectively, with corresponding mean errors of 0.0950, 0.1099 and 0.1094. The mean variance of trade cycle time is 0.2101, 0.2085 and 0.1932 for the Bertram, Linetsky Exact and Linetsky Approximate models respectively, with corresponding mean errors of -1.2718, -1.2618 and -1.2511.

In summary, the trading models examined show the following common attributes: overestimation of the expected return per unit time; underestimation of the expected trade cycle time; overestimation of the variance of return per unit time; and underestimation of the variance of trade cycle time. These observations are similar to the last section. Furthermore, the trading models all show mixed results for the Sharpe ratio, with evidence of either over- or underestimation.

CONCLUSION

This study presents a comprehensive model specification analysis of the Bertram (2010) optimal statistical arbitrage trading model on quoted ISEQ stocks. A number of key contributions to the literature are made. Firstly, the empirical analysis allows for the identification and quantification of model mis-specification errors in the Bertram trading model. That is, it looks to investigate the mis-specification error introduced in using a Gaussian OU process to describe non-Gaussian empirical cointegration spread series. Significant errors are reported on average in the key measures underlying the trading model. In particular, for both maximisation of the expected return per unit time and maximisation of the Sharpe ratio, it is found that the trading model generally overestimates the expected return per unit time and underestimates the expected trade cycle time relative to the empirical data. Errors in the Sharpe ratio show evidence of both overestimation and underestimation. In general, and as expected, the closer the data is to normal, the better the trading model performs.

Secondly, the study contributes by means of unifying the optimal statistical arbitrage trading criteria set out in the Bertram trading model with the first-hitting time density framework of Linetsky (2004) in order to develop two alternative trading models for benchmark purposes. Comparison of the Bertram trading model against these benchmark models shows the former to be much more robust to high mean reversion and/or volatility parameter estimates. The analysis further helps to understand the sensitivity of the Bertram trading model to variations in the key parameters of the OU process by reporting results for individual pairs. Thirdly, in implementing the benchmark trading model based on the approximate first-hitting time density of Linetsky (2004), the error introduced as a result of the approximation is investigated and quantified in the context of a trading application.

The key advantage of the Bertram trading model is that the analytic approach to determining optimal entry and exit levels provides significant computational efficiencies, which is of particular advantage for the implementation of statistical arbitrage trading at a high-frequency level. However, given that the underlying OU process only allows for a normal distribution for changes in the spread series, model mis-specification error is a feature when applied to non-normal empirical data. Therefore, for practitioners, there is a tradeoff to be made between the computational efficiencies that the Bertram trading model offers and the error that it introduces. This study shows that the errors in the key underlying measures using ISEQ data are significant on average. However, on an individual pair basis, the closer the spread series is to normal, the less the error will be in general. It is advisable that practitioners be cognisant of the model mis-specification error issue when using the Bertram trading model and where possible to comprehensively backtest any statistical arbitrage trading strategy based on the resulting optimal entry and exit levels.

Finally, informed by the model specification insights of this study, a formal trading strategy validation would significantly extend the literature. Examination of the performance of the Bertram trading model against alternative statistical arbitrage models, in addition to alternative trading strategies (e.g. technical rules), would be of particular interest to practitioners. However, such analysis would need to proceed while controlling for data snooping through the use of appropriate techniques, such as the reality check bootstrap of White (2000) and the superior predictive ability test of Hansen (2005).

ENDNOTES

1 The author would like to thank Professor Ciarán Ó hÓgartaigh and the two anonymous referees involved in the review process, whose comments and feedback greatly improved the paper.

2 The zero mean assumption does not present any issue in practice. The optimal entry and exit levels obtained can be easily translated to account for a non-zero mean in empirical data.

3 Data were obtained using the equity price database available via the Thomson Reuters Xtra 3000 platform. A full listing of the 32 stocks is available from the author upon request.

4 It has been pointed out by one of the anonymous referees that including only stocks which are live at the end of July 2010 introduces survivor bias. The author would like to thank the referee for pointing this out. Including dead stocks would need to be coupled with extended analysis of structural change effects in any cointegration relationships identified. For a given pairing that includes a stock that ultimately delists or ceases trading, any long-term statistical relationship that exists is likely to undergo some form of structural change or may indeed break down entirely during the lead-up period. Such analysis is defered for future research.

5 For the implementation of the trading models in this section and the next, the transaction costs parameter is arbitrarily set at a negligible level of ten basis points. As the objective is to investigate errors between the models and empirical data, it is only necessary to apply the transaction parameter consistently. In practice, of course, transaction costs are an essential consideration.

6 A key assumption made in the calculation of sampled trade cycle times is that the spread may be transacted at the entry and exit levels exactly. In practice, of course one or more of the assets underlying the spread may be illiquid and so it may not be possible to transact immediately once the entry and exit levels are reached. The author would like to thank one of the anonymous referees for raising this issue.

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THE ROCKET SCIENCE: READING FINANCIAL ACCOUNTING STANDARDS

Brian Farrell
University of Technology, Sydney
Helen Farrell
University of New South Wales
and
Peter Wells
University of Technology, Sydney

ABSTRACT

This paper identifies readability as a significant obstacle to the international harmonisation of financial accounting standards. In the study, the Flesch Reading Ease and the Flesch–Kincaid Grade Level tests are used to analyse the International Financial Reporting Standard on leases (using the Australian equivalent, AASB 117), the other international standards (using the remaining 46 AASB standards), and the US standard on leases, FAS 13. The results show the language of AASB 117 and FAS 13 exceeds the expected ability of many readers and represents an impediment to the interpretation of accounting standards. T*-tests indicate that, on average, the Reading Ease and Grade Level scores of the other 46 AASB standards are significantly more demanding than even AASB 117. Consequently, the readability of the International Financial Reporting Standards ought to be comprehensively addressed by the International Accounting Standards Board to ensure the efficacy of efforts to harmonise accounting internationally.*

Frankly, accounting is not rocket science.
(Tweedie, 2007, p. 5)

INTRODUCTION

Doubtless the greatest change to have occurred internationally in financial reporting in recent years has been the adoption of International Financial Reporting Standards (IFRS) in many countries, including Ireland. Australia is typical and, since 2005, firms have been required to use the Australian equivalent of the IFRS, known as the Australian Accounting Standards Board (AASB) standards. Numerous motivations have been identified by regulators in support of this regulatory change, including improvements in the quality of financial reports, broader access to international capital markets and lower cost of capital for firms (see, for example, Financial Reporting Council, 2002). Reflecting the significance of these changes, researchers have expended considerable effort to determine whether these benefits are being delivered (Barth, Landsman and Lang, 2008; Barth, Landsman, Lang and Williams, 2007; Armstrong, Barth, Jagolinzer and Riedl, 2007). However, the existence of the accounting standards alone is not sufficient to achieve these benefits, and little attention has been directed towards other factors which influence whether the benefits associated with them are realised. This includes the ability of accounting professionals and students to understand and apply the accounting standards.

A feature of the accounting standards developed by the International Accounting Standards Board (IASB) is the complexity of their language and concepts. While this may be seen by some as necessary to deliver precision and to ensure that financial reports capture the underlying economic substance of transactions, a consequence is that readability may be sacrificed. Accordingly, the major objective of this study is to evaluate whether the readability level of the language used in accounting standards constitutes an impediment to the financial accounting harmonisation project. This is of concern for practitioners, auditors and regulators, and academics training accounting professionals.

A secondary objective of this paper is to compare the readability of lease standards issued in the United States (US) by the Financial Accounting Standards Board (FASB) and the IASB. This is relevant for a number of reasons. Firstly, these standards are written in a different style, and the comparison provides evidence as to whether style impacts the readability of the standards. Secondly, it may provide insights relevant to the present debate in the US surrounding regulatory change. In relation to the latter point, it is recognised that there are other perhaps more important issues, such as how different regulatory styles impact auditor judgement (see, for example, Nelson, Elliott and Tarpley, 2002). However, the issue of whether standards are easily read is not trivial.

On Terminology

At the outset, a threshold clarification of two terms used in this paper is relevant (Smith and Taffler, 1992). First, we use the term 'understandability' in this paper. This relates to the degree a reader can decode the language of a text so as to derive its meaning and 'receive the message' that is intended to be conveyed by the author. Understanding text depends on many factors. Some relate to the reader personally and are subjective. Such factors include intellectual ability, topic interest, education, attention span, eyesight health and shared knowledge with the author. Other factors are external to and independent of a reader, and may be considered 'objective'. These are items such as the available light illuminating the text, the size and style of font used, the colour of the print and the contrasting colour of the paper or screen on which the text appears. The language of the text, including its register (be it academic, conversational, legalistic or other), also falls within this category.

The second term to clarify is 'readability'. This is a quality of the text itself, and is independent of the characteristics and circumstances of an individual reader. It is objectively assessed. The readability quality as a generally understood term relates to the structure of the language and how easily it is managed by a reader. Readability contributes to the ability of the reader to decode the text in a process of ascertaining its meaning. Readability is one factor among many that contribute to an understanding of text by a particular reader. In a practical sense, it is not possible for a person to distinguish what they understand from exposure to a text from what they gain from its reading. The reading is linked to a level of understanding to which it contributes. Despite this, it is possible to measure the text itself based on aspects that determine the level of difficulty the text structure itself presents to the reader.

The remainder of this paper is organised as follows. The next section provides an overview of the institutional setting and literature review. Research design is addressed in the third section and the results are presented in the fourth section. In the final section, the conclusions are discussed.

INSTITUTIONAL SETTING AND LITERATURE REVIEW

The most significant innovation in financial reporting in recent years has been international harmonisation. This has typically occurred through countries aligning their financial reporting standards with the model set issued by the IASB (Heffes and Graziano, 2007; Callao, Jarne and Lainez, 2007; Cormier, Demaria, Lapointe-Antunes and Teller, 2009; Paananen and Lin, 2009).[1] In developing standards, the IASB has faced a number of challenges, including an increasingly complex business environment and the need for precision in the standards. Doubtlessly, this contributed to the adoption of one language, English, as the authoritative text of the standards (International Accounting Standards Committee, 2007, article 32). Importantly, this avoids conflict in interpretation across various language versions, and limits the potential for alternative, official versions of the regulations that could undermine the quality of outcomes to be expected from harmonisation.[2]

However, the need for precision in the standards and the focus on English as the official language present problems. In fact, the issue of the language used in the standards has been raised in convergence and harmonisation discussions. Concerns have been expressed that the English of accounting narratives is not plain and simple (Courtis, 1998; Rutherford, 2003). The argument presented here is that an outcome of the increasing complexity is the lessening of the readability contribution to the understanding of the standards.

The English used in financial reporting has attracted the interest of accounting researchers and not only within English-speaking countries. Jeanjean, Lesage and

Stolowy (2010) report that 50 per cent of their sample of 3,994 firms for 2003 (49 per cent of 3,844 firms for 2004) across 27 non-English-speaking countries issued English language annual reports. While focusing on the text of management discussion and analysis, Courtis (1998) notes that communication would be enhanced if regard was given to the reading and comprehension abilities of report users. Similarly, Rutherford (2003) provides evidence of the language in financial reports for poorly performing companies being particularly complex. While this lack of clarity cannot be attributed to obfuscation, the issue of whether financial reports are sufficiently readable remains. The same issues arise with respect to accounting standards, due to the way in which they dictate the content of financial reports. Critically, if preparers and users have difficulties reading the text of standards, the quality of those reports will be indirectly undermined. Furthermore, the language requirement of financial reporting standards is clearly articulated by Sir David Tweedie, chairman of the IASB, who expressed the view that:

> …a good principles-based standard must pass four tests:
>
> i. Is the standard written in plain English? …
> ii. Can the standard be explained simply in a matter of a minute or so?
> iii. Does it make intuitive sense?
> iv. Does management believe it helps them to understand and describe the underlying economic activity?
>
> (Tweedie, 2007, p. 5)

The problem of developing accounting regulations is not unique to the IASB. In the US, the FASB[3] faces a similar challenge, and it is noteworthy that over the last few years these two organisations have increasingly cooperated and sought to minimise differences in accounting practices (see, for example, the *Norwalk Agreement* (Financial Accounting Standards Board and the International Accounting Standards Board, 2002)). However, there remain apparently significant differences in the written style of accounting standards. In contrast to the standards developed by the IASB, which are typically described as 'principles-based', the standards developed by the FASB are commonly labelled 'rules-based' (for a discussion, see, for example, Benston, Bromwich and Wagenhofer, 2006). Critics of the FASB regulations allege that this approach fosters a 'check box' or compliance mentality, and that this contributed to financial reporting crises in the US (Schipper, 2003). Furthermore, there have been calls to adopt a principles-based approach to standard setting in the US (MacDonald, 2002). Whether this should occur has been the subject of discussion (see, for example, Maines, Battov, Fairfield, Hirst, Iannaconi, Mallett, Schrand, Skinner and Vincent, 2003), and has brought into question the appropriateness of the labels typically applied to the regulatory styles. For example, it is difficult to argue that the standards developed by the FASB are not based upon principles, captured for instance in the conceptual framework statements. The requirements of these principles are expressed as objective statements which look like rules. The IASB is developing standards based upon essentially the same principles. However, these are expressed as subjective statements. The behavioural implications of this different regulatory style (objective versus subjective statements) have been considered (Nelson, 2003), but not the impact on the readability of the standards.

Readability

As this paper is concerned with the readability of the standards developed by the accounting community, the focus is necessarily on external factors independent of the reader. 'Readability' is one element that contributes towards understanding text, but is itself a somewhat nebulous concept and so this paper provides a range of predictions of the readability of accounting standards. It should be noted that the objective tests used in this study are predictions related to the characteristics of the text alone. They provide indications of whether the text may be difficult to 'handle'. The tests do not predict the complexity of the subject matter nor whether a particular reader is able to grasp the meaning intended by the author. The indicators of readability used in the analysis are the Flesch Reading Ease Index, the Flesch–Kincaid Grade Level Index, and Lexical Density and Grammatical Intricacy from Functional Grammar.

Flesch Reading Ease Index

Many of the original, non-grammatical tests of readability were based on mathematical formulae, and this continues today for most tests (see McLellan and Dobinson, 2004 for a brief survey of several tests). Other methods involve objective question-and-answer techniques, tables and charts, and sentence completion. For example, the Cloze Procedure is a sentence completion method. It requires a person to recall and supply every fifth word in a passage which has been previously read without words missing (Gilliland, 1972). In this way the text is judged as having a particular level of readability depending on the age of the tested reader. However, some researchers (e.g. Woods, Moscardo and Greenwood, 1998) regard the Cloze Procedure to be more related to comprehension than to readability, and thus not relevant here.

