An Empirical Study of Rights Issues, Managerial Equity Control, and Technical Analysis of Financial Markets: Recent UK Experience

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Abstract

The present thesis is an empirical investigation into various aspects of the functioning of financial markets. The first chapter includes two studies of the behaviour of the stock market: in the first one, the reaction to announcements of rights issues is analysed and several hypotheses are tested for a sample of UK companies. In the second study a switching regression model is applied to aggregate stock price data to see if a two-states model is better able to describe the behaviour of stock market prices.

The second chapter investigates the empirical relationship between managerial ownership of shares and corporate performance, using a panel dataset of UK manufacturing companies. The two measures of performance investigated are: market valuation, as expressed by Tobin's Q, and total factor productivity growth, measured by estimating a production function. The explicit consideration of companies with dual structures of voting rights enables me to study the effects of a disparity in the ownership of equity and votes by managers, and the effects of the concentration of voting rights which is made possible by departures from one share-one vote.

Finally, the ability of technical analysis to predict future price behaviour is analysed in the third chapter which consists of three studies. The first reports the results of an experiment in which a Chartist product has been tested for its ability to help users to predict future asset price movements. The second analyses the behaviour of three major exchange rates around support and resistance levels. The third tests two competing theories for their ability to explain the clustering observed in quoted prices. The approach used in this study of technical analysis differs from the previous ones since it employs inputs provided by technical analysts themselves and subjects them to empirical analysis, rather than trying to reproduce the 'data generation process' of technical analysts.

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Joint Work of Riccardo Curcio and Mushtaq Shah

Riccardo Curcio and Mushtaq Shah have jointly worked on two research papers:

a) 'UK Equity Rights Issues: Announcement Day Effects and Long-Run Performance, 1981-1988'.

b) 'Business Conditions and Stock Returns: A Markov Switching Regression Model for the US Stock Market', under submission to the *Journal of Business*.

Riccardo had the idea for the first paper after reading Ritter's paper on the long-run performance of Initial Public Offerings in the Journal of Finance, 1991. Ritter finds that the initial outperformance of IPOs is more than offset by the subsequent underperformance on a three-year horizon. Riccardo wanted to investigate whether a similar phenomenon was present for UK companies undertaking rights issues, which experience positive abnormal returns before the announcement. This work also provided the opportunity for undertaking a comprehensive study of the announcements effects of UK rights issues and to investigate whether differences exist between rights issues in the UK and underwritten security offerings in the US. Riccardo and Mushtaq shared the painstaking data collection and jointly devised a series of tests, which then Riccardo carried out. The paper was drafted jointly.

Mushtaq had the idea for the second paper. Cutler, Poterba and Summers's paper in the Journal of Portfolio Management, 1989 suggests that a small proportion of the variation of the US stock market returns can be explained in a linear manner by economic factors. In addition, Jim Hamilton's recent work suggests that several economic time series can be modelled as a Markov switching process. Mushtaq thought of applying this type of model in a regression framework to see whether this can explain more of the variation in stock returns. Riccardo was responsible for adapting Hamilton's maximum likelihood estimation procedure for a multivariate regression and running the statistical tests. Riccardo and Mushtaq shared the work of analysis and interpretation and jointly drafted the paper.

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Joint Work with Riccardo Curcio

I have worked with Riccardo Curcio on three research papers:

a) 'The Clustering of Bid/Ask Prices and the Spread in the Foreign Exchange Market', FMG Discussion Paper No. 110, January 1991.

b) 'Chartism: A Controlled Experiment', FMG Discussion Paper No. 124, October 1991; forthcoming *Journal of International Securities Markets*.

c) 'When Support/Resistance Levels are Broken, Can Profits be Made? Evidence from the Foreign Exchange Market', FMG Discussion Paper No. 142, July 1992, under submission to the *Journal of International Money and Finance*; the journal has now replied with suggestions for revision and resubmission.

These original papers have been subsequently revised, both separately and by Riccardo for putting together in his thesis chapter.

The idea for the first paper arose from my reading of Lawrence Harris' work on 'Stock Price Clustering' in *The Review of Financial Studies*, 1991. I wanted to use my high frequency data set for the foreign exchange market to see if we could replicate his results in another market. While the initial idea and the data set were mine, Riccardo designed the exercise and carried out all the computing. We shared the work of analysis and interpretation as the work proceeded, and the subsequent drafting.

In the case of the second paper my initial idea had been to try to examine how Chartists might have applied their approach to my data set. In pursuit of that (unavailing) endeavour, I interviewed a number of prominent London Chartists who might operate with high frequency data. Among those I interviewed was Mr. Brad Georges who was prepared to let us set up a 'controlled' experiment to examine whether his system would improve performance. Riccardo and I then jointly worked on the actual design of the tests. He then organised the test runs by himself, handled all the test output, was responsible for the continuing (difficult) diplomatic relationships with Mr. Georges, and decided what econometric/statistical procedures to use, i.e. the work on stochastic dominance. We again shared the work of analysis and interpretation in the course of the exercise, and the final drafting.

In the third paper the basic idea, to use the data on support/resistance levels from Reuters, FXNB to test some well-known Chartist propositions, was largely joint. I provided the data base. Riccardo designed the tests, and did all the computing. Again we shared the analysis, interpretation and drafting.

In our work together we were mainly trying to extract useful empirical results from data sources that I had earlier constructed, or discovered. I tended to have general ideas about how this could be done, which Riccardo then transformed into operational tests. All the technical work, the test designs, the computing and the econometrics are his. The drafting was joint.

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As the supervisor of Riccardo Curcio, who is submitting a thesis entitled *An Empirical Study of Rights Issues, Managerial Equity Control, and Technical Analysis of Financial Markets: Recent U.K. Experience* as part of his Ph.D., I have read the **Declarations of Joint Work** by Professor Charles Goodhart and Mr. Mushtaq Shah and can certify that they accurately reflect the contributions to work related to this thesis. The thesis is an original and independent piece of work and the joint work which is related to it meets the requirements of the University.

Yours faithfully,

Max Steuer

Max Steuer

Acknowledgements

The studies included in this thesis were written during my years as a Ph.D. student at the London School of Economics and Political Science. The School, with its helpful staff and superb facilities, has provided a great environment for my research. During these years I have been a member of two groups within the School - the Financial Markets Group and the Centre for Economic Performance.

I would like to thank the Financial Markets Group for providing the facilities needed to run the experiment documented in this thesis and for the assistance in organising its various stages. Also, I would like to thank the Centre for Economic Performance for making available their panel dataset on UK companies which has been collected, and extended, over many years, and by providing a forum for the discussion of the practical and methodological issues which are encountered in the study of the various influences on the performance of UK companies.

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I also found encouragement and support from many students and staff. In particular, the Research Students Seminar, run by Max Steuer and John Sutton, served as a forum for students to discuss their work and exchange ideas: all three chapters of my thesis have greatly benefited from discussions at the seminar.

In particular, I would like to thank those who have assisted me at various stages of my work: Daron Acemoglu, Manuel Arellano, John Board, Stephen Fisher, James Hamilton, Mervyn King, Steve Machin, Enrique Sentana, Mushtaq Shah, Allan Timmermann, Jari Vainiomaki and Mark Walsh.

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1.

Equity Market Studies

1.1. UK Equity Rights Issues: Announcement Effects and Long-Run Performance, 1981-1988

1.1.1. Introduction

We investigate two aspects of equity rights issues: the stock price reaction on the announcement day, and the long-run relative performance of the companies participating in rights issues.

Rights issues are a common way for UK companies to raise capital. The method by which additional equity is issued in the UK is different from the one used in the US, where companies mainly place equity with an underwriter at a discount to the current price: the underwriter then sells the shares in the market. In the UK, a company has to offer the new shares first to the existing shareholders, in proportion to their existing holdings, who may subscribe the issue. If they refuse to subscribe it, then the company can sell the shares in the market. In practice, however, most of UK rights issues are also underwritten, with the underwriter agreeing to buy any shares not taken up by the existing shareholders[1].

In the US, several studies have documented negative abnormal returns at the announcement of an equity issue and have attempted to relate their magnitude to several variables, in order to test which theory best explains the observed average price fall. These studies often find contradictory results, and, generally, the explanatory power of the empirical models is very low.

In the UK we know of no study which investigates the price reaction at the announcement of rights issues and which tries to relate it to existing

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1 Generally subject to a minimum amount being sold to the public.

theories[2]. This study fills this gap by providing evidence for the UK stock market, detecting any behavioural differences which may be due to the existence in the UK of pre-emptive rights of shareholders.

Another aim of this study is to analyse the long-run performance of companies undertaking rights issues. A recent study by Ritter (1991) for the US stock market found that the evidence on the long run performance of initial public offerings was consistent with the existence of fads in the stock market which cause investors to be periodically overoptimistic about future prospects. We undertake a similar analysis for companies participating in a rights issue and find similar results.

The paper is organised as follows: in section 1.1.2 we briefly review the theories which can explain the observed price drop at issue announcements and their empirical implications; in section 1.1.3 we describe our methodology and data, in section 1.1.4 we investigate the abnormal returns at the announcement of rights issues, testing several theoretical explanations; in section 1.1.5 we analyse the long-run performance of companies issuing equity. Section 1.1.6 concludes.

1.1.2. Rights Issues: Theoretical Considerations

Companies can raise funds in several ways. They can use internally generated funds by retaining profits, or issue new securities such as equity, debt, or a combination of the two. The historical reliance of companies on internally generated funds has generally been seen as anomalous by academics[3], but the view of many investment bankers and practitioners is that the reluctance by companies to issue additional equity is caused by the expected price drop for the existing shares which accompanies the new issue announcement. Negative abnormal returns at the announcement of equity issues have in fact been widely

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2 Since we commenced our study, we have seen a preliminary version of a UK study of rights issues (Davidson and Mallin 1992).

3 See Asquith and Mullins (1986) and references therein.

documented for the US stock market[4].

Several theories have been put forth to account for the abnormal returns at the announcement of equity issues. These fall broadly into three categories:

1) theories based on asymmetric information;

2) theories based on redistribution of wealth;

3) theories based on a price-pressure hypothesis.

All of these theories have implications for the magnitude and direction of the price change at the announcement of the issue. We would like to mention at this point that the actual inflow of the new shares into the market will be taken into account at the announcement of the issue, so that any abnormal return which is due to the higher supply of shares should occur at the announcement, rather than at the issue date.

Theories based on asymmetric information maintain that the announcement of an equity issue is a signal based on the superior information that managers and insiders have on the prospects for the company. This superior information may relate to the fact that the existing shares are overvalued or that the internally generated funds are not sufficient to provide enough working capital. Alternatively, the equity issue may signal that the management wants to undertake new investment spending: this may be necessary in order to expand into new markets or to exploit new opportunities.

Myers and Majluf (1984) develop a model in which managers possess information on the company not available to non-insiders, and show that all equity issues convey negative information to the market since managers are supposed to act in the interest of current shareholders. This happens because, in their model, managers would not find it convenient to issue equity unless the current share price were overvalued.

Similarly, Leyland and Pyle (1977) construct a signalling model of

---

4 Asquith and Mullins (1986), Masulis and Korwar (1986), Mikkelson and Partch (1986), Schipper and Smith (1986).

managerial ownership in which the percentage of shares owned by management is a signal of the value of a company. In their model, an equity offering which is not taken up by the management is a negative signal since it reduces the percentage of shares owned by managers.

The free cash flow theory by Jensen (1986) also predicts a negative effect of equity issues since the associated reduction in leverage gives more scope for slack on the part of managers. According to the free cash flow theory, debt is a mechanism by which managers commit themselves to pay out part of the cash flow generated by the company; a lack of constraints on the management may lead them to use the excess "free" cash flow in a wasteful way.

In summary, theories based on information asymmetries predict a negative reaction to the announcement of a rights issue. The price drop should also be related to the size of the issue to the extent that size is a good proxy for the amount of information released. In particular, the free cash flow theory also predicts that equity issues made to fund new investment should cause the strongest negative reaction.