Formulae tests that have received support and usage over the years include the Fog Index designed by Gunning (1952), which is based on counts of words, sentences and complex words; the Dale and Chall approach (1948), in which a count is made of words outside a list of 3,000 commonly used words; and the Simple Measure of Gobbledegook (SMOG) (McLellan and Dobinson, 2004), based on adding three to the square root of a polysyllable count. Indeed, there are many tests available, suggested to be about 200, with some of them listed in Woods et al. (1998) and DuBay (2004). However, Zakaluk and Samuels (1988, p. 117) conclude that:

> … classic readability formulas … are intended to and do predict an approximate level of difficulty. Critics would like these formulas to account for more of the complexities of text. Readability research has shown that the addition of attributes does not increase the reliability of the formulas.

The Flesch Reading Ease Index was selected as representative of these formulae-based methods since it is accepted as a 'highly reliable measure' of literature for adults (Rogers, Harrison, Shuman, Sewell and Hazlewood, 2007). Devised in 1948, it is based on a formula relating readability to sentence length expressed in words and the syllable count per 100 words (Flesch, 1950). The higher the score achieved in the analysis of a text, the better the readability. The formula for the Flesch Reading Ease Index (FREI) is:

$$FREI = 206.835 - 1.015ASL - 84.6ASW \quad (1)$$

where *ASW* represents the average number of syllables per word, while *ASL* is the average sentence length. Literature on the FREI suggests that a score around 90–100 means the text can be easily read by fifth graders (US education system), who are typically 10 to 11 years old. A score around 60–70 can be handled by eighth and ninth graders while scores below 30 are managed by university graduates. This is reflected in Table 1, which relates index scores to readability.

TABLE 1: FLESCH READING EASE INDEX (FREI)

Score	Interpretation
0–30	Very difficult
30–50	Difficult
50–60	Fairly difficult
60–70	Normal
70–80	Fairly easy
80–90	Easy
90–100	Very easy

Source: Flesch, 1950, p. 388.

Flesch–Kincaid Grade Level Index

Closely related to the Flesch Reading Ease Index is the Flesch–Kincaid Grade Level Index (FKGLI), which is based on the same language variables, but the results are expressed as a grade level (US education system) required for readability. Its development was commissioned by the US Navy in 1976 and, importantly, a validation process was included in the project (DuBay, 2004). The outcome of the study was the Flesch–Kincaid Grade Level Index. It is calculated according to the following formula:

$$FKGLI = 0.39ASL + 11.8ASW - 15.59 \quad (2)$$

where, as in the previous formula, *ASW* represents the average number of syllables per word and *ASL* is the average sentence length.

Both the Flesch Reading Ease Index and the Flesch–Kincaid Grade Level Index have been used extensively in diverse contexts. Examples include the readability of health materials and, in particular, directions for contraceptive use (Williams-Deane and Potter, 1992), health promotions (Harvey and Fleming, 2003), diabetes information (Kerr, 2007), hospital discharge forms (Fung, Willer, Moreland and Leddy, 2006), and nutrition websites (Stalebrink and Sacco, 2007). The tests have also been employed in studies on newspapers (McLellan and Dobinson, 2004), privacy notices (Fung et al., 2006), Miranda warnings[4] (Rogers et al., 2007), agricultural contracts (Goodhue and Hoffmann, 2006), tax rulings (Wallis, 2005), political science textbooks (Heilke, Joslyn and Aguado, 2003), psychology reports (Harvey, 2006) and the Australian Goods and Services Tax Act (Richardson and Smith, 2002). In the accounting discipline, numerous analyses of readability using these tests have been undertaken in such areas as annual reports (Beattie, McInnes and Fearnley, 2004; Clatworthy and Jones, 2001), accounting disclosure in corporate governance (Rutherford, 2003), auditors' suggestion letters (Hagge and Kostelnick, 1989) and accounting narratives (Sydserff and Weetman, 1999). The tests have also been used by Davidson (2005) to analyse the readability of accounting textbooks published over a 100-year period.

In summary, there is ample evidence of these tests being used widely.[5] Moreover, the nature of the measures is consistent with the objectives of this paper, being the evaluation of the language of regulations against the benchmark of 'plain and simple' set by Tweedie (2007). Contrary to the views of some critics, both tests were designed to evaluate texts for adults and were validated using adult readers (Stockmeyer, 2009).

RESEARCH DESIGN

Regulatory Context

An initial concern with this study was determining the specific standards to evaluate. The issue of leases was identified and the regulations AASB 117 *Leases* (the Australian equivalent of International Accounting Standard (IAS) 17 *Leases*) and Financial Accounting Standard (FAS) 13 *Accounting for Leases* (both versions as at 2007) were selected for a number of reasons. Firstly, for comparability the standards must address a common issue, and their scope limited to that issue. Secondly, the standards needed to be a clear demonstration of the different regulatory styles. Thirdly, the issue is non-trivial and the accounting alternatives have been widely canvassed. Finally, there is broad agreement about appropriate accounting practices.[6] AASB 117 *Leases* was chosen rather than IAS 17 *Leases*, as it is consistent with the international standard and addresses a potential criticism that the analysis in this paper is not of an accounting standard as applied in practice.

While the focus on one accounting area is a limitation of this study, the results from *t*-tests on non-grammatical readability scores on all the AASB standards other than AASB 117 indicate that on average the latter is significantly easier to read than the other 46 AASB standards (see results section below).

The Flesch Reading Ease and Flesch–Kincaid Grade Level tests were applied to each standard as one text, and also to paragraphs separately.[7] The latter provided an insight into the range of reading ease and grade level indices which might otherwise be lost if the only scores taken were of the full text as one piece of literature. The readability of individual passages of each standard analysed was calculated, omitting tables, headings, illustrations and lists of contents, to ensure a focus on the core content. Other than a two-page Implementation Guide, there was no additional material annexed to AASB 117, but such was not the case for FAS 13. For that standard of 84 pages, 57 contained annexures and schedules to the standard. Only the standard itself was included in the analysis as this was considered sufficient to assess for readability.

Both the above methods require a definition of a sentence. For the purpose of these tests, sentences were defined by the use of a 'full stop' (US 'period') punctuation mark rather than the presence of a finite verb, which is sometimes applied. A consequence of this is that in the US standard where paragraphs consisted of a stem and several branches and there was a full stop at the end of each branch, the stem and the first branch was counted as one sentence and all the subsequent branches as separate sentences. In comparison, for the Australian standard the end of each branch had a semi-colon so that the stem and all branches constituted just one sentence. While the difference in punctuation caused a difference in scores, the number of such cases was small and adjustment was not considered necessary. All headings, whether with or without a following full stop, were not counted.

A simple word count per sentence of a text is also commonly used in conjunction with the above indices. While this is a relatively naïve measure of readability, it can highlight significant differences across regulations, and so a word count was also undertaken.

Systemic Functional Grammar

A potential criticism of the above tests is that they focus quite mechanistically on the number of syllables and length of sentences. While this is well suited to the evaluation of significant volumes of text, a more detailed analysis is possible through techniques available from Systemic Functional Grammar and using samples of the texts. Systemic Functional Grammar is a recognised methodology for textual analysis.[8]

One method of analysing texts available from Systemic Functional Grammar is Lexical Density, which focuses on the words used in sentences. The extensive use of 'content' words may contribute to Lexical Density, and this may be evaluated by 'expressing the number of content carrying words in a text/sentence as a proportion of all the words in the text/sentence' (Eggins, 2004, p. 97). The higher the proportion of content words the higher the Lexical Density, and the more difficult it is to read and understand the text (see, for example, Halliday, 1994; Martin, 1992; Eggins, 2004). Other factors contribute to Lexical Density, including the compression of words into clauses or phrases. A simple example of this would be the reduction of 'term of the lease' to 'lease term'. A more detailed explanation of the application of this technique is deferred to the results section where it is related to the text being analysed.

Another linguistic indicator for analysing texts is Grammatical Intricacy. This focuses more on the sentence structure, and is assessed on the basis of sentence clauses and themes (Eggins, 2004). In the first instance, Grammatical Intricacy is 'calculated by expressing the number of clauses in a text as a proportion of the number of sentences in the text' (Eggins, 2004, p. 97). The argument is not that all sentences in technical texts should ideally be composed of few clauses per sentence. Often, to express a complex idea the writer needs to construct a complex sentence composed of several clauses in order to do justice to the complexity of thought. However, when complex grammatical sentences are combined with high Lexical Density, the texts may become inaccessible for many readers (Eggins, 2004). Other factors impacting Grammatical Intricacy include the themes of clauses. Again, a more detailed explanation is deferred to the results section where it is related to the text being analysed.

As the techniques of Systemic Functional Grammar involve the detailed analysis of text it was not feasible to apply it to the text of an entire standard. In this research, the techniques were applied to samples of text chosen at random from positions one-, two- and three-quarters of the way through each of the accounting standards.

RESULTS AND DISCUSSION

This section contains the results and discussion of the Readability Ease and Grade Level scores for AASB 117 and FAS 13. It should be noted that some of the paragraphs analysed have less than 100 words. The validation and early use of the Readability Ease and Grade Level tests were with sample passages of 100 words, and so the results for paragraphs of less than 100 words are outside the validation testing of the indices. The section concludes with findings from the analysis of AASB 117 using Lexical Density and Grammatical Intricacy from Systemic Functional Grammar.

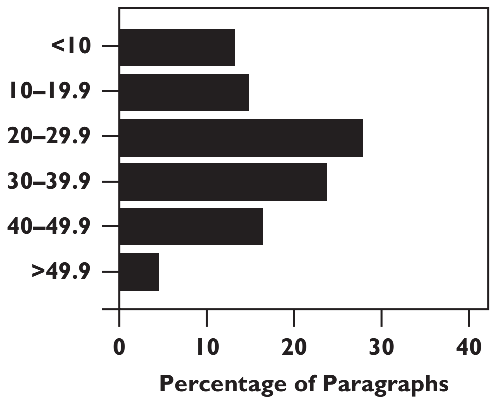
Flesch Readability Ease Index

Attention is directed in the first instance towards the results from the estimation of the Flesch Readability Ease Index (FREI). For AASB 117, when evaluated as a single text, the score was 30.5, which suggests that the standard was 'difficult', bordering on 'very difficult', to read. When the paragraphs were evaluated separately, the mean (median) paragraph score was 29.6 (29.2), which was consistent with the result when the standard was evaluated as a single text. However, it was apparent that there is considerable variation across paragraphs, with a minimum score of 0[9] and a maximum score of 53.4. Given that a score below 30 is indicative of 'very difficult' to read text, this suggested that the readability of the text was generally poor. This is highlighted in Figure 1, which shows that 52 per cent of the paragraphs had scores below 30 and were 'very difficult' to read, while less that 6 per cent of paragraphs had scores above 50 and were at best 'fairly difficult' to read.

The evidence clearly suggested that AASB 117 did not rate well for readability by this measure.

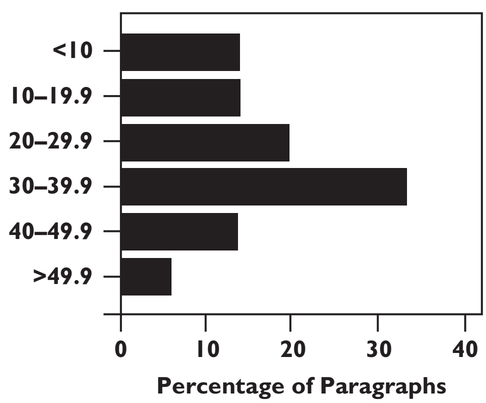
For comparative purposes, FAS 13 was also evaluated. For the entire text the score was 31.9, which is a slight improvement on AASB 117, although this was still near the top end of the 'difficult' range. For the analysis by paragraph, the mean (median) paragraph score was 28.4 (30.8), with a minimum of 0[10] and a maximum of 57.2, which was consistent with the results for AASB 117. The results are summarised in Figure 2, which shows that 47 per cent of paragraphs had a score below 30 and would be considered 'very difficult' to read. There were marginally more paragraphs (7 per cent) with a score of more than 50, which would be considered at best 'fairly difficult' to read.

FIGURE 1: AASB 117 READABILITY EASE BY PARAGRAPH (N = 68)



Accordingly, the results for the FREI suggested that while FAS 13 was marginally more readable than AASB 117, both had non-trivial readability problems.

FIGURE 2: FAS 13 READABILITY EASE BY PARAGRAPH (N = 51)

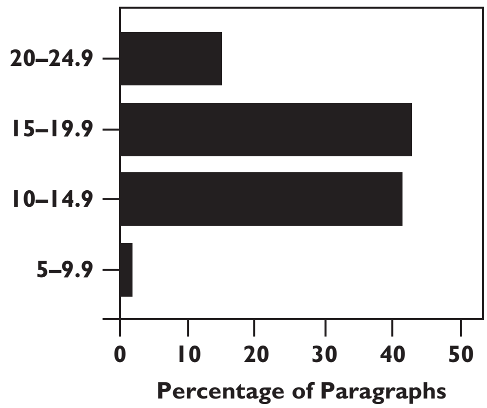


Flesch–Kincaid Grade Level Index

An alternative readability measure is the Flesch–Kincaid Grade Level Index (FKGLI), which expresses readability in terms of the education required to read the text, and the results are broadly consistent with those reported above.

When evaluated as one single text, AASB 117 achieved a FKGLI score of 15.4. Consistent with this, when paragraphs were evaluated separately the mean (median) score was 16.2 (15.5), with a minimum of 9.2 and a maximum of 24.8. The results are summarised in Figure 3, indicating somewhat problematically that 14.7 per cent of the paragraphs required a notional educational grade of 20 or more. This contrasts with grade 12, the highest grade in the US school education system.