The second set of theories which have been proposed in order to explain the abnormal returns at the announcement of rights issues are those based on the redistribution of wealth caused by the issue of new shares. These transfers are from the shareholders to the bondholders in the form of less risky debt, and from the shareholders to the Treasury in the form reduced tax savings.

A security issue which increases the equity capital without increasing at the same time the amount of debt makes the existing debt less risky (holding everything else equal) and this causes a redistribution of wealth from existing shareholders to bondholders. The latter in fact find themselves, after the issue, with a better quality debt. In addition, since a share issue changes the capital structure of a firm and given the presence of tax advantages for capital structures with a high debt proportion, a share issue causes a redistribution from existing shareholders to the Treasury. Both theories predict price drops at the announcement of an equity issue which are smaller for new investment funding than for capital structure changes, and which have a negative relationship with

the size of the issue. The higher leverage after the equity issue should lower the share price by an amount which compensates for the tax loss and for the reduced riskiness of debt associated with a lower debt/equity ratio.

The third set of theories predicts a negative abnormal return due to the existence of price pressure and due to transaction costs. The existence of transaction costs may cause a price drop because it is costly to readjust existing portfolios in order to absorb the new issue. In contrast, the price-pressure hypothesis simply states that an increase in the supply of a security causes its price to fall, since demand curves for stocks are believed to be downward sloping.

The justification for the price-pressure hypothesis, that each security has some unique features so that close substitutes for it do not exist, contrasts with the current theoretical literature in finance which argues that demand curves for securities are horizontal and that prices for securities are determined only by their risk attributes and their expected returns. If markets are efficient, the price of a security is independent of the amount of such security in the market, and is also independent of the amount which is being offered for sale at any moment in time.

Both the downward sloping demand curve hypothesis and the transaction costs explanations predict that the drop in share price should be uncorrelated with the reason for the issue, but that there should be a positive correlation between the size of the issue and the price drop.

These three groups of theories do not allow positive price reactions to announcements of rights issues; however, possible positive effects may arise from favourable information released at the time of the announcement. Furthermore, if a firm in financial distress issues equity, this may be a signal (especially if the offer is underwritten) that bankruptcy is less likely and the stock market reaction is expected to be positive.

In summary, we can group the possible effects on prices at the announcement of rights issues into the three categories:

1. no price effect: efficient markets hypothesis coupled with perfect information and no transaction costs;

2. positive price effect: favourable information, leverage reduction which reduces financial distress;

3. negative price effect: downward sloping demand curves, redistribution of wealth, asymmetric information, transaction costs.

In the next sections, we will investigate the abnormal return at the announcement of a rights issue, and we will relate it to the stated reason for the rights issue, the abnormal return before the issue, the size of the issue, and the change in the debt/equity ratio induced by the equity issue. Although most of the US studies of equity issues have found significant and negative abnormal returns at the announcement of equity issues, they generally obtain weak and contrasting results about the relationship between the abnormal returns and several explanatory variables, and no theory has been found to be able to explain much of the cross sectional variation of abnormal returns. In addition to exploring each relationship in isolation, we will employ a multivariate regression approach to see if a combination of variables is able to achieve a better explanatory power.

After having analysed the announcement day effect of rights issues, we investigate the long-run performance of the companies offering new equity. The efficient markets hypothesis implies that no abnormal performance should be observed after the day of the announcement of the equity issue, and Marsh's (1979) study of UK rights issues was principally aimed at investigating this hypothesis. He was unable to reject the hypothesis of efficient markets by looking at the cumulative abnormal returns for the two years after the equity issue, using a variety of benchmarks. His study reveals that the choice of the benchmark can affect the results considerably, especially in the presence of a strong size effect for UK companies.

We will analyse the long-run performance of companies participating in rights issues by computing the cumulative abnormal returns for the three years after the announcement, employing a variety of benchmarks. Although we cannot control for the size effect, we find that in our sample period this is likely to have a neutral effect on the average cumulative returns. In contrast with Marsh (1979), we find that our results are consistent with Shiller's (1984) idea that markets may

be affected by "fads" or waves of pessimism and optimism which are exploited by managers deciding whether or not to issue equity.

1.1.3. Methodology and Data

We started our sample selection with the set of all capital changes made by companies included in the 1988 release of the London Share Price Database (LSPD). This database contains price and dividend data on all companies quoted in London since 1975, including those traded on the Unlisted Securities Market[5]. From these capital changes, we extracted all rights issues occurring between 1981 and 1988, which amounted to 1253 issues made by 867 companies. The starting year 1981 was chosen since the Financial Times started to publish the annual index to its articles then.

Having identified all the companies making rights issues in the years 1981-1988, we then searched in the Financial Times (FT) for the announcement dates of these rights issues, using the annual index as a guide. We were able to find FT articles for 369 simple rights issues[6] (made by 312 different companies) reporting the announcement, together with the reason for the rights issue. For these companies we then obtained daily price data around the announcement date from Datastream, together with monthly data on total returns from the LSPD database, which also reports the industrial classification.

The distribution by year of the rights issues included in the LSPD database and those for which we were able to find announcement dates is reported in table 1.1.

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5 The LSPD database contains also data from 1955 for a selection of companies.

6 In selecting our sample of rights issues, we excluded those which were combined with other securities issues, in order to avoid possible extraneous effects.

Table 1.1 Distribution of rights issues by year

Year	LSPD	Our Sample	Percentage
1981	77	19	24.7
1982	61	20	32.8
1983	128	35	27.3
1984	101	26	25.7
1985	130	42	32.3
1986	204	41	20.1
1987	346	109	31.5
1988	206	77	37.4
Total	1253	369	29.4

We were able to find announcement dates for about 30% of the rights issues occurring during 1981-1988, with the percentage varying from 20.1% in 1986 to 37.4% in 1988. Therefore, we believe that our sample is fairly representative of the population of rights issues during this period.

For all the companies in our sample we also collected the reason for the rights issue as reported in the Financial Times. We classified the reason for the issue into one of four categories:

1) Finance an acquisition;

2) Finance expansion;

3) Restructuring and strengthening of the balance sheet;

4) Debt repayment.

Many companies state the reason for the rights issue with its announcement, while for others we had to rely on the comment from the

Table 1.2 Distribution of the reason for the rights issue

Year	Acquisition	Expansion	Restructuring	Debt Reduction	Total
1981	4	8	1	6	19
1982	3	8	3	6	20
1983	10	13	6	6	35
1984	7	9	7	3	26
1985	10	21	7	4	42
1986	6	22	9	4	41
1987	70	20	12	7	109
1988	40	20	13	4	77
Total	150	121	58	40	369

journalist. In several cases more than one reason was reported; in such cases we selected what appeared to be the most important one (i.e. the one focused on by the journalist or article, the one appearing in the heading of the article, or the one mentioned first in a list or reasons). An alternative to this was to have multiple classifications with all the reasons reported. We decided in favour of the first one to avoid classifying most companies under category 2) since most announcements report growth and expansion as one of reasons for the issue.

The distribution by year of the reason for the rights issues is reported in table 1.2.

We can see from this table that during both 1987 and 1988 a high proportion of the rights issues have been motivated by acquisitions, in stark contrast to the previous years.

For each company and equity issue, we also computed various descriptive

statistics: the company size (market value) and the issue size, the dilution of the new issue and the discount.

The size of the issue is defined as the ratio of the amount of the proceeds of the rights issue (issue price times new shares issued) to the market value of the existing shares on the day before the announcement. The dilution is defined as the ratio of the change in the market value of the existing shares to the proceeds of the issue[7]. A dilution of 0 means that the price of the existing shares has not changed, while a dilution of -100 means that the market value of the existing shares has decreased by the same amount as the proceeds of the rights issue. A negative value of the dilution tells us by how much the market value of the existing shares has decreased as a percentage of the amount being raised. The discount is defined as the percentage difference between the price before the announcement and the issue price of the new shares. We report in table 1.3 these descriptive statistics for our sample.

Table 1.3 Descriptive statistics

	Mean	Median	Minimum	Maximum
Market value	151.26	38.88	0.24	3525.0
Size of issue	28.80	21.60	4.63	116.3
Discount	22.20	18.40	0.00	90.7
Dilution	-9.65	-8.32	-600.00	134.6

The median company in our sample is relatively small, having a market capitalisation of £39 million. Our sample includes also some very large companies, causing the distribution of the market value to be highly skewed and

7 Our definition follows Asquith and Mullins (1986).

with a mean of £151 Million[8]. The median and the mean size of the issue are respectively 22% and 29% of the existing equity. The mean and median discount are around 20%, while the median dilution is only 8%. The median value of the dilution in our sample is substantially smaller then the 28% in Asquith and Mullins (1986).

Having described our sample we now investigate the stock market reaction to the announcement of rights issues.

1.1.4. Announcement Day Effects

For the companies in our sample we computed the abnormal return around the announcement of the rights issue. Since we do not know at what time of the day the announcements were made, we computed the abnormal return in a two-day period comprising the day of the announcement and the following working day, in order to be certain to capture the market reaction to the issue announcement: this is standard practice in event studies such as this one.

In order to compute the abnormal return, we adjusted the two-day return of the stocks by subtracting the return on the stock market index during the same days. The stock market index that we used for this purpose is the FT All Share Index, a capitalisation weighted index of over 600 UK companies quoted on the London Stock Exchange. The FT All Share Index includes about 94% of stock market capitalisation, but a much smaller percentage, 45%, of companies. We chose this index since it is broadly based and computed daily: in any case, for an analysis of a two-day announcement return, the choice of the benchmark is not likely to affect the results[9].

The average (median) two-day abnormal return for the 369 companies in

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8 The market capitalisation refers to the pre-issue value of the company. No adjustment for movements in the general price index has been made.

9 See Dimson and Marsh (1986) for a discussion of benchmark issues.

our sample is -1.63% (-2.34%) with a t-statistic[10] of -8.20. The abnormal return in our sample is of the same magnitude than the one reported in Davidson and Mallin (1992) for a sample of UK companies for the same period[11]. In Figure 1.1 we report the distribution of the two-day abnormal return: there is considerable variation in the reaction to the announcement of a rights issue, with 33% of the stocks experiencing a positive abnormal return. We will investigate next the relationship between the abnormal returns and several characteristics of the companies and the issue, in order to identify the determinants of the magnitude and direction of the abnormal return.

We would like to mention at this point that a limit of our analysis is given by the impossibility of controlling for the effects of news released during the two days in which we compute the return. In more then one occasion, several other pieces of news - such as new earnings forecasts, the willingness of the directors to participate in the issue, a bid to take over another company at a specific price - accompanied the announcement of the rights issue. The two-day abnormal returns will therefore include components due to these other pieces of news which we will not be able to identify.