FIGURE 3: AASB 117 GRADE LEVEL BY PARAGRAPH (N = 68)

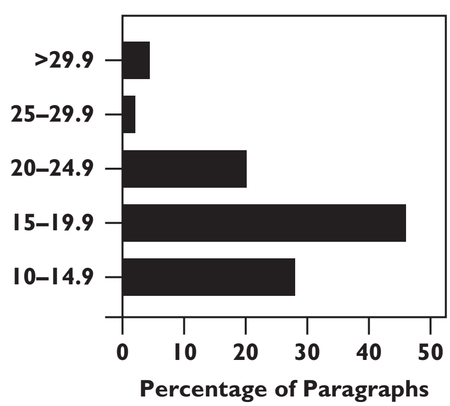


In comparison, when FAS 13 was evaluated as a single text, the FKGLI score was 16.3. When individual paragraphs were evaluated, their mean (median) score was 17.2 (16.4), and the paragraph scores ranged from 10.1 to 30.9. The results are summarised in Figure 4. Again, it is problematic that 27.5 per cent of the paragraphs required an education in excess of a notional grade of 20.

Thus, while there was evidence that more paragraphs in FAS 13 have extremely high FKGLI scores when compared to AASB 117, it cannot be argued that either standard rated well with this readability measure.

Grade level scores as high as those reported above are problematic. They could be regarded as artificial for the lack of a degree, course or educational process requiring 30 years of education. That view is not rejected here. However, the position is taken that, even if the measure is a 'phantom' grade, it does clearly indicate the level of difficulty the paragraphs present to a reader, even with a university education of around four years. In this context, where there are relatively numerous paragraphs

FIGURE 4: FAS 13 GRADE LEVEL BY PARAGRAPH (N = 51)



at or exceeding Grade 20, accounting students are required to comprehend and apply the standards early in their post-school education – at Grade 14 or 15.

Word Count by Sentences

Possibly contributing to the results above for readability is the length of the sentences. While not typically considered a measure of readability, it is recognised as having an impact on readability. Reflecting this, the number of words in the sentences of both standards was analysed. As a benchmark it should be noted that well-written sentences typically contain 30 to 40 words.

The mean (median) number of words per sentence for AASB 117 was 40 (32). Thirty-five per cent of the sentences in that standard had in excess of 40 words, six sentences exceeded 100 words, and the longest sentence had 191 words. A summary of the results is presented in Figure 5.

An analysis of FAS 13 produced a similar result. The mean (median) number of words per sentence was 37.9 (33), and a similar percentage (36 per cent) of sentences exceeded 40 words. Five sentences exceeded 100 words, with the longest having 154 words. Although the latter was slightly more modest than for AASB 117, it remains a worrying aspect with its likely impact on readability. Figure 6 provides a summary of the results.

Not captured in the above analysis were a number of factors relevant to the determination of readability. Firstly, it was striking that FAS 13[11] contained 11,632 words, compared to 6,035 words in AASB 117.[12] Interestingly, the length of the texts did not impact the readability measures reported above, either positively or negatively. Secondly, the extensive number of words per sentence was consistent with the predominant linguistic register being legalistic. This is a recognised problem in the legal fraternity. Long sentences traditionally used in law have been the subject of extensive reform efforts to employ plain English in legal documents.[13]

As highlighted above, there was little difference in the readability test results for the 'principles-based' AASB 117 standard and the similar 'rules-based' FASB standard (if that distinction is maintained). From the nature of the tests used, which only

Figure 5: AASB 117 WORD COUNT BY SENTENCE (N = 151)

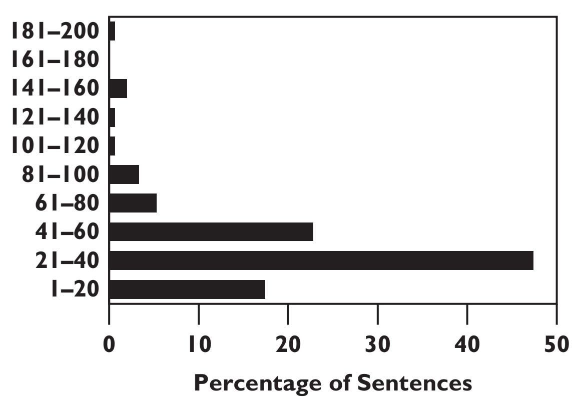
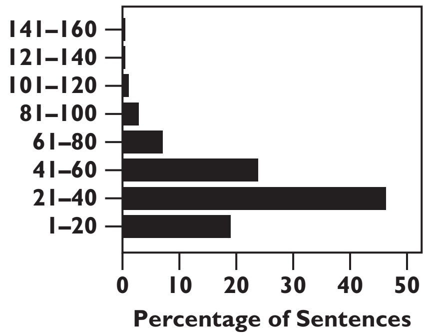


FIGURE 6: FAS 13 WORD COUNT BY SENTENCE (N = 274)



incorporated the number of words, sentences and syllables, the results were not unexpected. Both standards suffered from complexity and extensive length.

The Representativeness of the Standard on Leases

To determine whether the readability scores by paragraph obtained for AASB 117 were representative of the other 46 AASB standards, Readability Ease and Readability Grade Level scores were also ascertained for all other AASB standards. The results from *t*-tests on the scores by paragraph for the other 46 AASB standards indicate that AASB 117 is significantly easier to read ($p < 0.01$) than all the others on average. The mean for Reading Ease of the 46 standards was 20.7, while it was only 29.6 for AASB 117. The Reading Grade mean was 17.5 for the 46 standards and 16.2 for AASB 117. Thus, the 46 standards pose an even greater challenge than reported in this paper for the standard on leases.

Systemic Functional Grammar

The above analysis is quite mechanical in its focus on words, sentences and paragraphs. Addressing this potential limitation, a Systemic Functional Grammar analysis was undertaken. Because of the extensive analytical work involved, the tests were based on a limited sample of three paragraphs from each standard. The analysed paragraphs are listed in Tables 2 and 3, with their Readability Indices (FREI and FKGLI) given to aid in the evaluation of the results.

TABLE 2: AASB 117 TEXTS USED FOR TEXTUAL ANALYSIS (WITH THEIR READABILITY INDICES)

Paragraph Number	Total Words in the Paragraph	Readability Ease Index	Grade Level Index
16	104	10.8	24.6
33	36	19.8	12.0
50	41	16.6	21.1

TABLE 3: FAS 13 TEXTS USED FOR TEXTUAL ANALYSIS (WITH THEIR READABILITY INDICES)

Paragraph Number	Total Words in the Paragraph	Readability Ease Index	Grade Level Index
12	254	22.3	20.6
24	44	19.8	21.4
36	37	25.2	18.9

Lexical Density was determined first, in particular the proportion of content words in a sentence. Content words include adjectives, nouns, some verbal forms and adverbs, while non-content words are typically articles (the, an, a), prepositions (e.g. on, in, under) and conjunctions (e.g. and, but, or). In the following extract from AASB 117 (para. 33), the content words are underlined:

> …unless another <u>systematic basis</u> is <u>representative</u> of the <u>time pattern</u> of the <u>user's benefit</u>.

Similarly, the content words of the opening sentence of FAS 13 (para. 12) are underlined below:

> During the <u>lease term</u>, each <u>minimum lease payment</u> shall be <u>allocated</u> between a <u>reduction</u> of the <u>obligation</u> and <u>interest expense</u> so as to <u>produce</u> a <u>constant periodic rate</u> of <u>interest</u> on the <u>remaining balance</u> of the <u>obligation</u>.

The results from the analysis of the sample paragraphs are presented in Table 4. To provide a benchmark for evaluating these results, Eggins (2004) describes a written text with a score of 42 per cent as having a 'high Lexical Density'. These results suggest that both AASB 117 and FAS 13 have high Lexical Density, and while experienced accounting professionals may be able to cope with this, it is likely to be problematic for inexperienced readers of the standards, and in particular accounting students.

TABLE 4: CONTRASTING THE LEXICAL DENSITY OF THE SIX PARAGRAPHS ANALYSED

	AASB 117			FAS 13		
Paragraphs	**16**	**33**	**50**	**12**	**24**	**36**
Number of content-carrying lexical items	35	7	25	121	27	20
Number of lexical items in paragraph	72	14	40	256	47	37
Total Lexical Density	*48%*	*50%*	*62.5%*	*47%*	*57%*	*54%*

The impact of Lexical Density may be mitigated when text has clear logical markers to guide the reader. For example, words such as 'next', 'furthermore', 'since' and 'consequently' provide the reader with identifiable cohesive links to assist with comprehension of the texts. However, these are not present in the text analysed.

Instead, the reader of these standards is reliant only on headings and paragraph numbering for cohesion.

A number of factors exacerbate Lexical Density and these were noted during the course of the analysis. A significant proportion of the content words were technical words. Technical language is the language used within any profession and for the accounting profession includes 'purchase options', 'credit', 'debit' and 'fair value'. Examples of technical language used in the standards include 'amortization', 'residual guarantee' (FAS 13, para. 12), 'inception of the lease' (AASB 117, para. 16) and 'unless another systematic basis is more representative of …' (AASB 117, para. 33).

Technical words form part of the professional jargon, but their combination with other linguistic patterns compounds Lexical Density. For instance, when verbs and adjectives are used as nouns (nominalised), the text becomes conceptually demanding for the reader. For example, 'depreciation' (AASB 117, para. 51), 'reduction', 'obligation', 'failure' and 'accordance' (FAS 13, para. 12), 'equipment' (FAS 13, para. 24) and 'agreement' (FAS 13, para. 36) are all examples of nominalisations. The following text has multiple examples of both technical language (underlined) and nominalisations (italics) occurring in the same sentence:

> In the *event* that …the asset and the *obligation* under the lease shall be adjusted by an amount equal to the *difference* between the present value of the future minimum lease payments under the revised *agreement* and the present balance of the *obligation* (FAS 13, para. 12).

In the following example, technical language and nominalisations overlap. In addition, the reader is required to recall information from other sections of the text.

> In *accordance* with paragraph 9, other *renewals* and *extensions* of the *lease term* shall be considered *new agreements*, which shall be accounted for in *accordance* with the *provisions* of paragraph 14 (FAS 13, para. 12).

The compression of clauses or phrases contributes further to Lexical Density. For instance, the noun groups 'the lease term' and 'lease payment' in 'During the lease term, each minimum lease payment shall be allocated …' (FAS 13, para.12) are reductions of the phrases 'the term of the lease', and 'payment of the lease'. Similarly, the texts from AASB 117 exhibit the same patterns: 'the minimum lease payments … are allocated between the land and the buildings elements in proportion to …' (AASB 117, para. 16). The noun groups underlined in the last example are interesting since not only are meanings condensed, but an additional sophisticated usage occurs. 'Land and buildings', which are usually used as nouns, are used here as descriptive words (adjectives).

Finally, the following sentence has a very high Lexical Density due to a combination of compressed phrases or clauses (bold), technical terms (underlined) and nominalisations (italics). This combination of linguistic features would require from most accounting professionals and experienced readers much effort to unpack:

> **Lease income** from **operating leases** shall be recognised in income on a straight line basis over the **lease term**, unless another systematic basis is more *representative* of the time pattern of the user's benefit (AASB 117, para. 33).

It is clear to the reader of these examples that the purpose of the writers is to achieve textual brevity, and in most instances the examples provided appear to be innocuous enough. However, when this usage occurs persistently throughout a text, the reader can be lost in the abstractions.

A further indicator of readability in Systemic Functional Grammar is Grammatical Intricacy. This is measured in the first instance as 'the number of clauses in a text as a proportion of the number of sentences in the text' (Eggins, 2004, p. 97). It should be noted that scores above 2.6 have been identified as high (Eggins, 2004); the results from the analysis of the sample texts are presented in Table 5.

TABLE 5: CONTRASTING THE GRAMMATICAL INTRICACY OF THE SIX PARAGRAPHS ANALYSED

	AASB 117			FAS 13		
Paragraphs	**16**	**33**	**50**	**12**	**24**	**36**
Number of clauses in the text	6	2	3	13	5	2
Number of sentences in the text	2	1	1	6	1	1
Grammatical Intricacy Score	*3.0*	*2.0*	*3.0*	*2.1*	*5.0*	*2.0*

These results are not as problematic as those for Lexical Density, but still suggest that at least sections of both standards are grammatically intricate, which is unlikely to ameliorate the impacts of Lexical Density.

A number of factors exacerbate Grammatical Intricacy and these were noted during the course of the analysis. This includes the positioning of the theme of a sentence, which is typically at the beginning. However, it should be noted that there is considerable flexibility in English to accommodate a variety of themes as the starting point for the 'message'. Generally, the theme contains all parts of the clause up to and including the topic of the clause. Furthermore, the theme may be a word or a phrase as in (a):

> (a) **Lease payments under an operating lease** shall be recognised as an expense … (AASB 117, para. 33).

In this case, the first phrase (in bold) functions as the theme of the first sentence. Alternatively, it may be a whole clause, as in (b):

> (b) **If the lease payments cannot be allocated reliably between these two elements**, the entire lease is classified as a finance lease … (AASB 117, para. 16).

It should also be noted that both extended themes in (a) and (b) are also technical and nominalised.

Text (a) above deserves further consideration. Usually a reader would expect the text to state 'Under an operating lease, lease payments shall …' since in written texts dependent clauses or prepositional phrases typically come first. The focus of the theme however is '**lease payments**'. By reordering a common pattern of English, the writer is highlighting a particular theme which also happens to be the topic of the text (leasing), but for the novice reader the usage of less typical patterns of

English increases the technical 'feel' of the text, especially when it is used in conjunction with high Lexical Density.

The clause, in (a) above, '**Lease payments under an operating lease shall be recognised as an expense** …' is then followed by a dependent clause, '**[u]nless another systematic basis is more representative of the time pattern of the user's benefit**', which identifies an exception to the application of the rule. Accordingly, this text is conceptually dense not only because of the atypical theme, but because experienced English speakers may predict that the dependent clause would be the theme of the sentence and so the anticipated structure would be:

> Unless another systematic basis is more representative of the time pattern of the user's benefit, lease payments under an operating lease shall be recognised as an expense on a straight-line basis over the lease term.

It was also noted that a pattern in FAS 13 is for the dependent clause to appear in a thematic position, as occurs in FAS 13, para. 36:

> **If the original lessee enters into a sublease/or the original lease agreement is sold or transferred by the original lessee to a third party**, the original lessor shall continue to account for the lease as before.

Further instances of this include:

> **If at any time the lessee and lessor** … (FAS 13, para. 9)
>
> **Except as provided in paragraphs 25 and 26** … (FAS 13, para. 11)
>
> **If the original lessee enters into a sublease** … (FAS 13, para. 36)

The dependent clause also commonly occurs as the theme in AASB 117:

> **Whenever necessary in order to classify and account for a lease of land and buildings**, the minimum lease payments (including any lump-sum upfront payments) are allocated between the land and the buildings elements in proportion to the relative fair values of the leasehold interests in the land element and buildings element of the lease at the inception of the lease (AASB 117, para. 16).
>
> **Because the transaction between a lessor and a lessee is based on** … (AASB 117, para. 9).
>
> **If such lease transactions are not reflected** … (AASB 117, para. 21).

When a writer sets up a pattern of the construction of a text, this assists the experienced reader to recognise the structure and to predict upcoming structures to maximise reading efficiency.

However, the next example is complicated by having four clauses in the sentence, which creates high Grammatical Intricacy:

> If the lease payments cannot be allocated reliably between these two elements,// the entire lease is classified as a finance lease,// unless it is clear that both elements are operating leases,// in which case the entire lease is classified as an operating lease (AASB 117, para. 16).

The first two clauses are relatively simple, having the common clausal structure of a conditional clause (If … then …): 'If the lease payments cannot be allocated reliably between these two elements,// [then] the entire lease is classified as a finance lease'. The third dependent clause 'unless it is clear …' imposes limitations on the main clause and the final clause offers a solution to the situation of the third clause.

A limitation of the Grammatical Intricacy test is that it does not take into consideration other textual complexities such as the use of strings of prepositional phrases, which add another layer of density to the standards. In the text below, the prepositional phrases are bracketed thus{ }:

> Whenever necessary in order to classify and account for a lease of land and buildings,// the minimum lease payments (including any lump-sum upfront payments) are allocated between <u>the land and the buildings elements</u> {in proportion} {to the relative fair values} {of the leasehold interests} {in the land element and buildings element} {of the lease} {at the inception} {of the lease} (AASB 117, para. 16).

The strings of prepositional phrases occur not only in the post-modifying position (that is after the noun group, underlined above), but also in the pre-modifying position (that is before the noun group, also underlined) as in the example below:

> The present value {of the future minimum} <u>lease payments</u> … (FAS 13, para. 12).

Strings of prepositional phrases are necessary to specify conditions, exceptions, etc. and enhance the accuracy of the text. However, a string of seven prepositional phrases in the one sentence, as occurs in AASB 117, is likely to test the reading skills of even the most experienced reader. Moreover, for inexperienced readers or for readers for whom English is not their first language, the lack of familiarity with such complicated structures poses potential comprehension difficulties because extended strings are not common in most other texts nor in speech. Furthermore, in addition to decoding the Grammatical Intricacy of at least sections of the accounting standards, the reader is contending simultaneously with the complexities of Lexical Density as discussed above.

Lexical Density occurs typically when there is a high proportion of technical words in a text, when words are nominalised and when writers condense meanings in a clause or phrase. To compensate for Lexical Density, academic texts usually have a low Grammatical Intricacy (Halliday, 1994). However, analysing AASB 117 and FAS 13 using a Systemic Functional Grammar approach demonstrates that the writers of these standards have combined high Lexical Density with high Grammatical Intricacy. Writers usually have good reasons for structuring texts the way they do (Martin, 1992). One reason can be to incorporate complex ideas and intricate detail to ensure comprehensive coverage of the requirements. However, the experience for many students and accounting practitioners is that reading a text which has both Lexical Density and high Grammatical Intricacy is conceptually very challenging and may be open to misinterpretation. To competently read the standards a student or accounting professional requires a sophisticated understanding of the grammar of English to be able to accurately and meaningfully deconstruct the standards.

CONCLUSION

The main objective of this paper was to evaluate whether the language used in accounting standards constitutes a readability impediment to the harmonisation of accounting standards. The results showed that readability is an impediment as the application and enforcement of the standards upon which financial reporting is based are constrained by the ability of accountants to comprehend and consistently apply them. Evidence was provided across a range of tests of readability (Flesch Readability Ease Index, Flesch–Kincaid Grade Level Index, Lexical Density and Grammatical Intricacy) that the language in the standards did not score well for readability. Consequently, the readability of text in accounting standards is compromised. As a secondary issue, there was no evidence of so-called 'rules-based' regulations having better readability scores than 'principles-based' ones.

It is acknowledged that not all paragraphs were difficult to read. However, there were many paragraphs that were beyond the abilities of a first degree university/college undergraduate at an educational grade level of around 16 to 18 (US educational system). Moreover, the easier paragraphs for readability do not alleviate the challenge for the reader who has to handle all the paragraphs in a standard as a continuum.

A limitation of this study is that it focussed exclusively on the construction of the texts. The concepts expressed in the texts were not analysed, nor could they be with the tests used. Expressions of ideas, processes and outcomes are complex not just because readability qualities create difficulties for readers. The full comprehension of standards involves much more. So solving the readability obstacles merely by using shorter sentences and fewer syllables in words, and by reducing Lexical Density and Grammatical Intricacy, will not necessarily lead to more comprehensible standards. A further limitation is that the paper focused specifically on US and international/Australian accounting standards dealing with one issue (leasing). However, the other 46 AASB standards were also assessed for readability and, on average, the Reading Ease and Grade Level scores of the other 46 AASB standards are significantly more demanding than even AASB 117.

The great challenge this paper identifies for regulators when developing regulations is to use readily understood ideas expressed in plain English. The current version of the IASB accounting standards, if judged by the analyses of the standard reported in this paper, require an exceptionally high level of education to read them accurately and comprehensively. The standard developed by the FASB is no better. The position is understated by the analyses of AASB 117. The results section reports that AASB 117 has significantly easier readability scores than all the other AASB standards on average. For those readers who converse in a diversity of non-English first languages in a world of ever-increasing globalisation, the IASB-based standards require skills in reading English at levels not achieved by a majority of fluent English speakers. This is a problem for students, practitioners and regulators.

Other readability research suggests that introductory textbooks for US post-secondary education in accounting to be around Grades 12–13 (Plucinski, Olsavsky and Hall, 2009). Why is it acceptable to have standards with paragraphs exceeding Grade 20 in the face of US research that identifies a pronounced gap between readability grades reached at high school and required at university (Williamson, 2008)?

The chairman of the IASB comments that:

> This is probably the standard-setters' last chance to move the clock back to try to write shorter, less complex standards, to remove the cottage industry of the expert and return accounting to the profession. We have to move away from the position where only the technical partner understands (or thinks he or she understands) the standards. Accounting is not rocket science – we have to try to write standards for the bulk of the profession. The IASB is trying to do this … (Tweedie, 2007, p. 8)

This paper suggests that if the road to effective standards that are comprehended by 'the bulk of the profession' and not just 'the technical partner', is to provide 'shorter, less complex standards', then the journey's end is far off indeed and the Tweedie benchmark is quite a way away. Indeed, a need for a much more intense language reform is indicated. It is not accounting but the reading of accounting standards that is the rocket science.

ENDNOTES

1 In Australia, this is achieved by the reissue by the Australian Accounting Standards Board of the relevant regulation issued by the International Accounting Standards Board.

2 Other potential factors impacting harmonisation include differing degrees of enforcement of harmonised accounting standards at the national level and the variations possible in their auditing process (dissimilarity of auditing standards or differences in interpretation and enforcement of harmonised auditing standards where used). These are beyond the scope of this paper.

3 The FASB authors standards of financial accounting that regulate the preparation of financial reports by non-governmental organisations in the US. These standards are recognised and enforced by that country's statutory regulator of securities exchanges, the Securities and Exchange Commission (SEC).

4 In the US, these warnings are given before interrogation by police to people taken into custody. The warnings are a result of a leading decision by the US Supreme Court (*Miranda v Arizona*, 1966) that incriminatory statements will only be admissible in a trial if the prosecution proves the defendant was informed of the right to a lawyer before and during interrogation and was informed of the right not to self-incriminate, and the prosecution also proves that the defendant understood these rights but voluntarily waived them.

5 The literature contains numerous criticisms of the many readability tests (Zakaluk and Samuels, 1988; Davies, 1979; Woods et al. 1998). Other criticisms are listed by Woods et al. (1998). That paper also lists authors presenting criticisms. Despite all the possible shortcomings of the Readability Ease and Grade Level Indices, there are many authors who subscribe to the tests' robustness over many years, many papers that validate the tests as legitimate and countless researchers who have applied the tests to a vast array of publications (for extensive coverage see DuBay, 2004).

6 This would not be the case if the focus was on regulations concerned with financial instruments.

7 The sections are referred to as paragraphs in the standards although they do not comply with the grammatical meaning of paragraphs as generally understood.

8 This is demonstrated through the work of Peter Fries, US (1970s–present); Norman Fairclough, UK (1980s–present); and, in Australia, Michael Halliday (1960s–present), Jim Martin (1980s–present) and Suzanne Eggins (1980s–present) among others.

9 Two of the paragraphs had Readability Ease scores so low they were off the scale (the formula gave negative results).

10 The Readability Ease Indices for five paragraphs were off the scale (a negative result from the formula).

11 Headings and information and guidance paragraphs from number 52 onwards were excluded.

12 Paragraphs 1–51, excluding headings and other items as described in the research design section.

13 The original problem was likely a historical consequence of paying lawyers 'a penny a word', together with their practice of ignoring punctuation in the interpretation of documents.

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FINANCIAL POLICIES AND PRACTICES OF COMPANIES LISTED ON THE IRISH STOCK EXCHANGE: CAPITAL STRUCTURE, DIVIDENDS AND CAPITAL BUDGETING

George W. Kester
Washington and Lee University
and
Geraldine Robbins
National University of Ireland, Galway

ABSTRACT

This paper reports the results of a recent comprehensive survey of the chief financial officers of companies listed on the Irish Stock Exchange. The survey focused upon three major areas of financial policy and practice: capital structure, dividends and capital budgeting. In the area of capital budgeting, discounted cash flow methods are used by the listed companies in our sample to a much greater extent than reported for Irish companies in previous surveys. Responses in this survey on capital structure policy are generally consistent with the pecking order hypothesis, whilst Lintner's lagged partial adjustment model continues to be generally consistent with the dividend policy and practices of listed Irish companies.

INTRODUCTION

This paper reports the results of a comprehensive survey of the chief financial officers of companies listed on the Irish Stock Exchange (ISE) regarding their views on various theoretical issues and their companies' financial policies and practices in three major areas: capital structure policy and financing decisions, dividends and capital budgeting. In this research project, we were also interested in how the current global financial crisis has affected listed Irish companies in these areas. Survey research is extensive in the accounting and finance literature with regard to capital budgeting practices. However, surveys of financing and dividend policies are less common. The goal of this paper is to assess the views of Irish executives regarding their views and their companies' practices and, where applicable, to compare our results to previous surveys carried out in both Ireland and other countries.

The responses of financial executives of listed companies in Ireland to the survey questions on capital structure policy are generally consistent with the pecking order hypothesis. They indicate a preference for following a financing hierarchy rather than adhering to a target capital structure. It would also appear that financial executives of listed Irish companies believe that a company's investment and dividend decisions are more binding than capital structure decisions. As in previous surveys of Irish companies, Lintner's lagged partial adjustment model continues to be generally consistent with the dividend practices of listed Irish companies and executives seem to be aware of signalling and clientele effects. The study also found that there is now more extensive use of discounted cash flow (DCF) techniques than evidenced in previous surveys of Irish companies. Net present value (NPV) is growing in popularity and is ranked by the respondents as the most important quantitative evaluation method for evaluating and ranking capital investment projects.

The results of this study should be of interest to both academics and practitioners. The survey questionnaire elicits executives' views on a variety of theoretical and practical issues related to capital structure policy, dividends and capital budgeting. The results also provide insight into company practices and the extent to which listed Irish companies use the assumptions, models and decision rules generated and taught by academics for making financial decisions.

The next section describes the survey design and method, which is followed by reviews of the relevant literature and discussions of the results in the areas of capital structure policy and financing decisions, dividends and capital budgeting. The final section presents our conclusions.

RESEARCH DESIGN AND METHOD

Postal questionnaires consisting of various closed- and open-ended questions were used to obtain information regarding the financial practices and policies of companies listed on the ISE.

In an attempt to identify the effects that the current global financial crisis has had on listed companies in Ireland, the survey questionnaire included open-ended questions asking the respondents to comment on how their companies' financial policies and practices have changed as a result of the crisis.

Copies of the four-page questionnaire, which did not ask respondents to identify themselves, their titles or their companies, were mailed with explanatory cover letters under the letterhead of the National University of Ireland, Galway to the chief financial officers of companies listed on the ISE. Companies listed on both the ISE's Main Market and the Irish Enterprise Exchange (IEX) were included. Companies in the finance and real estate sectors were excluded. In total, the survey questionnaires were mailed to 43 companies in November 2009. A complete second mailing was conducted to further improve the response rate. Eighteen questionnaires were returned, resulting in a survey response rate of 41.9 per cent. Table 1 contains an industry breakdown of the responding companies.

TABLE 1: INDUSTRY SECTORS OF RESPONDENTS

Number	Sector
1	Agricultural
1	Aviation
2	Distribution
1	E-learning software services
2	Media
1	Mining and exploration
1	Oil and gas exploration and production
4	Pharmaceutical and healthcare
1	Retail
2	Transportation
2	Technology and telecommunications

The previous literature and the results of the survey on capital structure, dividends and capital budgeting are discussed in the following sections.

CAPITAL STRUCTURE POLICY AND FINANCING DECISIONS

Background

In a seminal paper, Nobel laureates Modigliani and Miller (1958) advanced the proposition that, based upon several simplifying assumptions, capital structure has no effect on the value of a company. However, recognising the impact of taxes, bankruptcy, agency costs and asymmetric information, capital structure theory has evolved to acknowledge that the use of debt does affect the value of a company. Modern theories of capital structure can be classified into two basic categories: 'static tradeoff models' and the 'pecking order hypothesis'. Static tradeoff models imply an optimal debt–equity mix, which is determined by a tradeoff between the benefits and costs of debt (i.e. balancing the tax advantages of debt against the risk of bankruptcy and agency costs). The pecking order hypothesis implies a hierarchy in raising funds, in which the company prefers internal to external financing and, if it obtains external funds, debt to equity. This empirically motivated hypothesis, which has been theoretically justified on the basis of asymmetric information by Myers (1984) and Myers and Majluf (1984), is consistent with Donaldson's (1961) classic description of actual financing practices, in which he observed that companies prefer internal financing and have an aversion to issuing common stock.