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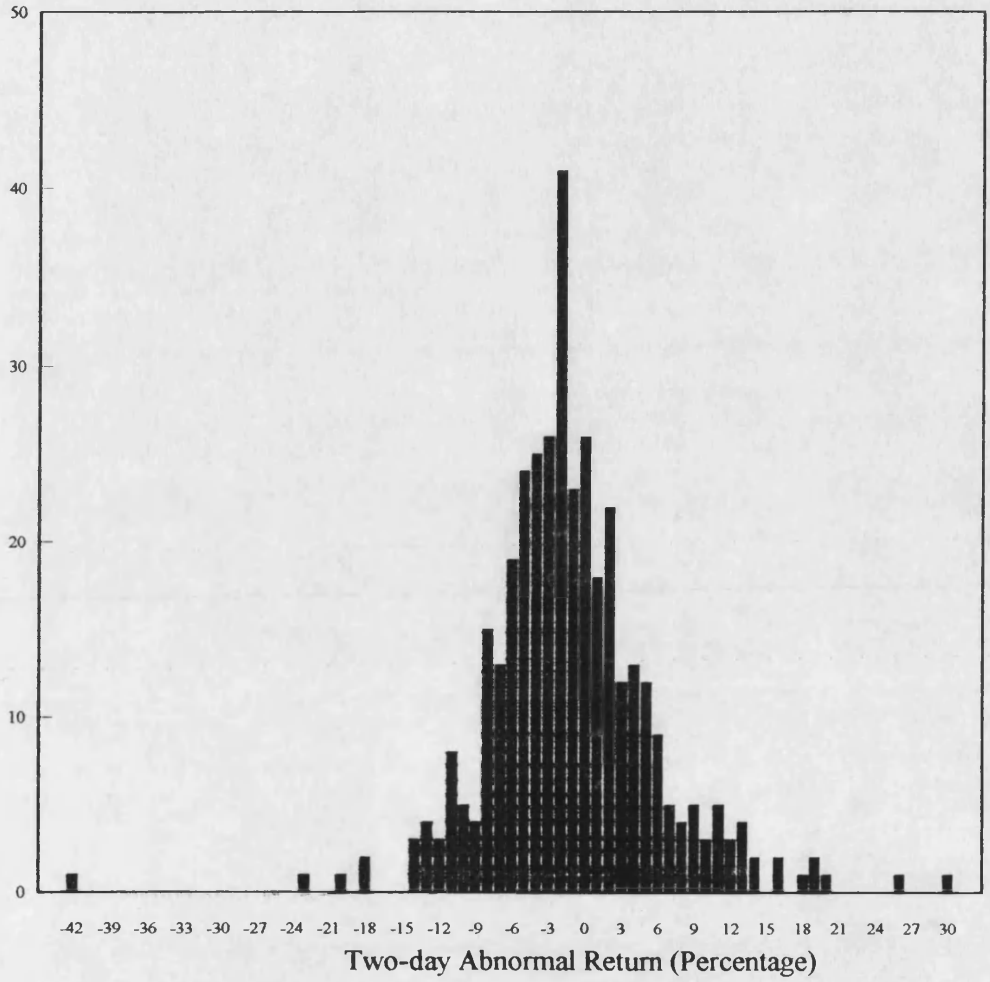
10 The standard error for the two-day abnormal return, 0.1988, has been computed, similarly to Asquith and Mullins (1986), as the standard error of the average abnormal return across all companies for the 48 days starting 68 days before the announcement. The exclusion of 20 days before the announcement is motivated by the possibility that some information on the issue might have already leaked into the market.

11 Davidson and Mallin (1992) find a much bigger abnormal return (-6.44) in 1991, a year not covered by our study.

Figure 1.1 Frequency distribution of the two-day abnormal return



Having established that the two-day abnormal return is negative on average, in order to discriminate among the various theories which attempt to "explain" a price drop at the announcement of a rights issue, we investigate the relationship between the abnormal return at the issue date and various explanatory variables:

1) the reason for the issue;

2) the abnormal returns before the issue;

3) the size of the issue;

4) induced change in leverage.

We then combine the explanatory variables in a multivariate regression to judge their ability to jointly explain the cross sectional variation in the abnormal returns.

1.1.4.1. Reason for the Issue

Several of the theories we have described in section 1.1.2 predict that the share price reactions to the announcement depends on the reason for the rights issue. While the overvaluation hypothesis predicts no correlation between the reason of the issue and abnormal returns, other theories based on asymmetric information, such as the free cash flow theory, predict that the stock price reaction should be negative for announcements of new capital spending, with no effect for issues which affect only the capital structure.

Conversely, redistribution theories predict a smaller price drop for issues motivated by new investment spending since these are the ones which affect the leverage of the company less. Downward sloping demand curve or transaction cost theories do not suggest different reactions depending on the reasons for the issue.

When we classify the rights issues according to the stated reason, we find that in all categories the average and median abnormal return is negative, but less so for acquisitions and expansions. Issues motivated by a reduction in leverage are accompanied by the biggest reductions in share price at the announcement; we report the results in table 1.4.

The abnormal return associated with acquisitions is significantly higher than the one associated with restructurings and leverage reductions, although it is still significantly negative (t-stat = 2.97). If we group together acquisitions and expansions, on one side, and restructuring and leverage reductions on the other, we find that the average abnormal return for the first group is -1.23, while for the second group it is -2.73: the t-statistic for the hypothesis that the two averages

Table 1.4 Two-day abnormal returns by reason of issue

Reason	Mean	Median	Minimum	Maximum
Acquisition	-0.59	-1.35	-14.1	25.8
Expansion	-2.03	-2.62	-23.5	29.6
Restructuring	-2.48	-2.47	-42.9	13.0
Leverage reduction	-3.08	-2.62	-21.0	18.9
Whole sample	-1.63	-2.34	-42.9	29.6

are different is 1.81, significant at the 10% level.

The result that the abnormal returns are lower for issues motivated by leverage reductions and restructurings is consistent with redistribution theories which maintain that changes in leverage are an important determinant of the price fall, since these issues are the ones with the biggest effects on leverage. The result is also consistent with theories which see new capital expenditure and expansion as a positive signal for the future profitability of the company.

Other authors have looked at the reason for the issue in order to discriminate among theories for the price fall: Mikkelson and Partch (1986) find a result similar to ours, that the average decline in share price is smaller when the purpose of the issue is to finance capital expenditure. Conversely, Barclay and Litzenberger (1988) do not find any relationship between stated reason and abnormal returns.

1.1.4.2. Abnormal Return Preceding the Issue

Rights issues are generally preceded by abnormal positive returns in the months before the issue. Although none of the theories presented in section 1.1.2 have strong implications for the relationship between abnormal returns in the run-up to the issue and abnormal returns at the announcement, several authors have

related the two variables, finding conflicting results[12].

In order to investigate this relationship in our sample, we regress the abnormal returns on a constant and the cumulative abnormal returns in the year before the issue[13]. We have then added as further regressors the outperformance in the previous two years[14]. We report the results in table 1.5

Our results show that the cumulative abnormal returns in the two years before the announcement is an important determinant of the reaction to the announcement of a rights issue. Although, as we have said above, no theory predicts a relationship of this kind, our result is consistent with theories based on asymmetric information. In fact, if we consider the cumulative outperformance as a manifestation of a decrease in the asymmetry of information, our results imply that companies in which the asymmetry of information has decreased experience a smaller drop.

Our results are also consistent with the empirical observation that rights issues tend to be made by companies which have experienced positive abnormal returns, since an outperformance before the announcement leads to a lower price fall. Lucas and McDonald (1989) show how this can arise in a model in which companies are temporarily overvalued.

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12 See Korajczyk, Lucas and McDonald (1989); Asquith and Mullins (1986); Masulis and Korwar (1986).

13 We have used an equally weighted index of the constituents of the FTA as our benchmark; see section 1.1.5 for a discussion of benchmarks.

14 Note that we lose some observations since we do not have a complete history for all companies. If we have only a few observations in a year for a company, we consider the abnormal returns in just those months as the abnormal return for the whole year. This is done to minimise the loss of observations.

Table 1.5 Two-day abnormal returns and cumulative abnormal returns before the announcement

constant	1-year	2-year	3-year	R^2	Obs.
-2.40 (-6.55)	3.96 (3.50)			5.80	369
-2.86 (-7.14)	3.55 (2.98)	2.98 (2.60)		8.58	347
-2.84 (-7.01)	3.74 (2.99)	3.13 (2.68)	0.89 (0.83)	9.37	322

Note: The dependent variable is the two-day abnormal return; heteroskedasticy consistent t-statistics are shown in parenthesis.

1.1.4.3. Size of the Issue

Several theories predict that there should be a negative relationship between the size of the issue and abnormal returns at the announcement. In particular, the price-pressure hypothesis, in both the downward sloping demand curve and the transaction costs versions, predict that the price drop should be a function of the relative size of the issue.

Asymmetric information theories do not have clear implications for the relationship, but the size of the issue can give an indication of the amount of information disclosed: in particular, if the issue is motivated by a decline in internal cash flow, the amount of the issue is a measure of the problem. Finally, redistribution theories based on the tax advantage of debt and transfer of value to bondholders predict a negative relationship since bigger issues have a stronger impact on leverage.

Several studies in the US have tried to relate the size of the issue to the abnormal returns at the announcement, but their results have been fairly negative. Three studies (Mikkelson and Partch 1986; Masulis and Korwar 1986; Barclay

and Litzenberger 1988) do not find any relationship at all, while two other studies (Korajczyk, Lucas and McDonald 1989; Asquith and Mullins 1986) find rather weak evidence for a negative size effect.

Table 1.6 The size effect

Constant	Logarithm of relative size	Logarithm of absolute size	Relative size dummy (RS)	Absolute size dummy (AS)	R^2
-0.88 (-0.73)	0.53 (0.64)				0.00
5.04 (1.06)		-0.41 (-1.45)			0.01
-1.90 (-3.91)			0.54 (0.75)		0.00
-1.04 (-1.89)				-1.19 (-1.64)	0.00

Note: The dependent variable is the two-day abnormal return; heteroskedasticy consistent t-statistics in parenthesis.

In order to investigate the size effect in our sample, we have regressed the abnormal returns at the announcement on a relative and an absolute measure of size. We experimented with the absolute size of the issue since, as Barclay and Litzenberger (1988 p. 92) point out, in the case of downward sloping demand curves for shares, it is not clear that relative size is the correct measure for comparisons across firms. We also used dummy variables to reduce the impact of outliers: RS (AS) which is equal to one if the relative (absolute) size is above the median size. The results in table 1.6 clearly show that the size effect is not present in our sample with all the regressions exhibiting a very low R^2 and insignificant coefficients.

1.1.4.4. Changes in Leverage

We now investigate whether changes in leverage induced by the rights issue can be responsible for the price drop at the announcement. Reductions in financial leverage can be a negative signal according to informational asymmetry theories which see leverage as a way for managers to commit themselves to pay out cash flow. A reduction in leverage achieved with a rights issue can then be seen as a relaxation of the constraints in which managers operate and can lead to non-maximising uses of cash flow, as in the free cash flow theory (Jensen 1986). Redistribution theories also see a decrease in leverage as a negative signal because of the lower tax advantages and the redistribution of wealth to bondholders who, after the issue, have a less risky debt.

We have computed the leverage before the issue as:

$$LEV = \frac{D}{(D+P+E)}$$

where

D total amount of debt (both including and excluding short term borrowings);

P preference shares and other equity capital such as deferred shares;

E equity capital.

We have included D and P at their book values since market values were not available to us[15], while E is the market value of the common stock. After a rights issue, the leverage of the company changes due to changes in the amount of equity capital and the amount of debt outstanding, in the case that a part of the debt is paid back.

In order to investigate whether the change in leverage can explain part of

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15 Indeed, we could not find company account data for 38 companies in our sample of rights issues, which are therefore excluded from this analysis.

the fall in share prices at the announcement of a rights issue, we have constructed variables measuring the change in leverage:

DLEV1 change in leverage excluding short term borrowings and repayment of debt;

DLEV2 same as DLEV1 but including short term borrowings.

DLEV1 and DLEV2 measure the changes in leverage induced by the planned change in equity capital, which is equal to the amount of the proceeds of the rights issue[16]. These measures ignore that fact that some, or all, of the capital raised can be used to repay debt; indeed, some of the companies in our sample have expressly indicated debt repayment as the main reason for the issue.

For this reason we have constructed the variables DLEV3 and DLEV4 which assume that the proceeds of the issues made by companies which have as the main reason for the issue debt repayment or restructuring are used in the first instance to repay debt, until this goes to zero. These variables are defined as:

DLEV3 change in leverage excluding short term borrowings but assuming that companies which issue equity in order to repay debt, or to restructure their balance sheet, use the proceeds to repay their debts;

DLEV4 same as DLEV3, but including short term borrowings.

In table 1.7 we report the results of our univariate regression of abnormal returns on the change in the leverage variables.

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16 We have ignored the costs incurred by the issuing company (underwriter and other fees).

Table 1.7 Changes in leverage

Constant	DLEV1	DLEV2	DLEV3	DLEV4	R^2
-0.58 (-1.13)	0.52 (3.79)				2.80
-1.05 (-1.92)		0.17 (1.52)			0.60
-0.92 (-2.01)			0.19 (3.50)		2.24
-1.25 (-2.54)				0.10 (1.46)	0.24

Note: The dependent variable is the two-day abnormal return; heteroskedasticy consistent t-statistics in parenthesis.