Over the years, the pecking order hypothesis has been supported empirically by Titman and Wessels (1988), Shyam-Sunder and Myers (1999) and others. In their survey of 176 *Fortune* 500 companies in the United States (US), Pinegar and Wilbricht

(1989) found that the financing hierarchy implied by the pecking order hypothesis is more descriptive of actual practice than the static tradeoff model. They also found that capital structure policy is less binding than either the company's investment decisions or dividend policy, a result also consistent with the US survey findings of Pruitt and Gitman (1991).

In a 2002 survey of 117 Irish technology-based software companies, Hogan and Hutson (2005) found that internal funds are the most important source of funding, a result consistent with the pecking order hypothesis. However, in contradiction to the pecking order hypothesis, they found that if external financing is required, the use of equity rather than debt is the preferred source of financing. This result, however, may be unique to new companies in the technology sector.

Survey Results: Capital Structure Policy and Financing Decisions

To assess executive views on capital structure policy, questions were adapted from the questionnaire used by Pinegar and Wilbricht (1989).

Target Capital Structure versus Financing Hierarchy

To assess whether the static tradeoff model or the pecking order hypothesis most accurately describes the views of executives of listed companies in Ireland, we asked respondents to indicate whether, in raising new long-term funds, companies should 'maintain a target capital structure by using approximately constant proportions of several types of long-term funds simultaneously' or 'follow a financing hierarchy in which the most advantageous sources of long-term funds are exhausted before other sources are used'. Only 22.2 per cent of the respondents indicated a preference for maintaining a target capital structure. The majority (77.8 per cent) expressed a preference for following a financing hierarchy. This result is consistent with the pecking order hypothesis as well as the results of Pinegar and Wilbricht (1989) in the US.

Financing Hierarchy

The respondents who expressed a preference for the financing hierarchy were asked to rank seven sources of long-term funds in order of preference for financing new investments: internal equity (retained earnings), new ordinary shares, preference shares, warrants, loans from affiliated companies, bank loans and bonds. The results are shown in Table 2. For each source, the percentage of responses within each rank, the percentage of respondents who did not rank the source and the mean of the rankings are shown. Higher means indicate higher preferences.

As indicated, 66.7 per cent of the respondents (who expressed a preference for following a financing hierarchy) ranked internal equity (retained earnings) as their first choice of financing; bank loans were ranked second; bonds ranked third; external equity (new ordinary shares) ranked fourth. These results are also consistent with the pecking order hypothesis, in which companies prefer internal to external financing, and if external financing is obtained, debt is preferred to equity.

These results are not consistent with the previously mentioned findings of Hogan and Hutson (2005) in their survey of Irish technology-based software companies, in which equity is preferred to debt if external financing is required. However, Hogan

TABLE 2: PREFERENCE RANKINGS OF LONG-TERM FUNDS*

Sources by Order of Preference	Percentage of Responses Within Each Rank								
	First	Second	Third	Fourth	Fifth	Sixth	Last	Not Ranked	Mean**
1. Internal equity (retained earnings)	66.7%	8.3%	8.3%	0.0%	16.7%	0.0%	0.0%	0.0%	6.08
2. Bank loans	25.0%	41.7%	16.7%	8.3%	8.3%	0.0%	0.0%	0.0%	5.67
3. Bonds	0.0%	25.0%	25.0%	25.0%	0.0%	16.7%	8.3%	0.0%	4.17
4. New ordinary shares	0.0%	8.3%	16.7%	25.0%	33.3%	8.3%	8.3%	0.0%	3.58
5. Loans from affiliated companies	8.3%	16.7%	25.0%	0.0%	0.0%	8.3%	33.3%	8.3%	3.33
6. Preference shares	0.0%	0.0%	8.3%	33.3%	25.0%	25.0%	0.0%	8.3%	3.00
7. Warrants	0.0%	0.0%	8.3%	0.0%	8.3%	33.3%	41.7%	8.3%	1.75

* These statistics are based upon the respondents (77.8%) who expressed a preference for the financing hierarchy.
** Mean ratings are calculated by multiplying the percentage in each category with assigned scores 7 through 1 for rankings from 1 through 7, respectively. A score of 0 is assigned when a score is not ranked.

and Hutson's (2005) sample of technology-based software businesses are small, private and extremely specialised companies that often have difficulty obtaining finance from banks that prefer fixed assets as collateral. Moreover, as reported by the authors, the companies' founders place more importance on the pursuit of innovation and being at the forefront of technological change than independence.

Relative Importance of Various Financial Planning Principles

The next question elicited ratings, on a scale of 1 to 5 (where 1 = unimportant and 5 = important), of the relative importance of various financial planning principles affecting a company's financing decisions. The results, ranked in order of importance, are shown in Table 3.

Ensuring the long-term survival of the firm and maintaining financial independence[1] were viewed as the two most important considerations affecting a company's financing decisions. Maintaining financial flexibility was the third most important consideration. Ensuring long-term survival and financial flexibility were also ranked highly by US executives surveyed by Pinegar and Wilbricht (1989). Graham and Harvey's (2001) survey of US companies found that financial flexibility was of primary concern to managers in making financing decisions. Bancel and Mittoo (2004) had a similar result in their survey of managers in sixteen European countries. Financial flexibility allows financial managers to take advantage of unforeseen opportunities whilst also allowing them to cope with unexpected events.

Most finance textbooks begin with an extended discussion of the rationale for the assumption that the goal of the business firm is to maximise shareholder wealth. However, as indicated in Table 3, the maximisation of share prices ranked only fourth as an important factor governing a company's financing decisions by Irish executives. The implication is that either the responding Irish executives do not explicitly consider maximising share prices as important as the other financial planning principles when making financing decisions or they believe that placing importance on the other financial planning principles will in turn ultimately lead to share price maximisation.

This result is consistent with the often-cited findings of Stonehill, Beekhuisen, Wright, Remmers, Toy, Pares, Shapiro, Egan and Bates (1974) from their survey of the financial executives of 87 companies in 5 countries (France, Japan, the Netherlands, Norway and the US), where they found that not a single country's financial executives ranked maximisation of the market value of shares as their first or even second most important financial goal. Similarly, in more recent surveys of executives of listed companies in Australia, Hong Kong, Indonesia, Malaysia, the Philippines and Singapore, Kester, Chang, Echanis, Isa, Skully, Soedigno and Tsui (1998) reported that maximising share prices was not ranked as an important factor governing a company's financing decisions in any of the six countries surveyed.

The need to maintain comparability with firms in the same industry was ranked least important by the responding Irish executives. Apparently, they do not attach a high level of importance to adhering to industry norms, at least relative to other factors affecting financial decisions. The executives responding to Pinegar and Wilbricht's (1989) survey in the US also ranked maintaining industry comparability last.

TABLE 3: RELATIVE IMPORTANCE OF VARIOUS FINANCIAL PLANNING PRINCIPLES

Planning Principle by Order of Importance	Percentage of Responses Within Each Rating						
	Unimportant	2	3	4	Important	Not Rated	Mean*
1. Ensuring the long-term survival of firm	16.7%	0.0%	0.0%	8.3%	75.0%	0.0%	4.25
2. Maintaining financial independence	0.0%	0.0%	25.0%	33.3%	41.7%	0.0%	4.17
3. Maintaining financial flexibility	8.3%	8.3%	8.3%	33.3%	41.7%	0.0%	3.92
4. Maximising prices of publicly traded shares	8.3%	8.3%	33.3%	16.7%	33.3%	0.0%	3.58
5. Maintaining a predictable source of funds	0.0%	16.7%	33.3%	33.3%	16.7%	0.0%	3.50
6. Maintaining long-term relationships with banks	8.3%	16.7%	25.0%	25.0%	25.0%	0.0%	3.42
7. Maintaining comparability with firms in same industry	8.3%	41.7%	25.0%	0.0%	16.7%	8.3%	2.50

* Mean ratings are calculated by multiplying the percentage in each category with values of 1 through 5 for ratings from 'unimportant' to 'important,' respectively. A score of 0 is assigned when not rated.

Relative Importance of Capital Structure

Another question examined the importance of capital structure decisions relative to other decisions. When presented with an attractive new growth opportunity that could not be taken without departing from the target capital structure or financing hierarchy, cutting the dividend or selling off other assets, 77.8 per cent of the respondents indicated that they would deviate from their target capital structure or financing hierarchy. Only two of the responding executives would forgo the opportunity, one indicated that dividends would be cut and one indicated that assets would be sold. These results, summarised in Table 4, suggest that capital structure decisions are less binding than either investment or dividend decisions.

TABLE 4: RELATIVE IMPORTANCE OF CAPITAL STRUCTURE

Likely Action to Be Taken in Response to a Growth Opportunity	Percentage
Forgo the opportunity	11.1%
Deviate from the target capital structure or financing hierarchy	77.8%
Cut the ordinary share dividend	5.6%
Sell off other assets	5.6%

Perceived Market Efficiency

Executives were also asked 'approximately what percentage of the time would you estimate that your company's outstanding shares are priced fairly by the market?' As indicated in Table 5, only one of the responding Irish executives believed that their companies' shares were priced fairly by the market 'more than 80 per cent of the time'. Pinegar and Wilbricht (1989) reported that 47.2 per cent of US executives believed that their companies' shares were priced fairly by the market 'more than 80 per cent of the time'. Conversely, 38.9 per cent of the Irish executives indicated that their companies' shares were correctly priced 'less than 50 per cent of the time', as compared to the 11.9 per cent of US executives reported by Pinegar and Wilbricht (1989). The remaining 55.5 per cent indicated that their companies' shares were priced correctly 'between 50 per cent and 80 per cent of the time'.

TABLE 5: PERCEIVED MARKET EFFICIENCY

Percentage of Time Firm's Shares Are Believed to Be Fairly Priced	Percentage
More than 80% of the time	5.6%
Between 50% and 80%	55.5%
Less than 50% of the time	38.9%

Effects of the Global Financial Crisis on Capital Structure Policies and Financing Practices

To identify some of the effects of the global economic crisis on capital structure policies in Ireland, which have been especially severe, the questionnaire included an open-ended question asking executives to identify how their companies' capital structure policies and financing decisions have been affected by the crisis and resulting global recession.

The respondents' answers to this question are listed in Table 6. As would be expected, respondents cited the higher cost and difficulty of obtaining debt financing, reduced investment and, in the case of two respondents, resorting to new share issues.

TABLE 6: RESPONSES TO QUESTION 'HOW HAS THE CURRENT GLOBAL FINANCIAL CRISIS AFFECTED YOUR COMPANY'S CAPITAL STRUCTURE POLICIES AND FINANCING DECISIONS?'

1. Limited as was conservative in any event.
2. No new funding is available from the banking community.
3. It hasn't.
4. Not at all as we have net cash.
5. Yes, the company is being taken private because access to capital via new equity issues is no longer an advantage of being listed in all practical reality.
6. It has put extreme pressure on the company to maintain its EBITDA [earnings before interest, taxes, depreciation and amortization] and cash flow and is now driven by meeting its required banking covenants.
7. It is more difficult to raise financing of any sort. Therefore, we maintain a conservative cost structure, seek to maximise short-term revenue and raise money when the opportunity arises.
8. Reduced availability of sources of funds and a substantial increased cost for those available.
9. Limited impact on capital structure. We have deferred any major financing and investment decisions.
10. Yes. Ability to raise debt financing due to credit crunch leading to many banks not being open for business. Funding done through new share issue rather than debt as a result.
11. Equity markets closed to new issues from small caps.
12. Reduced appetite for investment due to high financing cost.
13. Shift away from bank debt (which was the cheapest in 2007) to new equity.
14. Crisis has severely limited available sources of external debt and lease financing.
15. We are reverting to export credit financing as opposed to traditional debt and sale-and-leaseback structure.
16. Mainly we cannot execute our M&A [merger and acquisition] strategy as public to private valuations are not aligned.
17. Cost of debt increasing and covenants tightening, therefore cash conservation has become a priority.
18. Cost-cutting measures necessary to streamline operations.

DIVIDENDS

Background

The focal point of financial management is the goal of shareholder wealth maximisation, which is operationalised by the NPV criterion for accepting or rejecting investments. According to the NPV criterion, a company should accept all investment opportunities promising returns greater than available elsewhere for the same level of risk. From this follows the residual dividend policy: dividends should be paid from earnings left over after financing the equity portion of all positive NPV projects. Any leftover earnings should be distributed to the company's shareholders, who can in turn earn higher returns on other investments with the same level of risk. However, depending upon the timing and magnitude of earnings and the investment opportunities available to the company, strict adherence to the residual policy on a year-to-year basis results in an erratic pattern of dividends. Much of the debate surrounding dividend policy deals with the effects that changes in dividends have on share value.

Traditionalists believe that shareholders prefer dividends to the capital gains that would be expected to result from the reinvestment of earnings by the firm. All else remaining constant, any cuts in dividends resulting from the residual policy would likely result in a decrease in share price. Early proponents of this so-called 'bird-in-the-hand' theory, Gordon (1959) and Lintner (1962) argued that dividends are less risky than capital gains. Capital gains depend upon not only the profitable reinvestment of earnings by the company, but also upon movements in the overall stock market. Because dividends are perceived to be less risky than capital gains, shareholders will more highly value the shares of companies with high dividend payout ratios than the shares of companies with low payout ratios, all else remaining constant.

An alternate view is that dividend policy is irrelevant. In another seminal theoretical paper, Nobel laureates Miller and Modigliani (1961) demonstrated that dividend policy is irrelevant in a world of perfect and efficient capital markets. This position, which has been extended by Black and Scholes (1974) and Miller and Scholes (1978), argues that shareholders are concerned only with the firm's earnings, not the proportions retained in the company and paid out as dividends. Shareholders are indifferent to whether or not dividends are paid and consequently would be indifferent to the erratic dividends that would result from adherence to the residual policy.

Notwithstanding the debate that continues among academics, practitioners behave as though dividend policy *does* matter; behaviour that may or may not be rational and theoretically justified. In a classic study based upon interviews with US corporate executives in the mid-1950s, Lintner (1956) reported that although many firms do have long-run payout ratios based upon earnings, year-to-year dividends respond slowly to earnings. Temporary increases or decreases in earnings have little effect on dividends in the short run. In short, he found that companies are reluctant to increase dividends to levels that cannot be sustained for fear of later having to cut dividends.[2]

As a result of these interviews, Lintner (1956) hypothesised a lagged partial adjustment model that relates changes in dividends to both past dividends and current earnings. Lintner's behavioural model, or variations of it, has been empirically tested over the years by a number of researchers. For example, it has been applied to market financial data in the US by Fama and Babiak (1968), Watts (1973) and Roy and Cheung (1985), in Canada by Chateau (1979) and in the UK by Ryan (1974). In general, the results of these studies are consistent with Lintner's hypothesised partial adjustment toward a target payout ratio.

Lintner's model has also been the focus of empirical studies of Irish companies. For example, based on an examination of 40 public companies in the manufacturing sector during the period 1980–1984, Barrett and Cotter (1990) concluded that the dividend behaviour of the Irish companies, which have a tendency to maintain dividends at constant levels, was consistent with Lintner's partial adjustment model. Using data on 38 Irish companies over the period 1984–1988, Green and McIkenny (1991a) found that although Lintner's model had predictive ability, a model developed by Waud (1966), which assumes that dividends are partially adjusted with a lag in response to changes in long-run expected earnings, had greater explanatory power.

Lintner's findings have also been supported by surveys of company executives. For example, Baker, Farrelly and Edelman (1985) surveyed the chief financial officers of firms in the US and found that executives continue to place importance on maintaining dividend continuity. Most respondents agreed that companies should avoid making changes in dividends that might soon be reversed and should strive for an uninterrupted record of dividend payments. In their survey of US firms, Pinegar and Wilbricht (1989) found additional evidence of a strong managerial preference for dividend continuity.

To explore the relationship between dividend, investment and financing decisions in Ireland, Green, Pogue and Watson (1993) surveyed the finance directors of 89 Irish companies and, based on responses from 36 companies, concluded that although the dividends of Irish companies tend to be stable, they are not determined in isolation from the companies' investment and financing decisions. A more recent survey was conducted by McCluskey, Burton and Power (2003), who surveyed 1,000 Irish companies in 2001. From a responding sample of 269 companies, they found high levels of agreement that companies should maintain uninterrupted dividend payments, avoid making changes in dividends that may later have to be reversed, and adopt a target payout ratio. Their respondents also believed that their companies should be responsive to their shareholders' preferences regarding dividends. The respondents in their survey were less certain about whether dividend policy affects share value.

Survey Results: Dividends

To assess executive views on issues concerning dividend policy, the respondents were asked to indicate their level of agreement with each of the thirteen closed-end statements based upon a seven-point scale. The statements were adapted from the questionnaire used by Baker et al. (1985). Table 7 contains summary statistics on the responses to the closed-end statements (identified below by 'S'). The statements are not shown in the order listed in the survey questionnaire.

TABLE 7: LEVELS OF AGREEMENT REGARDING DIVIDEND POLICY

	Disagree-ment (-3, -2)	(-1, 0, +1)	Agreement (+2, +3)	Mean
Attitudes on Dividends and Share Value				
1. Dividend payout affects the share price.	0.0%	16.7%	83.3%	2.11
2. Capital gains expected to result from earnings retention are less certain than expected dividends.	22.2%	55.6%	22.2%	0.78
Attitudes on Lintner's Findings				
3. A company should strive to maintain uninterrupted dividend payments.	11.1%	33.3%	55.6%	1.33
4. A company should avoid increases in dividends that might have to be reversed in a year or so.	0.0%	33.3%	66.7%	1.94
5. A company should have a target payout ratio and periodically adjust its payout toward that target.	0.0%	50.0%	50.0%	1.22
6. A change in the existing dividend payout is more important than the actual amount of dividends.	0.0%	83.3%	16.7%	0.83
Attitudes on Signalling Effects				
7. Reasons for dividend policy changes should be adequately disclosed to investors.	0.0%	5.6%	94.4%	2.72
8. Dividend payments provide a device for 'signalling' future company prospects	5.6%	33.3%	61.1%	1.50
9. The market uses dividend announcements as information for assessing security values.	0.0%	33.3%	66.7%	1.61
Attitudes on the Clientele Effect				
10. Management should be responsive to its shareholders' preferences regarding dividends.	5.6%	38.9%	55.6%	1.56
11. Investors are basically indifferent between returns from dividends versus those from capital gains.	50.0%	27.8%	22.2%	0.52
2. Capital gains expected to result from earnings retention are less certain than expected dividends.	22.2%	55.6%	22.2%	0.78
Attitudes on the Residual Policy				
12. New capital investment requirements of the company generally have little effect on modifying the pattern of dividend behaviour.	16.7%	50.0%	33.3%	0.78
13. Dividend distributions should be viewed as a residual after financing desired investments from available earnings.	11.1%	44.4%	44.4%	1.39

Attitudes on Dividends and Share Value

As previously noted, much of the controversy in the literature deals with the relationship between dividends and share value. Irish executives strongly agree with the statement that dividend payout affects share prices (S1) and therefore is not irrelevant. There was only slight agreement that the capital gains expected to result from earnings retention are less certain than expected dividends (S2), the basic justification offered by traditionalists in support of their belief that shareholders prefer dividends to capital gains.

Attitudes on Lintner's Findings

Four statements pertained to Lintner's lagged partial adjustment model: (S3), (S4), (S5) and (S6). The responding Irish executives agreed that a company should have a target payout ratio and periodically adjust its payout toward that target (S5) and that a company should strive to maintain uninterrupted dividend payments (S3). There was strong agreement that companies should avoid making changes in dividends that might have to be reversed in a year or so (S4). These results are consistent with Lintner's model and the findings of McCluskey et al. (2003) in their survey of Irish companies.

Lintner's findings also suggest that managers prefer to maintain stable dividends and focus on changes in the existing rate of dividend payout rather than the total amount of dividends paid. There was only slight agreement with the statement that a change in the existing payout is more important that the actual amount of dividends (S6).

Attitudes on Signalling Effects

One explanation offered to justify stable dividends is the 'signalling effect' (or 'information content of dividends'), which focuses upon the information that changes in dividends convey to investors. According to the signalling effect, changes in the level of dividends may convey new information to investors regarding future earnings or cash flows. This is due to information asymmetries between managers and investors. Therefore, reductions in dividends that may periodically result from year-to-year adherence to the residual policy would send out negative signals to shareholders regarding the prospects of the firm, thereby adversely affecting its share price.

Three statements involved signalling effects: (S7), (S8) and (S9). Executives strongly agreed that reasons for dividend policy changes should be adequately disclosed to investors (S7). (This statement received the highest mean level of agreement of all thirteen statements.) Executives also agreed that dividend payments provide a 'signalling of the company's prospects' (S8) and that the market uses dividend announcements as information for assessing security values (S9). These results are consistent with the survey evidence of McCluskey et al. (2003) and the findings of McCluskey, Burton, Power and Sinclair (2006) who, based upon an examination of the stock market reaction to dividend announcements of 50 Irish companies over a 15-year period, found that dividend announcements are important to Irish investors.[3]

Attitudes on the Clientele Effect

Another reason offered to justify stable dividend policies is the 'clientele effect', which describes the tendency of each firm to attract its own clientele of investors who are in part attracted to the firm because of its dividend policy.[4] Some investors prefer high payout shares, whereas others prefer capital gains. If the firm strictly adheres to the residual policy on a year-to-year basis, the resulting volatile dividends would cause shifts in the composition of its shareholders (its clientele) which may at least temporarily disrupt its share price as the old shareholder group sells its shares.

Three statements dealt with clientele effects: (S10), (S11) and (S2). As in the case of the survey results of McCluskey et al. (2003), the responding executives agreed that management should be responsive to its shareholders' preferences regarding dividends (S10). No strong opinion was expressed regarding the statement that investors are indifferent between returns from dividends versus those from capital gains (S11). As previously mentioned, there was only slight agreement that the capital gains expected to result from earnings retention are less certain than expected dividends (S2).

Attitudes on the Residual Policy

As previously discussed, an implication of the signalling and clientele effects is that the residual policy should not be adhered to in the short run (i.e. year-to-year) due to the erratic pattern of dividends that may result. If applied, it should be applied over a longer period in order to smooth the firm's dividend payments. Statements (12) and (13) address application of the residual policy. Whereas the responding executives expressed slight agreement with the statement that new capital investments generally have little effect on modifying the pattern of dividend behaviour (S12), they agreed with the statement that dividend distributions should be viewed as a residual after financing desired investments from earnings (S13). The latter result is consistent with the findings of Green et al. (1993), who found that interdependency exists among dividend, investment and financing decisions.

Effects of the Global Financial Crisis on Dividend Policies

To identify some of the effects of the global economic crisis on dividend policies in Ireland, the questionnaire included an open-ended question asking executives to identify how it has affected their companies' dividend policies. The responses to this question are listed in Table 8. Eight of the respondents indicated that their companies do not pay dividends. In three cases, the companies have reduced dividends. One company increased its dividend in 2009. One respondent indicated that no dividends were declared. It is unclear whether this represents a cut in dividends or that the company does not pay dividends. The other respondents reported no significant changes.

TABLE 8: RESPONSES TO QUESTION 'HOW HAS THE CURRENT GLOBAL FINANCIAL CRISIS AFFECTED YOUR COMPANY'S DIVIDEND POLICY?'

1. No impact.
2. Yes. Earnings have been badly hit and the dividend was cut significantly (but one was paid).
3. It hasn't.
4. Not at all – increasing dividend in 2009.
5. No change. We have never paid dividends.
6. For the first time since the company was formed (50 years), no interim dividend was paid and there is uncertainty about a final dividend.
7. We have never paid a dividend and don't anticipate doing so in the medium term – no change from prior to the crisis.
8. Reduced dividends.
9. No change.
10. We don't pay dividends at present.
11. N/A.
12. More cautious on dividends.
13. We don't currently pay dividends, but would like to do so as soon as possible. Investors are now more focused on dividends and we are more reliant on new equity. Therefore [there is a] clear imperative to pay dividends.
14. The company has not paid a dividend since flotation.
15. We don't have a dividend policy – no dividend as we are a growth stock.
16. N/A.
17. Not significantly.
18. No dividends declared.

CAPITAL BUDGETING

Background

Executives of large corporations in the US have been extensively surveyed regarding their companies' capital budgeting practices, especially during the 1970s and 1980s.[5] Among the oft-cited surveys include those reported by Mao (1970), Klammer (1972), Fremgen (1973), Petty, Scott and Bird (1975), Gitman and Forrester (1977), Schall, Sundem and Geijsbeek (1978), Kim and Farragher (1981), Hendricks (1983), Klammer and Walker (1984), Bierman (1993), Trahan and Gittman (1995), Chen (1995), and Payne, Heath and Gale (1999). These surveys, which have focused upon methods of evaluating project profitability and risk, have shown that the analytical techniques used by US executives have increased in sophistication over time. Discounted cash flow (DCF) techniques, such as NPV and internal rate of return (IRR), have become the dominant method of evaluating and ranking proposed capital investments. For example, whereas Klammer (1972) found that only 19 per cent of his sample of large industrial firms used DCF techniques as the primary basis for ranking projects in 1959, the percentage increased to 57 per cent in 1970. Klammer and Walker (1984) found that over 70 per cent of the respondents in their 1980 survey of large firms used DCF techniques; Hendricks (1983) reported that the percentage was 76 per cent in 1981. Bierman (1993) reported that 99 per cent of the respondents in his 1992 survey of the 100 largest *Fortune* 500 companies used IRR or NPV as either the primary or secondary evaluation measure. These studies have shown that although non-DCF techniques such as payback and accounting return of return (ARR) continue to be used, their use as primary evaluation measures has declined. However, they are used as secondary measures. For example, Bierman (1993) found that although payback was used extensively (84 per cent of the respondents in his 1992 survey), not a single respondent used it as a primary measure.

Chen (1995) studied the use of different quantitative evaluation techniques across three types of investments: equipment replacement, expansion of existing products and expansion into new products. The certainty of the related cash flows varies greatly when comparing proposals for routine equipment replacement with expansion into new products. He found that DCF techniques are used more widely than non-DCF techniques such as payback and ARR to evaluate all three types of investments. He also found that DCF techniques are relied upon more heavily in expansion projects than in equipment replacement decisions and that non-financial considerations play a significant role in capital budgeting, especially in decisions related to new products.

In the UK, Pike (1988) found that larger companies are more likely to use DCF methods than smaller companies. He found that payback was the most popular evaluation method used, followed by IRR. Sixty-three per cent of the responding companies in his survey use three or more methods. In a longitudinal survey of 100 companies between 1975 and 1992, Pike (1996) found that the analytical techniques used by executives in the UK, like those in the US, have increased in sophistication over time.

In a survey of 89 Irish companies in 1989, Green and McIlkenny (1991b) found payback to be the most popular evaluation method among the 23 responding companies. They reported that 70 per cent used payback, with NPV ranked second, at 35 per cent. They also found that 39.1 per cent of the respondents used a DCF method alone or in combination with other methods. In a more recent survey in 1993 of 1,000 Irish companies with 424 responses, Lucey, McCabe and McHugh (1995) found that 49.1 per cent of the respondents used a DCF method, alone or in combination with other methods. They also found a strong size effect: larger companies are more likely to use a DCF technique. They also found that Irish companies that are subsidiaries of multinational companies are more likely to use DCF methods than indigenous Irish companies.

Survey Results: Capital Budgeting

Table 9 shows the distribution of the average size of the responding companies' annual capital budgets.

TABLE 9: SIZE OF CAPITAL BUDGETS

Average Size (in € millions)	Percentage
0–10	27.8%
11–25	22.2%
26–50	5.6%
51–100	11.1%
101–1,000	16.7%
>1,000	5.6%
No response	11.1%

Quantitative Evaluation Techniques

One of the goals of this study was to determine the quantitative investment evaluation techniques used by listed companies in Ireland. Several techniques are available for use in evaluating projects. Two of these, NPV and IRR, consider the time value of money and hence are DCF techniques. Although there are numerous non-DCF techniques, two of the more widely used and better known are payback and ARR.