It appears from our results that the induced change in leverage has a significant effect on the abnormal return at the issue announcement, with higher reductions in leverage being associated with bigger price falls. This is consistent with both the incentive theories such as the "free cash flow" theory and the redistribution theories. Also, the leverage variable with only the long-term debt seems to have a bigger effect, while the inclusion of the (assumed) repayment of debt for those companies which have as the main reason for the rights issue either leverage reductions or strengthening of the balance sheet, do not alter our conclusions.

1.1.4.5. Multivariate Analysis

As we have seen, several possible reasons for the abnormal return at the announcement of rights issues have been proposed, but none has been able to explain empirically a substantial proportion of the cross sectional distribution of

abnormal returns. We now put together the univariate results obtained above in a multivariate regression framework in order to asses our overall ability to explain the dispersion of the abnormal returns.

In addition to the variables considered above, we include one additional dummy variable in our multivariate regressions, D1, which takes the value of one if the company had a rights issue in the year preceding the announcement. The rational behind this is that companies which had a rights issue in the year preceding the issue under analysis were probably not expected to have another issue so soon. Since the reaction at the announcement of a rights issue will depend on how much the issue was anticipated, we expect this variable to have a negative impact on abnormal returns.

In table 1.8 we report 4 versions of the multivariate regression. In the first column we report the regression which includes as regressors all the variables that we have analysed before which are available for all companies. The second columns includes also the 2-year cumulative abnormal performance, which is not available for 22 companies. In the third column we add DLEV1 to the first equation and we lose of 38 companies. Finally, in the fourth column both variables are added with the sample shrinking by a total of 50 observations.

The multivariate analysis shows that we are able to explain between 7% and 15% of the cross sectional variation of the abnormal return at the announcement of rights issues. The variables maintain their sign and generally their significance, with changes in significance levels due to the loss of some of the companies rather than to the collinearity among the variables[17].

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17 We do not report the regressions which support this statement.

Table 1.8 Multivariate analysis

Variable				
Constant	6.47 (1.54)	8.12 (1.88)	8.90 (2.29)	9.94 (2.49)
Expansion	-1.47 (-1.92)	-1.30 (-1.73)	-0.61 (-0.79)	-0.81 (-1.05)
Leverage reduction	-1.83 (-1.68)	-2.32 (-2.10)	-1.03 (-0.95)	-1.86 (-1.64)
Restructuri ng	-2.14 (-1.57)	-1.98 (-1.42)	-1.85 (-1.17)	-1.78 (-1.18)
1-year	3.90 (3.63)	3.55 (3.19)	3.90 (3.42)	3.87 (3.26)
2-year		3.41 (2.98)		4.00 (3.12)
Logarithm of relative size	0.73 (0.89)	1.07 (1.30)	1.42 (1.41)	1.06 (1.15)
Logarithm of absolute size	-0.41 (-1.50)	-0.56 (-2.25)	-0.42 (-1.48)	-0.62 (-2.49)
DLEV1			0.44 (2.38)	0.18 (0.93)
D1	-2.38 (-2.11)	-2.27 (-2.08)	-2.04 (-1.79)	-2.02 (-1.83)
R^2	0.0742	0.1134	0.0983	0.1481
Obs.	369	347	331	319

Note: The dependent variable is the two-day abnormal return; heteroskedasticy consistent t-statistics in parenthesis.

In summary, our results do not differ substantially from the ones obtained for US underwritten equity offerings. We find that the reason for the rights issue is a determinant of the abnormal return, with acquisitions attracting the highest abnormal returns. The cumulative abnormal return in the two years before the issue is an important determinant of the size of the abnormal return at the announcement, a result which is also obtained in the US. The size of the issue in its relative definition has a positive but insignificant effect while in its absolute definition has a negative (sometimes significant) effect; it is difficult from these results to draw conclusions about the effect of size on abnormal return, a result similar to the US experience. Changes in leverage induced by the equity issue explain a portion of abnormal returns, although the significance of the variable is reduced substantially by the loss of a few companies in the last regression. Finally, an equity issue which is preceded by another in the previous year attracts on average a two percent lower abnormal return than other equity issues.

1.1.5. Long-term Performance

In this section we investigate the long-run performance of companies undertaking rights issues. In a similar investigation of the long-run performance of initial public offerings (IPOs), Ritter (1991) finds that the underpricing of IPOs at their issue is a short-run phenomenon which is more than reversed in subsequent years. We want to assess whether this happens for rights issues too, in order to throw more light on the determinants of their timing and abnormal returns.

In order to assess the abnormal performance of a stock in the long-run, we have to define an expected return for that stock. Several methods have been used in the literature to compute expected returns with the most popular involving the return on an index of the total market (both equally and capitalisation weighted). The expected return is then calculated as the return on the index, either raw or adjusted by the Market Model or the Capital Asset

Pricing Model (CAPM)[18].

In this study we use four different ways to compute abnormal returns by subtracting from the raw returns of the issuing company:

1) the total return of the FTA All Share Index;

2) the total return of an equally weighted version of the FTA index;

3) the total return of the index of the FTA sector in which the company belongs to;

4) the CAPM expected return defined as $(1-\beta)$ RF + β RM; where RF is the risk-free rate (here defined as the 90-day Treasury Bills Rate), RM is the return on the FTA All Share Index, and β is computed with an OLS regression for the whole 6 years period, excluding the month of the announcement.

The choice of the FTA All Share Index, which is a capitalisation weighted index of over 600 stock quoted in the London Stock Exchange, is a natural choice for a UK benchmark, being the most broadly based index published for the UK stock market. However, since its constituents are weighted by market capitalisation, its movements are affected to a great extent by the price behaviour of the largest companies. Since in this study we analyse sample averages in which all observations are equally weighted, we constructed an equally weighted version of the FTA All Share Index and used this as our preferred benchmark.

In order to control for the possible differential behaviour of the various sectors of the economy, we also used, as a benchmark for each company, the return of the sectors to which the company belongs. For the various sectors, we used 31 FT-SE Actuaries Share Indices which are capitalisation weighted indices of the constituents of the FTA All Share Index grouped into sectors.

In addition, we also used as a benchmark the expected return computed with the simple CAPM. For the computation of the companies' β, we have excluded the month of the announcement since its inclusion would have biased

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18 Marsh (1979) discusses the relative merits of these models.

the estimation; in fact, as we have seen in the previous section, abnormal returns are generated during that month. For similar reasons, some authors exclude also the period before the announcement since abnormal returns are generated in the run-up to the issue announcement, while others exclude the period following the rights issue since they claim that the issue changes the riskiness of the company. We decided to exclude only the issue month from the estimation period since we did not have any particular reason to favour one argument over the other and we preferred to keep the sample size for the estimation as large as possible.

For the calculation of the cumulative abnormal returns we used month-end data of total returns for both our companies and the indices. We started 36 months before the month of the announcement, and we ended 36 months after the month of the announcement[19]. In Figure 1.2 we report the average cumulative abnormal returns for the six years period, computed in the four different ways detailed above.

Several interesting phenomena are evident from this figure. First, there is not much difference in the pattern of the cumulative abnormal return computed in the four different ways. Second, the cumulative abnormal return peaks in the month preceding the announcement of the issue, after a substantial run-up of around 25%. More interestingly, the abnormal performance after the issue reveals a substantial underperformance of about 35% in the three years after the issue.

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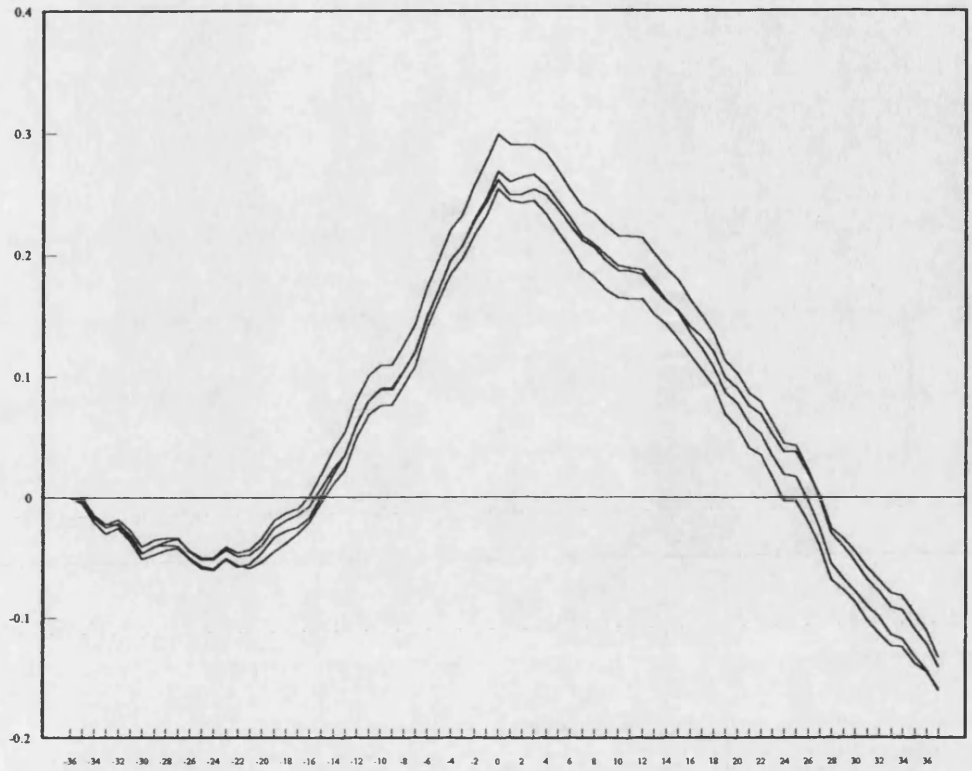
19 When the two-day announcement period felt into two months, we aggregated the two months into one.

Figure 1.2 Cumulative abnormal returns around the issue announcement



The positive cumulative abnormal return before the issue has been documented in several studies and does not call into question market efficiency, but the one after the issue would imply that the market is inefficient. We now investigate the significance and the robustness of this result.

Several recent studies (Ritter, 1991; Dimson and Marsh, 1986; Franks, Harris and Titman, 1991) have found that abnormal return calculations over long horizons are sensitive to the benchmark used to compute them. In particular, for the UK, where a strong size effect is present, Dimson and Marsh (1986) have shown that the different size composition of the sample under analysis and the benchmark, can conduce to wrong inferences with regard to long-run performance.

In order to control for size one would ideally want to have a number (usually 10) of size ranked portfolios rebalanced annually, as in Dimson and Marsh (1996), or a control portfolio constructed with companies matched by size (and possibly industry) as in Ritter (1991). Unfortunately, these were not available to us and we could not compute them since the version of the LSPD that we had access to extended only to 1988 (while we needed returns up to the end of 1991) and Datastream does not have total returns data and only limited dividend data[20].

In order to evaluate the extent of the size bias in the post-announcement performance of our sample, we employed two methods. First, we computed the abnormal returns by using the equally weighted FTA All Share Index for all companies in our sample which had a market capitalisation bigger that £50 million before the announcement, and we used an index of the lowest decile of quoted companies[21] for the rest[22].

An inspection of the index of the lowest decile of companies by size, reveals that smaller companies outperformed, or performed in line with the FTA equally weighted index during the years 1981-1988, while they underperformed in the years 1989-1991. We therefore computed the cumulative abnormal returns after the announcement in the way detailed above for two subsamples: earlier rights issues (1981-1986) and later rights issues (1987-1988). The number of rights issues in the two subsamples are respectively 183 and 186. In the first subsample only the 1986 issues include one of the three post issue years in which

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20 In order to construct total returns for the companies in our sample, for which the post-announcement period extended beyond 1988, we had to obtain dividend information from Datastream, Extel Financial Services, and Bloomberg, and price data from Datastream.

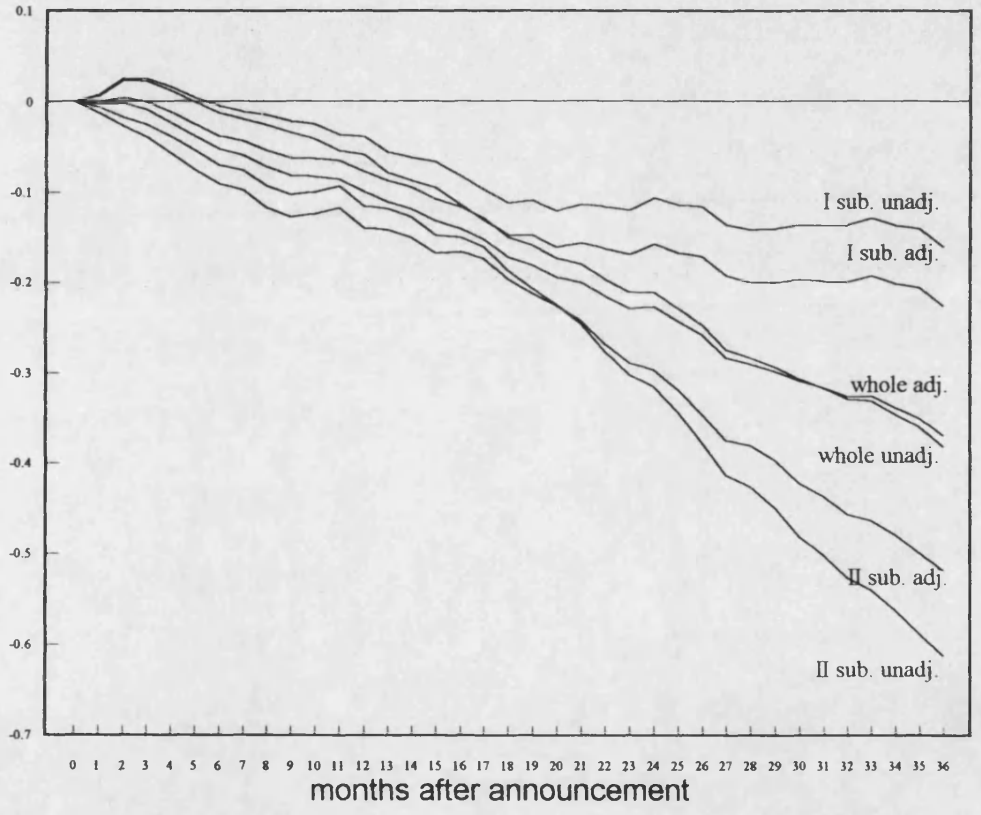
21 We used the Hoare Govett Smaller Companies Index, which is a market capitalisation weighted index of the smallest decile by market capitalisation of all the shares quoted in the London Stock Exchange. At the end of 1988, the last year of announcements in our sample, the Hoare Govett Smaller Companies index included all companies with a market capitalisation less than £112 million.

22 The number of companies adjusted with the Hoare Govett Smaller Companies Index is 211.

smaller companies underperformed the larger ones, while the second subsample only the 1987 issues include one of the three post issue years in which smaller companies outperformed the larger ones. We expect to see the size effect clearly in this two subsamples.

Figure 3.1 reports the post announcement cumulative abnormal returns for the whole sample and the two subsamples, computed with and without the adjustment for size explained above.

Figure 1.3 Post announcement performance



As expected, the size adjustment lowers substantially the performance of the companies in the first subsample, bringing a cumulative abnormal return of -10% (top line) to -20% (second from top). Conversely, in the second subsample, the size adjustment increases the returns from -60% (bottom line) to -50% (next

to bottom line). Surprisingly, when the two subsamples are combined, the cumulative abnormal performance is similar with and without the adjustment (central two lines); this is due to the fact that on average, in our sample period, larger and smaller companies have had a broadly similar performance.

Another interesting fact revealed by the split sample analysis is that, both with and without the adjustment, the cumulative underperformance is much higher for companies undertaking rights issues in the high-volume years 1987-1988 (period in which there were an average of 276 rights issues per year) than the 1981-1986 period (when only an average of 117 rights issues per year were made).

Although the size adjustment adopted here is rather unsatisfactory, since only two portfolios are considered, the results obtained point to the conclusion that the size effect does not seem to be responsible for the average underperformance of companies undertaking rights issues, since the outperformance of rights issues in the first subsample is compensated by the underperformance in the second subsample. Obviously, the cross sectional dispersion of the cumulative abnormal returns will be affected by the size adjustment, as our figure 1.3 suggests, but here there is no reason to believe that a size effect can be the cause for our results.

In table 1.9 we report the values of the abnormal returns and cumulative abnormal returns[23] from three years before to three years after the issue, computed by adjusting the raw returns with the FTA All Share equally weighted index, and their respective t-statistics for the hypothesis that the returns are different from zero[24].

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23 The cumulative abnormal returns have been calculated by adding monthly abnormal returns cumulatively, starting from the month before the announcement and going backwards, and starting with the month after the announcement and going forward.

24 The variance for each monthly average abnormal return has been computed from the sample of abnormal returns in that month. For the cumulative abnormal returns we used the average variance across all periods (separately for the pre and post announcement months) in the whole sample, times the number of months in the cumulation.

Table 1.9 Abnormal and cumulative abnormal returns

TIME	Cum. Abn. Return	t-stat	Abn. Return	t-stat	TIME	Cum. Abn. Return	t-stat	Abn. Return	t-stat
-36	26.09	6.18	-0.22	-0.28	0			-1.19	-1.52
-35	26.30	6.34	-1.37	-2.40	1			0.05	0.09
-34	27.67	6.76	-0.67	-1.27	2	0.41	0.49	0.35	0.61
-33	28.35	7.06	0.42	0.65	3	-0.02	-0.02	-0.43	-0.73
-32	27.92	7.06	-0.87	-1.42	4	-1.14	-0.98	-1.12	-2.26
-31	28.79	7.43	-1.38	-2.23	5	-2.48	-1.90	-1.34	-2.68
-30	30.17	7.94	0.54	0.82	6	-3.75	-2.63	-1.28	-2.19
-29	29.63	7.96	0.17	0.26	7	-4.34	-2.81	-0.58	-1.14
-28	29.46	8.07	-0.01	-0.01	8	-5.39	-3.27	-1.05	-2.08
-27	29.47	8.26	-1.09	-1.84	9	-6.19	-3.54	-0.80	-1.25
-26	30.56	8.75	-0.69	-1.12	10	-6.25	-3.39	-0.06	-0.12
-25	31.25	9.14	0.02	0.02	11	-6.50	-3.36	-0.25	-0.49
-24	31.23	9.40	0.79	1.22	12	-7.71	-3.82	-1.21	-2.46
-23	30.45	9.37	-0.55	-0.81	13	-8.73	-4.15	-1.02	-1.88
-22	31.00	9.83	0.13	0.20	14	-9.53	-4.37	-0.79	-1.61
-21	30.86	10.06	0.79	1.39	15	-10.78	-4.77	-1.25	-2.08
-20	30.07	10.08	1.40	2.46	16	-11.64	-4.99	-0.87	-1.49
-19	28.67	9.87	0.65	0.92	17	-12.86	-5.35	-1.22	-2.37
-18	28.02	9.94	0.47	0.72	18	-14.97	-6.05	-2.11	-3.63
-17	27.55	10.09	0.70	105	19	-15.89	-6.25	-0.92	-1.81
-16	26.85	10.15	1.50	2.16	20	-17.36	-6.65	-1.47	-2.87
-15	25.35	9.91	1.63	2.29	21	-18.01	-6.73	-0.66	-1.07
-14	23.72	9.63	1.09	1.23	22	-19.67	-7.18	-1.66	-3.13
-13	22.64	9.56	2.63	3.98	23	-21.15	-7.54	-1.48	-2.49
-12	20.01	8.83	1.87	2.72	24	-21.14	-7.35	0.01	0.01
-11	18.13	8.39	1.02	1.85	25	-22.89	-7.75	-1.75	-2.86
-10	17.11	8.35	0.08	0.14	26	-24.69	-8.17	-1.80	-3.31
-9	17.03	8.74	1.36	1.83	27	-27.44	-8.89	-2.75	-5.00
-8	15.67	8.57	1.61	2.63	28	-28.36	-9.01	-0.91	-1.37
-7	14.06	8.23	2.87	3.63	29	-29.39	-9.17	-1.04	-1.71
-6	11.19	7.09	2.24	2.88	30	-30.73	-9.43	-1.33	-1.80
-5	8.94	6.24	2.39	3.38	31	-31.74	-9.55	-1.01	-1.71
-4	6.56	5.13	1.18	1.84	32	-32.90	-9.72	-1.16	-1.80
-3	5.37	4.87	2.11	2.95	33	-33.13	-9.62	-0.23	-0.23
-2	3.26	3.62	1.43	2.34	34	-34.63	-9.90	-1.50	-2.44
-1			1.83	3.14	35	-36.00	-10.13	-1.37	-2.30
0			-1.19	-1.52	36	-38.22	-10.54	-2.22	-3.58

Note: **Cum. Abn. Return** is the cumulative abnormal return from the issue month; **Abn. Return** is the abnormal return in that month; **t-stat** is the t-statistic for the hypothesis that the abnormal returns are equal to zero.

Table 1.9 reveals a steady decline in the performance of the companies in our sample, with an average cumulative abnormal return of -38% in the three years following the issue. Two explanations are possible for our results: benchmark errors, or the existence of "fads" in the market. We have already suggested that our benchmark can be deficient in many respects. More appropriate benchmarks can be constructed which control for size and industry classification simultaneously; other factors could also be controlled for, such as the riskiness of the stock and its exposure to risk variables. Franks, Harris and Titman (1991), in order to analyse the postmerger performance of acquiring firms in takeovers, employ multifactor benchmarks which control for size, dividend yield and past performance.

The second possible explanation for our results is the existence of "fads", periods of optimism and pessimism in the market which are exploited by companies which issue equity at a relatively low cost. This is the explanation that Ritter (1991) finds consistent with his results and which is also consistent with ours. In particular, the fact that companies which issued equity in high-volume years experienced also the biggest underperformance suggests that managers may be exploiting the temporary optimism of the market with respect to rights issues.

1.1.6. Conclusions

We have analysed, for a recent sample of UK companies, the abnormal return at the announcement of rights issues and the long-run performance of companies undertaking rights issues. Our study of UK rights issues does not reveal sharp differences with similar previous studies of US underwritten security offers.

We document a negative abnormal return of -1.63% (median -2.34%) at the announcement of a rights issue and we relate it to the stated reason for the issue, the size of the issue, the change in leverage, the abnormal returns before the issue and whether the company had another issue in the previous year.

In a multivariate regression framework we are able to explain between

7% and 15% of the cross sectional dispersion of the abnormal return with these variables. In particular, the cumulative abnormal returns with respect to the equally weighted version of the FTA All Share Index during the two years before the issue, and the change in leverage implied by the issue, have a positive effect on the abnormal returns, while the absolute size of the issue and the presence of an issue in the year preceding the announcement have negative effects. Among the reasons for the issue, acquisitions attract the smallest price falls compared to expansions, leverage reductions and restructurings.

The analysis of the long-run performance of companies undertaking rights issues reveals the surprising result that these companies experience an abnormal return of -38% in the three years starting the (calendar) month after the issue. Although we employed several benchmarks, our result is still subject to benchmark errors: in any case, we find no evidence in our sample that the size effect is likely to have affected our results.

Although our analysis was not a test of this hypothesis, our results are consistent with the existence of "fads", or periods of optimism and pessimism, in the stock market which lead to the overvaluation and undervaluation of shares. Managers who possess superior information take advantage of the opportunities given by the mispricing of the shares of their company, by issuing new equity when it is temporarily overvalued, effectively raising capital when it is cheap to do so.

1.2. Business Conditions and Stock Returns: A Markov Switching Regression Model for the US Stock Market

1.2.1. Introduction

Several recent studies have found that macroeconomic factors explain only a small proportion of the variance of realised stock returns[25]. For example, Cutler, Poterba and Summers (1989) find that only about 19% of the variation in monthly US stock returns can be attributed to various types of economic news. In addition, Roll (1988) tries to explain the returns of large US companies by relating them to contemporaneous information about market returns, industry influences and company specific news, but can only explain about 35% of the variation in these returns[26].