In their surveys of Irish companies, Green and McIlkenny (1991b) and Lucey et al. (1995) asked executives to indicate which quantitative methods were used in their companies to evaluate proposed capital investments. The same approach was used by Kim and Farragher (1981) in the US. However, as acknowledged by Wong, Farragher and Leung (1987), this approach has a weakness, in that it does not provide information about the weight that executives place on each method in making final accept/reject decisions. To overcome this weakness, we asked executives to rate the various methods on a scale of 0 to 5 (where 0 = not used, 1 = unimportant, and 5 = very important). This approach not only reveals which of the methods are used, it also provides information on the relative importance of each method in making final accept/reject decisions.

The results are shown and rated according to perceived importance in Table 10. For each evaluation technique, the percentage of responses within each rating, the percentage of executives who did not rate the technique and the mean of the ratings is given. Higher means imply higher perceived importance.

Whereas Lucey et al. (1995) found that payback was the most frequently used method among the Irish companies in their 424-company sample, the respondents in our survey indicated that the DCF technique NPV was the most important measure for decision making, followed closely by payback. Because cash flows expected in the distant future may be viewed as more risky than near-term cash flows, payback also may be viewed as a method of assessing the temporal dimension of risk. IRR was ranked third. The least important technique was ARR, with 18.8 per cent of the respondents indicating that it was not used by their firms. This result is similar to the findings of Payne et al. (1999) in a 1994 survey of 90 US and 65 Canadian companies. In both countries, NPV and IRR were the most important measures for decision making, followed by payback.

TABLE 10: COMPARATIVE MEAN RATINGS OF QUANTITATIVE EVALUATION TECHNIQUES RANKED BY ORDER OF IMPORTANCE*

	Percentage of Responses Within Each Rating						
Evaluation Technique	**0 (Not Used)**	**1 (Unimportant)**	**2**	**3**	**4**	**5 (Very Important)**	**Mean****
1. Net present value	0.0%	12.5%	0.0%	6.3%	18.8%	62.5%	4.19
2. Payback period	0.0%	6.3%	0.0%	31.3%	25.0%	37.5%	3.88
3. Internal rate of return	6.3%	25.0%	6.3%	25.0%	12.5%	25.0%	2.88
4. Accounting rate of return	18.8%	25.0%	18.8%	25.0%	6.3%	6.3%	1.94
5. Other	81.3%	12.5%	0.0%	0.0%	0.0%	6.3%	0.44

* Executives were asked to indicate the relative importance of the quantitative evaluation techniques on a scale of 0 to 5, where 0 = not used, 1 = unimportant and 5 = very important.
** The mean ratings are calculated by multiplying the percentage of responses in each category with values of 0 through 5. A score of 0 is assigned when not rated.

One hundred per cent of the respondents in our survey indicated that they use a DCF method, as compared to the earlier surveys of Green and McIlkenny (1991b) and Lucey et al. (1995), who found that 39.1 per cent and 49.1 per cent of their respondents, respectively, used a DCF method alone or in combination with other methods.

Risk Assessment Techniques

Another area of interest in our survey was the techniques used to assess risk. Again, in order to obtain information on the relative importance of each method, we elicited ratings, on a scale of 0 to 5 (where 0 = not used, 1 = unimportant and 5 = very important) of various techniques for assessing risk, including scenario analysis (optimistic/most likely/pessimistic forecasts), sensitivity analysis, decision trees and probabilistic (Monte Carlo) simulation. The results are summarised and ranked according to perceived importance in Table 11.

Scenario analysis (optimistic/most likely/pessimistic forecasts) and sensitivity analysis were perceived to be the two most important techniques for assessing risk. More sophisticated probabilistic techniques, such as Monte Carlo simulation, appear to be seldom used by listed companies in Ireland.

These results are consistent with the findings of Green and McIlkenny (1991b) for Irish companies and Pike (1983) for UK companies. In these surveys, the most frequently used method of risk analysis by the Irish companies was sensitivity analysis (82.6 per cent of respondents), followed by scenario analysis (78 per cent). For UK companies, the most popular method was scenario analysis (93 per cent), followed by sensitivity analysis (71 per cent).

Income Taxes

Respondents were asked whether estimated cash flows (or earnings) of proposed capital investments were evaluated before or after corporate taxes. The majority (64.7 per cent) of respondents indicated that cash flows are evaluated before corporate taxes. Only 35.3 per cent indicated that cash flows (or earnings) are evaluated after corporate taxes.

Capital Rationing

Under ideal circumstances, classic microeconomic theory tells us that a firm should expand (accept investment projects) to the point where its marginal return is just equal to its marginal cost. However, some firms place an absolute limit on the size of their capital budgets. The principal reason for capital rationing is that some firms are reluctant to obtain external financing. There may be a limit placed upon the firms' borrowing by internal management or external lending institutions. In the case of external equity (selling shares), there may be a fear of losing voting control. In their 1976 survey of large US firms, Gitman and Forester (1977) found that 52 per cent of their respondents engaged in capital rationing. By far the most prevalent cause was a limit placed on borrowing by internal management. In a more recent survey of *Fortune* 500 companies in 1992 and 1993, Mukherjee and Hingorani (1999) reported that 64 per cent of their respondents encountered capital constraints some of the time. Of those companies, 82 per cent reported that the constraints were

TABLE 11: COMPARATIVE MEAN RATINGS OF RISK ASSESSMENT TECHNIQUES RANKED BY ORDER OF IMPORTANCE*

	Percentage of Responses Within Each Rating						
Evaluation Technique	**0 (Not Used)**	**1 (Unimportant)**	**2**	**3**	**4**	**5 (Very Important)**	**Mean****
1. Sensitivity analysis	0.0%	5.6%	0.0%	22.2%	22.2%	50.0%	4.11
2. Scenario analysis	0.0%	0.0%	11.1%	16.7%	33.3%	38.9%	4.00
3. Decision tree analysis	61.1%	11.1%	5.6%	11.1%	0.0%	11.1%	1.11
4. Probabilistic simulation	83.3%	5.6%	5.6%	5.6%	0.0%	0.0%	0.33
5. Other	94.4%	5.6%	0.0%	0.0%	0.0%	0.0%	0.06

* Executives were asked to indicate the relative importance of the risk assessment techniques on a scale of 0 to 5, where 0 = not used, 1 = unimportant and 5 = very important.
** The mean ratings are calculated by multiplying the percentage of responses in each category with values of 0 through 5. A score of 0 is assigned when not rated.

internally imposed. The primary reason for capital rationing was the reluctance to obtain external financing.

To determine whether listed companies in Ireland engage in capital rationing, respondents were asked to indicate 'yes' or 'no' to the question, 'Does your company place a limit on the size of its annual capital budget?' The majority (70.6 per cent) of respondents indicated that their companies do not practice capital rationing. The remaining companies (29.4 per cent) do practice capital rationing.

Discount Rates Used to Evaluate Proposed Capital Investments

Respondents were asked to indicate whether their firms used a single discount rate for all investments, multiple risk-adjusted discount rates, or a discount rate based upon the costs of the specific capital used to finance proposed capital investments. The results are shown in Table 12.

TABLE 12: DISCOUNT RATES USED TO EVALUATE CAPITAL INVESTMENTS

Discount Rate*	Percentage
Single discount rate based on company's overall weighted average cost of capital is used to evaluate all proposed capital investments.	66.7%
The discount rate used for each project is the cost of the *specific capital used to finance project* (i.e. the discount rate for a project that will be financed entirely with debt is the cost of debt).	11.1%
Multiple risk-adjusted discount rates are used; the riskier the investment, the higher the rate.	22.2%
Other	0.0%

* Italics added by authors; not used in survey questionnaires.

The majority (66.7 per cent) of the responding executives indicated that their firms use a single discount rate based on their firms' overall weighted average cost of capital (WACC) to evaluate all proposed capital investments. Theory tells us that in order to use the WACC as the discount rate for all proposed capital investments, they must be homogeneous with respect to risk and have the same risk level as the average risk of the company. If the risk of a proposed investment differs substantially from that of the overall company, then it is necessary to determine a specific return for that investment. In other words, if proposed capital investments are heterogeneous with respect to risk, a multiple risk-adjusted discount (hurdle) rate system should be employed, with riskier investments requiring higher minimum rates of return. Otherwise, accept/reject decisions will be biased in favour of poor high-risk investments and against good low-risk investments. Interestingly, only four of the respondents indicated that their companies use multiple risk-adjusted discount rates.

As also shown in Table 12, two of the respondents indicated that their firms based the discount rate on the specific capital used to finance the investment under consideration. This of course conflicts with the theory of weighted average cost of capital (WACC), which implies that investments are financed out of a pool of funds, as opposed to being individually financed out of debt, preferred stock or ordinary shares.

Method of Estimating Multiple Risk-Adjusted Discount Rates

For those four firms that use multiple risk-adjusted discount rates, estimating the risk and required returns for individual projects can be a difficult task. One common approach is to classify proposed capital investments into subjectively defined risk categories (i.e. replacement, expansion of existing products, expansion into new products or markets, and so forth). The discount rate for higher-risk investments is a rate higher than the firm's overall WACC. The discount rate for lower-risk investments is a rate lower than the firm's WACC.

Another approach is to use a two-step procedure, which first requires estimating the divisional cost of capital for each major operating division of the firm. This reflects the different levels of risk inherent in the different businesses in which the firm operates. Generally speaking, this involves estimating the costs of capital for other firms with the same risk characteristics as the division under evaluation ('pure play' method). The result is that higher-risk divisions have a higher cost of capital than the firm's overall WACC; lower-risk divisions have a cost of capital lower than the firm's overall WACC. Recognising that there is also a risk-return spectrum with each division, the second step is to classify proposed capital investments within each division into risk categories. Then, each division uses its divisional cost of capital for average risk investments, and higher and lower discount rates for investments of higher and lower risk, respectively.

A third approach is to estimate each investment's beta (market risk) and use the Capital Asset Pricing Model (CAPM) to determine the WACC for individual investments. From a theoretical standpoint, the rationale of this approach is that well-diversified investors should be concerned only with market risk as measured by beta.

To determine which of these methods are used in practice, the respondents who indicated that their firms use multiple risk-adjusted discount rates were asked which method was used. All four of the respondents adjust for risk by classifying proposed investments into subjectively defined risk categories. None of the respondents estimate divisional WACCs and risk categories within each division or use the CAPM to determine project-specific discount rates.

Methods of Estimating the Cost of Equity Capital

Finance textbooks usually describe three methods to estimate a company's cost of equity capital.[6] These usually include (1) the CAPM, based upon the firm's beta, (2) dividend yield plus expected growth rate and (3) the risk premium method (cost of debt plus risk premium). To determine which methods are used by listed companies in Ireland, we asked respondents which method their companies used. The results are shown in Table 13.

The most popular method was the CAPM, with 50.0 per cent of the respondents indicating that their companies use it to estimate the cost of equity capital. By comparison, Graham and Harvey (2001) found that 73 per cent of surveyed US and Canadian companies used the CAPM. In a telephone survey of 27 US firms judged by

TABLE 13: METHOD OF ESTIMATING COST OF EQUITY CAPITAL

Method	Percentage
Capital Asset Pricing Model (CAPM, based upon the firm's estimated beta)	50.0%
Dividend yield plus growth rate	5.6%
Cost of debt plus risk premium	44.4%
Other	0.0%

their peers to be 'among those with the best financial management', Bruner, Eades, Harris and Higgins (1998) found that the CAPM is the dominant model for estimating the cost of equity capital. Over 80 per cent of respondents used the CAPM. Brounen, De Jong and Leodijk (2004) found that 31 per cent of surveyed companies in the UK, 31 per cent in the Netherlands, 18 per cent in Germany and 27 percent in France used the CAPM. In their survey of companies in the UK, McLaney, Pointon, Thomas and Tucker (2004) found that 47 per cent used the CAPM.

Of the remaining respondents in our survey of listed Irish companies, 44.4 per cent indicated that that their companies use the risk premium method and one respondent uses the dividend yield plus growth rate method.

Effects of Global Financial Crisis on Capital Budgeting Policies and Practices

To identify some of the effects of the current financial crisis on capital budgeting policies and practices in Ireland, our questionnaire included two open-ended questions asking executives to identify (1) how it has affected their companies' capital budget, and (2) how it has affected their companies' capital investment analysis procedures. Listings of the respondents' responses to these questions are listed in Tables 14 and 15 respectively.

TABLE 14: RESPONSES TO QUESTION 'HOW HAS THE CURRENT GLOBAL FINANCIAL CRISIS AFFECTED YOUR COMPANY'S CAPITAL BUDGET?'

1. No impact.
2. Cut it by 90%. 'Cash is King', so hold onto it until there is more certainty.
3. It hasn't.
4. Not at all.
5. Some fiscal tightening, but no dramatic change.
6. Yes, there has been no capital investment.
7. No significant impact, but generally more conservative approach.
8. Reduced availability of funding means reduced capital expenditure budgets.
9. Major investment decisions have been deferred.
10. Source of funding has changed.
11. Reduced it.
12. Reduced it.

(*Continued*)

TABLE 14: (*CONTINUED*)

13. More conservative as WACC increased. Therefore, fewer projects get green light.
14. Limited funding available for new vehicle acquisition.
15. Not at the moment.
16. No response.
17. Key banking covenants likely to reduce therefore restricting cash available for strategic investment.
18. Reduced it.

TABLE 15: RESPONSES TO QUESTION 'HOW HAS THE CURRENT GLOBAL FINANCIAL CRISIS AFFECTED YOUR COMPANY'S CAPITAL INVESTMENT ANALYSIS PROCEDURES?'

1. No impact.
2. Not changed.
3. It hasn't.
4. Not at all.
5. No change.
6. Yes. Investments are being analysed more regularly and options considered.
7. More detail required for approval.
8. Yes, more detailed analysis and more financial analysis of project undertaken.
9. No.
10. More emphasis on pessimistic forecasts in sensitivity/scenario analysis.
11. No change.
12. More rigorous.
13. Use more methods.
14. No.
15. None.
16. No response.
17. We use more aggressive discount rates reflecting higher bank margins.
18. As before.

As shown in Table 14, four respondents indicated that the financial crisis has had no impact on their companies' capital budget. Nine respondents indicated that their companies have reduced and, in one case, eliminated their capital expenditures due to limited funding availability. Regarding the effects on the capital investment analysis procedures used, the list of responses in Table 15 shows that ten of the respondents indicated that the financial crisis has not resulted in changes to their companies' capital investment analysis procedures. The other respondents cited the requirement for more rigorous and detailed analysis, the use of higher discount rates, and more emphasis on pessimistic forecasts.