Some authors conclude that the presence of a large unexplained component of stock returns suggests that "fads" or other investors' irrationalities may be responsible for a large part of the variation in stock returns[27].

In this paper we investigate an alternative explanation: we argue that, a priori, the economic factors which supposedly affect stock returns may do so in a non-linear manner. We propose and estimate a two-state switching regression and find that the response of stock returns to macroeconomic news clearly depends on whether or not the economy is in a recession, as, in most cases, there are substantial differences in the response coefficients in the two states. Using the same data as Cutler, Poterba and Summers (1989), we find that the explained

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25 A review of the literature is contained in McQueen and Roley (1990).

26 In theory, it should be possible to explain up to 100% of the variation in returns by using contemporaneous information (Roll, 1988).

27 For example Shiller (1984).

component of the switching regression model goes up to around 30%. Even though this still leaves a large unexplained component, nevertheless we feel that this may constitute a step in the right direction and that there is certainly scope for future research.

Our study is organised as follows: section 1.2.2 outlines our theoretical and econometric models; our results are presented in section 1.2.3 and section 1.2.4 summarises our conclusions.

1.2.2. Theoretical and Econometric Model

Asset pricing theories do not require that the relationships between state variables and asset prices are linear.

In the Lucas (1978) equilibrium asset pricing model, the prices of the various assets (p_t) are a general function of a vector of state variables (x_t)

$$p_t=F(x_t)$$

The state variables then evolve according to a transition equation

$$x_t=T(x_{t-1},\eta_t)$$

where η_t are innovations. The F and T functions are not linear in general, and models have been generated were non-linearities are explicit. For example, Scheinkman and Weiss (1986) construct a model of aggregate economic activity where a non-linearity arises because the distribution of income varies with the economic cycle: one of the results of their model is that unanticipated expansions in money supply increase output when output is low, and reduce output when output is high.

We believe that non-linearities can also be present in the reaction of stock returns to unexpected shocks to economic activity, although we have not derived this from a formal model. For example, on one hand, in a recession, positive innovations in economic activity may have a strong positive effect on stock returns due to expectations of higher future cash flows. On the other hand, in

periods of economic growth, the same type of positive innovation may not have a positive effect on stock returns, since the expectation of higher dividends could be offset by the possibility of higher future discount rates induced by monetary policy tightening. In other words, it may well be the case that in "particular" states of the world some pieces of information have a much bigger effect than in "normal" states; the direction of the effect could also change with the state.

This suggests that non-linearities may be present in the response of stock returns to economic news: ignoring it could lead to a model misspecification problem, and bias downward the importance of economic news. Therefore, modelling the relationship between stock returns and these economic variables in a linear manner may not be appropriate.

The issue to be addressed next is how to model these potential non-linearities. Several recent studies suggest that there is strong evidence for regime switching in US stock market returns. For example Schwert (1989) estimates a Markov switching model according to which the stock market may either be in the low or high variance state. Turner, Startz and Nelson (1989) consider a more general model in which either the mean, the variance, or both may vary with the state; they find that the hypothesis of constant mean and variance can be rejected at usual levels of significance. Van Norden and Schaller (1993) also find evidence for an asymmetric response of stock returns to the lagged dividend yield (used as a predictor variable).

These studies suggest that it is possible that stock returns could be affected differently by the same economic forces across different regimes. McQueen and Roley (1990) allow various pieces of economic news to affect stock returns in different ways at various points in the business cycle, and find significant effects. However, the disadvantage with their approach is that they define in which state the economy is by employing an arbitrary rule. Their conclusions are likely to be sensitive to the particular definition of the states. In addition, their model can only capture differences between pre-defined states.

In order to model the differential response of stock returns to news about economic fundamentals, without having to predefine the different states of the

economy, we propose a two-state Markov switching regression model, first introduced by Goldfeld and Quandt (1973) and developed by Hamilton (1989), which not only allows the same pieces of news to have a different effect in the two states, but at the same time estimates the probability of the system being in each particular state. The state becomes then an unobservable variable and the estimation of the model in fact requires the maximisation of the likelihood function which includes the parameters determining the state.

Specifically, we assume that news about various fundamental variables affect the US real stock market returns according to the equation

$$Y=\beta_i*X+u_i$$

where

Y the real total return of the value-weighted NYSE index

β_i vector of response coefficients

X the matrix of the explanatory variables (including the constant)

u_i error term, distributed $u_i \sim N(O,\sigma_i^2)$

i the subscript for the state, 1 or 2 in which the system is.

By construction, the error terms are uncorrelated with the explanatory (news) variables. We allow both the constant and the variance to be different across regimes following the results of Turner, Startz and Nelson (1989) who find that in a two-state switching model for the US stock market returns, the version with a switching constant and switching variance is superior to the restricted ones.

In addition, we assume that the transition between states is governed by a first-order Markov process described by two parameters:

$$p_i = \text{Prob}(\text{State}(t) = i \mid \text{State} = i\ (t-1)) \qquad \text{for } i=1,2$$

which represent the probability that the system stays in state i at time t, given that it was in state i at time t-1. This model has been proposed by Hamilton (1990) as an extension of his switching model for time series, and is applied here in a regression framework. The assumption that the states evolve according to a

Markov process constitutes the structure on the evolution of the states. If the two estimated probabilities p_1 and p_2 are not significantly different from 0.5, this implies that no Markov process exists for the evolution of the states. Values of the probabilities significantly lower than 0.5 mean that the system is more likely to switch state than to remain in the current one; conversely, values higher than 0.5 imply persistence in the states.

The parameters to be jointly estimated are: the two vectors of regression coefficients β_i, the two variances σ_i^2, and the two transition probabilities p_i. We employ a maximum likelihood estimator, conditional on initial conditions, implemented via the EM algorithm of Dempster, Laird and Rubin (1977); a more formal presentation of the model, together with a description of the estimation procedure is contained in the Appendix.

1.2.3. Results

We use the same monthly dataset as Cutler, Poterba and Summers (1989) for the 1926-1986 period and, as in their work, we examine seven different pieces of news. The dependent variable is the real return (including dividends) on the value-weighted NYSE index (RR), the explanatory variables are innovations in: real dividends (RD), industrial production (IP), nominal long term (LI) and short term (SI) interest rates, the inflation rate (IR), the real money supply (RM) and stock market volatility (VO)[28].

We made no attempts to select the variables to include in our multivariate two-state regression according to specific theories, since we wanted to investigate the explanatory power of a switching regression model as compared with a one-state model. Moreover, the inclusion of variables which may be irrelevant for determining stock returns does not affect our model, as they would attract a (near) zero coefficient in the estimation procedure. We have therefore used all the series included in the Cutler, Poterba and Summers (1989) dataset.

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28 For details of the definitions and sources of the variables, see the Data Appendix.

In order to compute the innovations in our series, we follow the same procedure as Cutler, Poterba and Summers (1989) and estimate a vector autoregression (VAR); we then assume that the residuals from this VAR represent the true innovations. We first reproduce Cutler, Poterba and Summers (1989)'s results in table 1.10. Using three lags in our VARs in order to generate innovations, the simple OLS regression of stock returns on the seven innovation variables can explain 18.5% of stock returns[29]. Unanticipated increases in dividends and industrial production have a positive and significant effect, while innovations in volatility have a significant negative effect. Surprises in real money, inflation or interest rates appear to have little impact on stock returns.

When the same estimation is conducted for the period 1946-1986, also reported in table 1.10, the innovation variables explain only 14.9% of stock returns, with volatility and real dividends having a similar effect as in the whole sample estimation, but with industrial production not having a significant effect any longer.

We then estimated the two-state Markov switching regression for both the whole sample and the shorter one, and we report the results in table 1.11. The estimation procedure may be sensitive to initial conditions, so we estimated the switching regression by starting with values for p_1 and p_2 equal to 0.5 and with values for the coefficients two standard deviations away from the OLS estimates, in several combinations; all our estimations have converged to the same maximum.

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29 As measured by the adjusted R^2.

Table 1.10 OLS results

Variable	1926-1986 sample	1946-1986 sample
Constant	0.010 (0.005)	0.010 (0.007)*
IP	0.427 (0.218)**	0.100 (0.148)
IR	-0.079 (0.054)	-0.075 (0.061)
VO	-0.022 (0.004)**	-0.017 (0.003)**
RD	0.081 (0.014)**	0.050 (0.012)**
SI	-0.0682 (0.889)	-1.23 (0.780)
LI	-2.64 (1.987)	-2.15 (1.58)
RM	0.195 (0.158)	0.180 (0.460)
R^2	0.185	0.149
Log likelihood	1112.47	893.40

Note The dependent variable is RR; the regressors are innovations in the respective variables; heteroskedasticity consistent standard errors are in parenthesis. A * (**) means that the t-statistic for that variable is significant at the 10% (5%) level.

Table 1.11 Two-state switching regression results

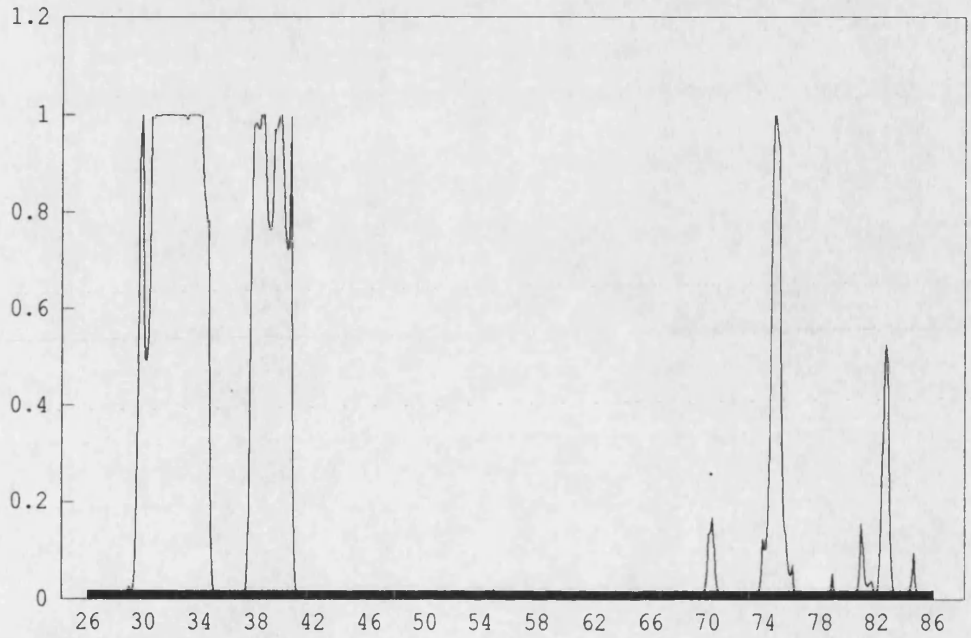
	1926-1986	sample	1946-1986	sample
Variable	State 1	State 2	State 1	State 2
Constant	0.010 (0.010)	0.008 (0.001)**	0.011 (0.005)**	0.005 (0.002)**
IP	1.14 (0.355)**	-0.057 (0.101)	0.807 (0.798)	0.054 (0.159)
IR	-0.005 (0.007)	0.000 (0.001)	-0.002 (0.002)	-0.001 (0.001)
VO	-0.029 (0.014)**	-0.021 (0.003)**	0.049 (0.012)**	-0.025 (0.003)**
RD	0.194 (0.039)**	0.035 (0.009)**	0.104 (0.038)**	0.037 (0.012)**
SI	0.010 (2.565)	-1.12 (0.557)**	1.29 (0.981)	-3.24 (0.722)**
LI	-4.28 (7.32)	-1.685 (1.37)	-4.97 (2.04)**	-0.385 (2.03)
RM	-0.725 (0.566)	0.361 (0.126)	0.012 (1.48)**	0.159 (0.340)
σ	0.008 (0.001)	0.001 (0.000)	0.002 (0.000)	0.001 (0.000)
p	0.946 (0.038)	0.991 (0.007)	0.929 (0.052)	0.984 (0.012)
R^2	0.366	0.195	0.372	0.293
Log Likelihood	1912.21		1359.32	

Note The dependent variable is RR; the regressors are innovations in the respective variables; heteroskedasticity consistent standard errors are in parenthesis. A * (**) means that the t-statistic for that variable is significant at the 10% (5%) level.

In our sample, the persistence in the two states is high and switching among them relatively infrequent: the estimated probability that next period we will remain in today's state is above 0.9 for both states and both sample periods. The expected duration of state 1 is one year and 6 months for the whole sample

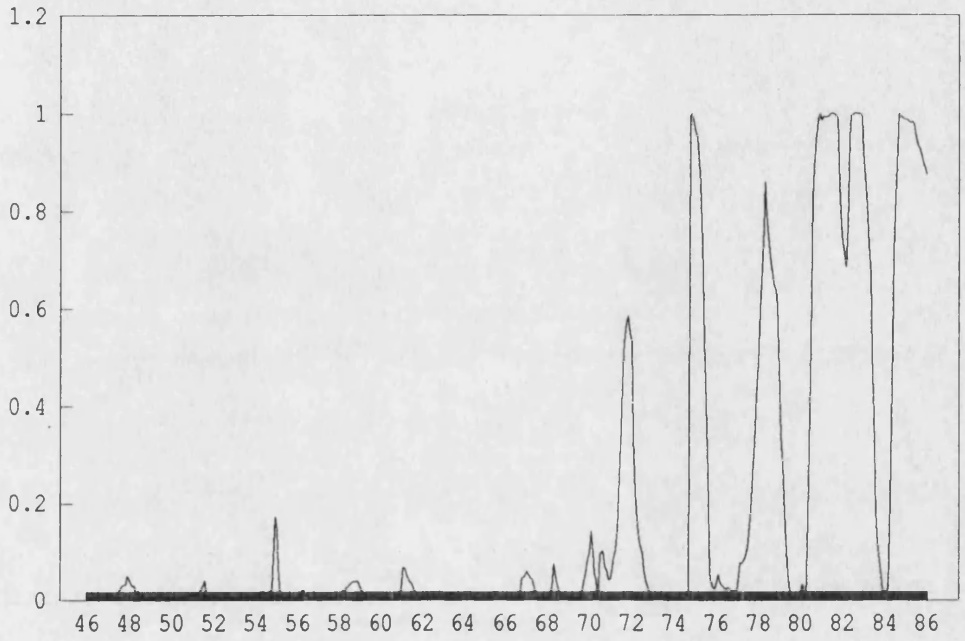
and one year and two months for the shorter sample; the expected duration of being in state 2 is respectively 9 and 5 years. The smoothed probabilities of being in the first state, which are the probabilities computed with information available for the whole sample, are plotted in Figures 1.4 and 1.5.

Figure 1.4 Probability of being in state 1, smoothed values: 1926-86



There appears to be a clear business-cycle interpretation of the states as they correspond to downturns in economic activity. Indeed, a regression of the probability of being in state 1 on changes in industrial production yields a coefficient of -2.41 with a "t" value of -4.36 for the whole sample and of -2.87 with a "t" value of -2.13 for the smaller sample. We will therefore call state 1 the "recession" state.

Figure 1.5 Probability of being in state 1, smoothed values: 1946-86



The whole sample estimation is clearly dominated by the 1929-1933 recession and fails to identify some of the switches which occurred in the period after 1946. A bigger number of switches are identified in the smaller sample: this is probably due to the fact that the estimation procedure assigns the same characteristics to all periods in the same state, so that some of the milder recessions which occurred after 1946 did not look like a downturn when compared with the 1929-1936 one. A switching regression model with three or more states would be necessary in order to identify milder and more severe downturns, together with periods of slow and high growth, but at the cost of increasing substantially the number of parameters to be estimated.

Turning to the parameter estimates for the whole sample and to the corresponding standard errors variable by variable, we can see that innovations in activity have three times as large an effect in recessions than in the restricted OLS case. Moreover, there appears to be an insignificant effect in the other state, possibly because the positive effect of future cash flow is offset by expected higher discount rates due to expectations of monetary policy tightening. Real

dividend growth seems to have a positive effect no matter what state we are in, although the effect in downturns is much stronger. Unanticipated increases in volatility have a similar significant effect across states (but of opposite sign in the shorter sample), while shocks to inflation have a bigger effect in downturns, with the coefficients not significantly different from zero. Turning to the effect of interest rates one can see that shocks to short rates only matter in non recessionary times, while shocks in long rates have a much greater (although not significant) effect in recessions. Finally, we find that unanticipated increases in real money only have a significant positive effect in normal times. Surprisingly, in downturns we see a negative though insignificant effect.

The results for the constant and the variance of the error term across the two states is suggestive of the presence of heteroskedasticity. The variance in the first state is 8 times as high as that in the second state (only twice as high in the subsample). The constant is also higher in the first state, but not significantly so. These results seem to be in line with intuition, in that the "recession" state is one where risk is relatively high and the investors are compensated for this risk by a higher average returns.

With the exception of the coefficient on volatility, the results for the smaller sample are qualitatively similar to the ones for the whole sample, with again the coefficient on real dividend growth several times higher than both the OLS and the normal state, and innovations to the long rate now significant in the recession state.

Having described the results of our estimation, we now discuss how the two-state model compares with the one-state OLS results. Testing for the two-state Markov switching model against the alternative of a one-state model (in this case the OLS model in table 1.10) cannot be done easily since under the null hypothesis the transition probabilities p_1 and p_2 are not identified and as a result, the asymptotic distributions of the likelihood ratio, Wald and Lagrange multiplier tests are non-standard. A few tests have been proposed in the literature for this particular problem, such as the standardised likelihood ratio test (Hansen, 1992) and Monte Carlo simulations (Cecchetti, Lam and Mark, 1990). The first one involves a grid search through all the dimensions of the parameter space and

would require a prohibitive amount of CPU time to conduct in this context; the second one, in addition to the similarly high computing time, suffers from the lack of an asymptotic theory for the test statistics.

Recently, an asymptotic test has been proposed by Garcia (1992). Van Norden and Schaller (1993) report the significance levels computed by Garcia (1992): for the case of switching means and variances, the critical values for the non-standard distribution of the likelihood ratio test at the 5% and 1% significance levels are respectively 14.11 and 17.38. At those significance levels, and for a similar dataset to the one employed here[30], both for the whole sample and for the post war sample, van Norden and Schaller (1992) find that the null hypothesis of a one-state model for the univariate series of excess returns over the 90 day Treasury Bill is easily rejected at the 5% significance level, suggesting that the two-state model is preferable to the one-state model.

Our specification, however, is multivariate and the same significance levels do not necessarily apply. Nevertheless, we feel that the results reported below, together with the univariate ones of van Norden and Schaller (1992) suggest that in our case too the two-state model is a better description of the data.

First, in order to have an idea of the fit of our switching regression model, we compute a "pseudo" R^2. For the whole sample, the R^2 for both states is 31.3 while for the shorter sample it is 34.1; in both cases substantially higher than the 18.5% and 14.9% of the OLS regression. Second, we compute a Wald test for the hypothesis that the two vectors of coefficients, excluding the constant[31], are equal, with the variance allowed to vary among the states, and find that we can comfortably reject the null hypothesis with a $X^2_{(7)}$ equal to 30.2: the results are reported in table 1.12. It should be noted that the main reason of this rejection is the difference of the coefficients on innovations in industrial production and real

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30 Specifically, the CRSP value-weighted US monthly stock market returns for the period 1927-1989.

31 With a switching constant, the two states are identified under the null hypothesis; therefore the Wald test is valid.

dividend growth which are significantly higher in the first state.

Table 1.12 Test of equality of the coefficients in the two states

Coefficient	Difference	Standard error	t-statistic
IP	1.196	0.371	3.220
IR	-0.004	0.007	-0.601
VO	-0.008	0.014	-0.535
RD	0.160	0.041	3.935
SI	1.132	2.698	0.419
LI	-2.593	7.526	-0.344
RM	-1.086	0.587	-1.849

1.2.4. Conclusions

General asset pricing theories suggest that prices may be related to the state variables which determine them in a non-linear manner. Our results provide evidence in support of the existence of non-linear relationships among US stock market returns and a series of innovations in macroeconomic variables. The two-state Markov switching model applied here clearly identifies two states which are related by us to periods of recession and normal growth.

The recession period lasts an average of one and one half year, while the normal growth period lasts an average of 9 years. The two states are highly persistent with few switches among them. Our results show that, in the recession state, positive innovations in industrial production have a three times higher effect on returns than the OLS results suggest; a similar result is present for

innovations in real dividend growth.

We confirm McQueen and Roley's (1990) finding that the stock market response to macroeconomic news depends on the state of the economy, but we do not have to define, as they do, the states *a priori* since these are identified endogenously by our model as part of the estimation procedure.

While in our model innovations in macroeconomic variables explain a much larger fraction of the real returns of the US stock market than one-state models, we still find a large unexplained component in stock prices. We feel, however, that our results are encouraging, showing that there is scope for research into more complex non-linear models, such as those with time variation in the transition probabilities.

1.2.5. Appendix

Hamilton (1991) shows that given an initial estimate of the vector of parameters $\lambda(\beta,\sigma,p)$, $\lambda^{(l)}$, the improved estimate $\lambda^{(l+1)}$ can be obtained by iterating once the following system:

$$(T-1)\left[\sigma_i^{(l+1)}\right]^2 = \frac{\sum_{t=2}^{T}\left(Y_t - X_t'\beta_i^{(l+1)}\right)^2 \cdot p\left(s_t = i \middle| Y_t; \lambda^{(l)}\right)}{\sum_{t=2}^{T} p\left(s_t = i \middle| Y_t; \lambda^{(l)}\right)}$$

$$\sum_{t=2}^{T}\left(Y_t - X_t\beta_i^{(l+1)}\right)X_t \cdot p\left(s_t = i \middle| Y_t; \lambda^{(l)}\right)$$

$$p_{ij}^{(l+1)} = \frac{\sum_{t=2}^{T} p\left(s_t = j; s_{t-1} = i \middle| Y_T; \lambda^{(l)}\right)}{\sum_{t=2}^{T} p\left(s_{t-1} = i \middle| Y_T; \lambda^{(l)}\right)}$$

where $p(s_t=i)$ are the smoothed probabilities: the probabilities of being in each state, based on the whole sample of observations, and the $\beta_i^{(l+1)}$ are the improved estimates of the switching parameters.

The implementation of the EM algorithm involves first the computation of the smoothed probabilities $p(s_t=1)$ for given parameter values; second, two OLS regressions are run, with the observations weighted by the square root of the associated smoothed probability, and estimates of the coefficients and the standard deviations are obtained; third, the parameters of the Markov transition matrix which are implied by the smoothed probabilities are computed.

This procedure is then iterated until a fixed point is found, which it has been shown by Hamilton (1990) to coincide with the maximum likelihood estimate for the system. The R^2 reported in the tables is the one from the latest set of OLS regressions.

If, as is our case, the variance of the two states is different, it is possible that the estimation technique finds the maximum of the likelihood function with one state having the variance close to zero. We have not encountered this problem: Hamilton (1990) shows, however, that the inclusion of Bayesian priors can overcome this problem.

1.2.6. Data Appendix

The definitions of the variables used in our regressions are:

RR Real returns computed from the value-weighted NYSE total return index

RD Log of real dividend payment on the value weighted NYSE portfolio

IP Logarithm of industrial production

LI Moody's AAA corporate bond yield

SI 3-Month Treasury Bills Rate

IR CPI inflation rate

RM Logarithm of real money supply M1

VO Log of stock market volatility (average squared daily return on S&P composite index during month)

The data were kindly supplied by the Interdisciplinary Consortium for Political and Social Research in Ann Arbour, MI.

2.