CONCLUDING COMMENTS

Before making any concluding comments, it is important to acknowledge several limitations of our survey. Firstly, the survey was limited to companies listed on the Irish Stock Exchange. The financial policies and practices of our small sample of listed firms are not likely to be representative of all companies in Ireland. Moreover, after excluding companies in the finance and real estate sectors, only 43 companies were surveyed. Even though the response rate was quite respectable (41.9 per cent), the number of returned questionnaires was small (18). This is especially problematic when examining subsets of the sample.

Secondly, surveys measure perceptions, not necessarily reality. As pointed out by Aggarwal (1980), responses to questionnaires by individuals in large companies do not always reflect the practices used throughout the firm. Thirdly, the results from our survey were compared with the results of previous surveys in Ireland and elsewhere. However, such comparisons among countries must be approached cautiously. The various cited surveys were conducted at different times and during different economic conditions. Lastly, it may be that the questionnaire itself caused non-response bias in the results. The survey results may largely reflect the responses of executives more familiar with finance theories, concepts and terminology inherent in the questionnaire. With these limitations in mind, the following conclusions can be drawn from our surveys.

Overall, the results of our study suggest that the assumptions, theories and models of modern finance are applicable in Ireland and for the most part are descriptive of the views and practices of Irish executives. As noted in the results sections, the responses of Irish executives to the various questions in the survey questionnaire were similar to their counterparts in other surveyed countries.

The responses of financial executives of listed companies in Ireland to the survey questions on capital structure policy are generally consistent with the pecking order hypothesis. They indicate a preference for following a financing hierarchy rather than adhering to a target capital structure. They rank internal equity (retained earnings) as their first choice for long-term financing and, if external financing is obtained, they rank debt ahead of new ordinary shares. They believe that the long-term survival of the firm and maintaining financial independence are the most important considerations affecting a firm's financing decisions. Maintaining comparability with companies in the same industry is ranked least important. Financial executives of listed Irish companies appear to believe that a company's investment and dividend decisions are more binding than capital structure decisions.

As in previous surveys of Irish companies, the responding executives agreed that reasons for dividend policy changes should be adequately disclosed to investors, dividend payout does affect share prices, and companies should avoid increases in dividends that might have to be reversed in a year or so. In general, Lintner's lagged partial adjustment continues to be generally consistent with the practices of listed Irish companies and executives seem to be aware of signalling and clientele effects.

Capital budgeting practices in Ireland, at least among listed companies, appear to have improved over the past decade or so with an increasing number of companies using more sophisticated DCF techniques. To assess risk, scenario analysis and sensitivity analysis are perceived to be the two most important techniques. More sophisticated probabilistic techniques appear to be seldom used. The survey results also indicate that most of the firms evaluate project cash flows on a before-tax basis and that the majority of firms do not practice capital rationing. In estimating the cost of equity capital, the most popular method is the CAPM, followed by the risk premium method.

The results of our survey have implications for both academics and practitioners. For example, in selecting the discount rates to be used in project evaluation, only four of the respondents indicated that multiple risk-adjusted discount rates are used. As previously mentioned, this result is not consistent with a basic principle of finance theory, that the return required on an investment should reflect the riskiness of the investment and the return available elsewhere from investments of similar risk. If proposed investments differ with respect to risk, a multiple risk-adjusted discount rate system should be employed. When selecting the discount (hurdle) rates to use for evaluating proposed investments, the majority of respondents indicated that a single discount rate is used. Capital budgeting decisions will be biased in favour of high-risk investments when single discount rates are used, even though the potential returns may not be high enough given the perceived risk. Conversely, decisions will be biased against low-risk investments. Because the discount rate is too high for low-risk investments, too few low-risk investments would be undertaken. Over time, a firm's risk will increase, but without higher commensurate returns, thereby reducing the value of the firm.

Another result that should be of concern to academics who study the Irish stock market and rely on models of risk and return that presume high levels of market efficiency, and investors who invest in listed Irish companies, is the perception of the responding executives about market efficiency. Only one of the respondents believed that his or her firm's shares were priced fairly by the market 'more than 80 per cent of the time', as compared to 47.2 per cent of executives in Pinegar and Wilbricht's (1989) survey of *Fortune* 500 companies in the US. A surprisingly high 38.9 per cent of the respondents indicated that their companies' shares were correctly priced 'less than 50 per cent of the time'. How much of the scepticism reflected in this result relates to questions regarding the efficiency of the ISE or is a consequence of the global financial crisis is an open question.

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ENDNOTES

1 Although we cannot be certain how 'maintaining financial independence' was interpreted by the respondents to our survey, the intended meaning pertains to being able to finance internally (using internal equity) and avoiding outside financing, which of course would be consistent with the pecking order hypothesis.

2 The 'stickiness' of dividends was also noted by Donaldson (1961) in a study of the financing practices of a sample of large US corporations published in 1961. He observed that although firms adapt target payout ratios to their investment opportunities, they do so gradually, trying to avoid sudden changes in dividends.

3 When both dividends and earnings were disclosed at the same time, McCluskey et al. (2006) found that the earnings signals had a greater impact on share prices.

4 The clientele effect was originally suggested by Miller and Modigliani (1961). However, they argued that one clientele is as good as another, thus concluding that its existence did not imply that one dividend policy is better than another.

5 Surveys have been so widely used in the US that a financial executive at Armco, Inc. was prompted to write an article to help researchers improve the quality and response rates of surveys. The author claimed to have received over 200 questionnaires over a 5-year period. See Singhvi (1981).

6 See, for example, Brigham and Davies (2002).

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PAPERS PRESENTED AT THE TWENTY-THIRD ANNUAL CONFERENCE

The titles of papers presented at the twenty-third Annual Conference of the Irish Accounting and Finance Association (8–9 May 2010), University of Ulster, were as follows:

Author(s)	Paper Title
Asien, A. Nuri, J. *University of Surrey*	Effects of Institutional Structures on Accounts Manipulation: An International Study
Bates, M. O'Donohoe, S. *Waterford Institute of Technology*	Insights into the Merger Integration Process: A Study of JP Morgan Chase & Co.
Bonache, A.B. Maurice, J. *Montpellier Research in Management* Moris, K. *LEG-FARGO, University de Bourgogne*	A Best Evidence Synthesis on the Link between Budgetary Participation and Managerial Performance
Bonache, A.B. *Montpellier Research in Management* Moris, K. *LEG-FARGO, University de Bourgogne*	Nonlinear and Chaotic Patterns in Japanese Video Game Console Sales and Consequences for Management Control
Bradley, E. *University of Ulster, Coleraine*	Can a Regional Economy Survive the Global Credit Crunch? The Case of Northern Ireland
Burke, R. *Waterford Institute of Technology* Demirag, I. *Queen's University Belfast*	Managing Demand Risk in Ireland's Public–Private Partnership Roads: A Network Governance Perspective
Canning, M. *Dublin City University* O'Dwyer, B. *University of Amsterdam*	Boundary Negotiation within a Changing Regulatory Space for Irish Accountants
Connolly, C. Hutchinson, M. *University College Cork*	Dedicated Short Bias Hedge Funds: Just a One-Trick Pony?

Connolly, C. *University College Cork* Wall, T. *University of Ulster, Jordanstown*	Considering the Impact of the Global Financial Crisis on Public–Private Partnerships: A UK Analysis
Cummins, M. *University of Limerick* Buccay, A. *BP Oil Limited, London*	Synthetic Floating Storage: Application of Statistical Arbitrage
Doran, J. Healy, M. McCutcheon, M. O'Callaghan, S. *University College Cork*	Case-Based Teaching in Large Group Settings: Identifying the Challenges
Doyle, E. *University of Limerick* Frecknall-Hughes, J. *Open University* Summers, B. *University of Leeds*	Cognitive Ethical Reasoning of Tax Practitioners: A Preliminary Investigation Using a Tax-Specific Version of the Defining Issues Test (DIT)
Doyle, G. *University College Dublin*	Accounting and the Everyday Life of Medicine: A Review of a Case Study
Egan, A. Coghlan, J. Maughan, R. *Dublin Institute of Technology*	Boards of Commercial Semi-State Bodies: An Exploration of Individual Director Motivations and Its Impact on Board Decision Making
Gallery, K. *University of Limerick*	Tax Compliance and Non-Compliance: Clarity or Confusion?
Green, P. *University of Ulster, Jordanstown*	The Impact of a Work Placement (or Internship) Year on Student Final Year Performance: An Empirical Study
Healy, M. McCutcheon, M. Hajbaba, A. *University College Cork*	Student Expectations of Studying Introductory Accounting Modules: A Review of the First Year Experience
Hong, H. O'Brien, F. Ryan, J. *University of Limerick*	An Evaluation of Market-Timing Strategies in the Chinese Stock Market
Hyndman, N. McMahon, D. *Queen's University Belfast*	The Evolution of the UK Charities Statement of Recommended Practice: A View through the Lens of Stakeholder Theory
Kirwan, C. *Waterford Institute of Technology* Brennan, N. *University College Dublin*	Investigating the Antecedents and Implications of Role Conflict for Non-Executive Directors: A Conceptual Model

Lammert, J. Watrin, C. *University of Münster, Germany*	Voluntary Disclosure, Accounting Quality, Personal Communication and Market Value
Maingot, D. Quon, T. Zeghal, D. *University of Ottawa*	The Effect of the Financial Crisis on Enterprise Risk Management Disclosures by Canadian Companies
Maughan, R. *Dublin Institute of Technology* O'Dwyer, B. *University of Amsterdam*	Exploring Sustainability Practices and Reporting at Musgrave Group: A Case Study of an Irish Private Company
McAree, D. *University of Ulster, Magee*	The Interaction Effects of Earnings, Dividend and Capital Gearing Signals: Additional UK Evidence
McCluskey, T. Mulcahy, P. *Dublin City University*	An Empirical Investigation of the Effect of Thin Capitalisation Rules on the Capital Structures Decision in UK Companies
McGeough, F. *Institute of Technology, Blanchardstown*	Performance Information in the Annual Reports of the Irish Public Sector: A Study of the County Enterprise Boards
McInerney, C. *University College Cork*	The Impact of Interconnection on the Irish and UK Wholesale Electricity Markets
McKillop, D. *Queen's University Belfast* Ward, A.M. *University of Ulster, Jordanstown* Wilson, J.O.S. *University of St. Andrews, Scotland*	A Synopsis of the Development of the United Kingdom Credit Union Movement
McNally, B. *NUI Maynooth*	Pension Scheme Deficits: Have Scheme Trustees a Case to Answer?
McNamee, S. *University of Ulster, Jordanstown*	Development and Use of a Web-Based Interactive Accounting Game
Murphy, F. *University of Limerick* Twomey, C. *First Derivatives plc, Newry*	The Explanatory Capacity of Single-Sided Lévy Parameters in the Credit Derivatives Market
O'Brien, A. *Carlow Institute of Technology* Brennan, N. *University College Dublin*	Hospital Governance: An Exploration of Case Study Methodology
Ó hÓgartaigh, C. *University College Dublin* Ó hÓgartaigh, M. *All Hallows College, DCU* Tyson, T. *St. John Fisher College, New York*	Accounting for the Irish Poor: Social and Financial Controls during the Immediate Pre-Famine Period, 1838–1845

O'Regan, P. *University of Limerick*	'The Variations of th' Thribe is Ma-arvelous': The Formation and Development of the Society of Incorporated Accountants and Auditors in Ireland
Pogue, M. *University of Ulster, Jordanstown*	The Evaluation of Strategic Investments by ISEQ Companies: The Emperor's New Clothes?
Quinn, M. *Dublin City University*	Rules and Routines in Management Accounting: Some Clarity?
Robbins, G. *NUI Galway* Kester, G. *Washington & Lee University, Virginia*	Financial Policies and Practices of Companies Listed on the Irish Stock Exchange: Capital Structure, Dividends and Capital Budgeting
Smyth, S. *Dublin City University*	Accounting and Social Movements: An Exploration of Praxis and the Class Nature of Accounting Information
Wall, T. Ballantine, J. *University of Ulster, Jordanstown*	Gender Diversity at Senior Managerial Levels within Northern Ireland NDPBs: An Empirical Analysis
Walsh, F. Byrne, S. *Waterford Institute of Technology*	Improving Company Retention on Student Placement Programmes: An Action Research-Based Case Study
Ward, J. McAteer, C. *University of Ulster, Magee*	A Marriage of Convenience? The Convergence of Tax and Accounting Rules in the UK and the Republic of Ireland
Whelan, G. Clarke, J. *Institute of Technology, Tallaght*	The Development of New Accounting Metrics for Supply Chain Risk and Inventory Management
Willis, P. McCluskey, T. *Dublin Institute of Technology* Farrelly, P. *PwC, Dublin*	Is 'Necessarily' Really Necessary? Evidence of Schedule 'E' Expenses Deductions amongst Irish Employees
Zholos, A. *Queen's University Belfast* Hamill, P. *University of Ulster, Coleraine*	Opening the Box: An Analysis of FTSE 100 Membership Changes from a Microstructure Perspective
IAFA PLENARY SESSION	
O'Brien, P.C. *University of Waterloo, Canada*	Securitization, Transparency and Failure Risk
CIMA PLENARY SESSION	
Bromwich, M. Bhimani, A. *London School of Economics*	Global Change and Management Accounting: Past, Present and Future

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The Trust was established in 1981 by the Institute of Chartered Accountants, from which it receives annual funding, to enable it to fulfil the objectives for which it was formed.

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NOTES FOR CONTRIBUTORS

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4. References should be listed alphabetically at the end of the manuscript in the following style:

DeAngelo, L.E. (1981). Auditor Size and Audit Quality, *Journal of Accounting and Economics*, Vol. 3, No. 3, pp. 183–199.

European Commission (1996). *Green Paper on the Role, the Position and the Liability of the Statutory Auditor Within the European Union*, October, Brussels: European Commission.

Faulkner, R.R. (1982). Improvising on a Triad, in *Varieties of Qualitative Research*, Vol. 5, Van Maanen, J., Dabbs, J.M. and Faulkner, R.R. (eds.), pp. 65–101, Beverly Hills, California: Sage Publications.

Fielding, N.G. and Fielding, J.L. (1986). *Linking Data: Qualitative Research Methods*, Beverly Hills, California: Sage Publications.

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