The Effect of Managerial Ownership of Shares and Voting Concentration on Performance

2.1. Introduction

The motivation of the studies presented in this chapter is to provide empirical evidence on the effects on corporate performance generated by both the ownership by managers of shares and votes of the company which they manage, and the distribution of voting rights among holders of claims to the cash flow of a company.

Empirical evidence on these issues is limited to the relationship between market valuation and ownership of shares by managers, and is generally inconclusive. We believe that further research on this relationships is of crucial importance since, as we will see below, several studies of the stock market reaction to announcements of restructurings which involve changes in managerial ownership rely on the presence of a strong and positive relationship between performance and managerial ownership of equity.

In addition to market valuation, we will also investigate another measure of company performance: total factor productivity growth. No empirical evidence is available on the effect of managerial ownership of shares on productivity, and, again, this is a serious gap in the literature since numerous studies which analyse the effects of restructuring mechanisms which involve dramatic changes in management ownership, such as leveraged and management buyouts, state that the increased productivity which usually follows restructurings is attributable to the increased managerial stakes in the company.

The literature on the incentive effects of the ownership of shares by management, reviewed in the section 2.2, often makes the claim that the reduction in the separation of ownership and control should result in lower agency costs, and therefore higher performance. An alternative view is, however, that managerial ownership of shares may help a management to entrench and isolate itself from the market for corporate control which supposedly disciplines them with the threat of a takeover. We will argue that these two opposing effects of managerial ownership of shares can be separately identified, since the first one is related to the ownership of claims to cash flow and the second one to the

ownership of votes: these are not necessarily held in equal amounts by managers of companies which issue shares with different voting rights.

Recently, another issue has become the focus of attention of researches in the corporate performance field: the possible effects on performance of voting structures with departures from one share-one vote. These voting structures are not very common, possibly because until recently it was a requirement of the New York Stock Exchange (NYSE) that shares traded on the Exchange had a one share-one vote structure. The theoretical academic debate which followed the relaxation of the NYSE rule has come to the conclusion that one share-one vote and a simple majority rule (50% of the votes) is generally the optimal voting structure. In particular, the existence of differential voting rights may lead an inefficient management to replace an efficient one: this could happen whether or not the management itself owns shares in the company.

Although several empirical studies have investigated the price differentials of shares with the same claims to dividends but with different voting rights, no such study, in our knowledge, has investigated the consequences of the presence of shares with differential voting rights on the performance of the company. In this chapter we will investigate the relationship between a voting concentration index, whose construction we explain in section 2.3, and two measures of performance: market valuation and total factor productivity growth.

The plan of the chapter is as follows: section 2.2 briefly reviews the theoretical and empirical literature on the relationship between corporate structure and performance; section 2.3 presents the methodology employed and the problems encountered; section 2.4 contains the study on the relationship between managerial ownership of shares and performance while section 2.5 contains the study on the relationship between voting rights and performance. Finally, section 2.6 contains our conclusions.

2.2. Corporate Structure and Performance

2.2.1. The Separation of Ownership and Control

Corporate control and the agency problems generated by the separation of ownership and control are the central issues in this chapter. The "classical" model of the firm, characterised by an entrepreneur-owner who provides the risk capital, employs the factors of production and maximises profits, has come under severe criticisms since at least the 1930's for not adequately representing the modern corporation, in which the entrepreneurial and risk bearing functions are provided by different individuals. In this section we will first introduce the main criticisms to the "classical" model and then see the mechanisms of control which have evolved to overcome this agency problem: these mechanisms are both internal to the firm (such as incentive contracts) and external (such as takeover pressure).

Berle and Means (1932) recognised that the separation of ownership and control, coupled with a dispersed ownership of the shares of a corporation, may give managers the possibility of pursuing their own interests instead of those of the shareholders. Managers may have as their objectives, aggrandisement and sales growth, rather than profit maximisation, and, especially in widely held corporations, have an opportunity for shirking and perquisite-taking given by the lack of monitoring by shareholders. Coase (1937)[32] views the firm as a set of contracts between an entrepreneur and a group of workers who are individually maximising their utility. However, an important feature of the literature developed around this idea has been the recognition that contracts are costly to write and enforce, and that an incomplete contract framework is more appropriate to the study of the modern corporation.

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32 And successively Alchian and Demsetz (1972) and Jensen and Meckling (1976).

The separation of ownership and control is the outcome of a trade-off between two opposing forces: on one side, there is the desire of the risk-bearers to diversify their risks by holding a small proportion of equity capital in various firms; on the other side, if managers do not own all the equity (risk) capital they will tend to do more on-the-job consumption, since they would not have to suffer the full consequences of their non-maximising behaviour. In theory, this last problem could be remedied by writing contracts which specify what type of actions managers can and cannot undertake, thereby safeguarding the interests of the shareholders. However, since contracts specifying all possible circumstances (in addition to being verifiable by a third party) are either too costly, or simply not enforceable, some other mechanism, internal or external to the firm, is necessary to prevent the management from taking actions which are not in the interest of the shareholders.

Incentive contracts can be used as a way of aligning the interests of managers and shareholders, but the incomplete-contract nature of the relationship among the two parties is such that performance-related compensation is not enough to make the interests of the two parties coincide. Performance on the part of managers is very difficult to assess, since the overall performance of a company is also affected by outside shocks whose effects cannot be properly quantified. When trying to judge the performance of managers, shareholders face a signal extraction problem and try to infer managers' ability from a noisy signal, the overall performance of the company. Campbell and Marino (1989) show that in such a situation, risk-averse managers are led to choose investments which do not maximise the value of the firm.

Nevertheless, performance-related contracts are widely used, taking sometimes the form of options to buy shares of the company at a pre-specified price, but the magnitude of their impact is questioned in a study by Jensen and Murphy (1990) who analyse the pay-performance relationship and find that although this is present and significant, it is too small, implying an increase of salary and bonus for the chief executive officer of only 45 cents per $1000 of

increase of shareholder wealth[33].

Even in the absence of external shocks, if monitoring costs are present, a manager who owns less then 100% of the equity of a company will not bear the full consequences of his actions and this may lead to non-maximising behaviour. This would be anticipated by shareholders who may allow some form of non-maximising behaviour as a substitute form of compensation. Demsetz (1983) argues that, in a world with no monitoring costs, when a manager is hired by the owner of a firm, the on-the-job consumption will be lower since the owner will demand a greater reduction in the remuneration of the hired manager that the owner's own on-the-job consumption. If, however, monitoring costs are high, on-the-job consumption will also be higher and the direct remuneration of the manager lower, but this would not necessarily be, according to Demsetz (1983), an inefficient means of production.

Since it is practically impossible to perfectly align the interests of owners and managers, there is the need for supervising the actions of managers. In theory, a check on management is provided by the board of directors, which is chosen by the shareholders; this is not always enough though to stop the non-value-maximising behaviour of managers. In fact, first, managers can influence the selection of the other (outside) directors, and, second, outside directors lack detailed information on which to base their judgement, since managers do not have an incentive to disclose correct and complete information unless it were favourable to them. In addition, even if shareholders have the power to appoint and fire directors, these face a free-rider problem since monitoring managers and choosing directors is a public good and few find it convenient to spend time and resources in these activities. Given the high costs involved in monitoring management, this will be done only by shareholders who have a sufficiently high stake in the company.

Since internal mechanisms of control may not be enough, there is the need for additional external mechanisms for controlling the management, to make it

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33 Kaplan (1992) finds similar results for Japan.

act in the shareholders' interest. The external checks on the management rely on the market for corporate control which uses the takeover mechanism as its main vehicle. As we will see, there are several possible effects which are generated by takeover pressure.

Scharfstein (1988) has shown that, under asymmetric information between shareholders and managers, the takeover threat is in fact more efficient than an incentive scheme in disciplining management, since an incentive scheme would have to be based on information which is known, and verifiable, by all parties. If shareholders cannot discriminate between a bad result which has been caused by self-interested managers and one caused by an unfavourable environment, any contract among the two parties would result in managerial inefficiency; in this case, an informed raider can mitigate this inefficiency by bidding for firms whose managers have shirked, but not for those whose managers were unlucky. The crucial hypothesis here is obviously that the bidder is better informed than the shareholders: if this is not the case, then the conclusion may be reversed.

The reason why the takeover mechanism may act as a monitoring device is that companies quoted in the stock market can be seen as subject to a continuous auction, so that, if the management of a company is not maximising the value of the firm and this is reflected in a low stock market value, then a competing management may buy the company at the current price, impose value maximisation and, once the share price has reacted, realise the difference.

However, the corrective properties of the takeover mechanism encounter some difficulties. One is the puzzle presented by Grossman and Hart (1980) who give reasons why the gain from a takeover would not go the new management, but to the existing shareholders. They argue that small shareholders of the target firm have no incentive to tender their shares to the bidder, until the bid price fully reflects the expected increase in profitability under the new management. If making a bid is costly, then a bidder who has to pass the whole gain to the shareholders would have no incentives. In practice, there are a number of reasons

why the bidder may still be able to extract gains from a takeover[34] but these are often offset by the high transaction costs involved in a bid, especially those which are resisted by the incumbent management. Commenting on these issues, Shleifer and Vishny (1988, p. 12) conclude that "with high transaction costs, hostile takeovers can punish only the most dramatic cases of non-value-maximising behaviour".

On the other hand, if a raider gets personal benefits from the acquisition, he could implement it and pay a premium even if there are no efficiency gains. This would be the case if a management, instead of distributing to the shareholders the cash flow remaining after all projects with positive net present value have been financed, uses it to make acquisitions with negative net present value. The "free cash flow theory" proposed by Jensen (1986) contemplates this possibility: this theory predicts that agency problems between managers and shareholders are bigger in those companies which have large cash flows and few investment opportunities. An interesting corollary of this theory is that a way for managers to commit themselves to pay out the free cash flow is to incur a large amount of debt which, unlike dividends, must be repaid to avoid bankruptcy: this is the reason why debt may act as a disciplinary device for managers.

In conclusion, takeovers can be either a solution or an expression of agency problems, depending on the motives behind them. They are a solution when they help to replace inefficient managers, or force good managers to maximise firm value; they are instead an expression of agency problems when they are undertaken by managers who have as their objectives aggrandisement or who are trying to extract personal benefits from the takeover.

Whether takeovers are a way to impose value maximisation or a way for managers to pursue their own goals, there is an incentive for managers of possible targets to adopt strategies that would make themselves less vulnerable to takeovers. Theorists in favour of takeovers argue that the desire of avoiding

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34 In the U.S. one such reason is given by the profits made by buying the first 5% of shares at the pre-bid price before disclosure of the stake has to be made by filing a SEC form.

being taken over makes managers act in such a way as to maximise the value of the firm, as expressed by the stock market, since, given that takeovers are costly, it would not pay an external management to replace the incumbent one, unless it believed that it could do better. According to this reasoning, takeovers are an effective way of preventing managers from pursuing their own objectives at the expense of shareholders, and a way of replacing managers who are simply not good enough.

Critics of the takeover mechanism argue, instead, that there are other ways of preventing takeovers which do not involve value maximisation, and which can take much time and energy for the management to implement, thus creating an undesirable waste of resources. These include antitakeover defences such as amendments to the corporate charter, poison pills, and share repurchases, as well as other methods of entrenching a management.

A potential negative effect of the takeover pressure may also be an excessive concern on the part of managers for short-term movements in share prices (called short-termism): since a higher share price would make a takeover more costly, and so less likely, if the market reacts disproportionately to current earning figures in forming earnings expectations, this concern on the part of managers is justified, and may force them to sacrifice projects which have a payoff in the long-run, in favour of others with a lower net present value, but with payoffs which occur in the short-term. It follows that one of the effects of short-termism would be the reduction in investments and R&D expenses, as a way of increasing current earnings. Although it is generally believed that short-termism can arise only in an inefficient market, Stein (1989) has shown that this problem can also arise in a perfectly efficient market, as long as managers care about current share prices.

2.2.2. Empirical Evidence

We will review below those empirical studies which provide insights, directly or indirectly, on the relationship between managerial ownership of equity

and voting rights, and on the consequences of separating voting rights and claims to cash flow. In particular, we will present the empirical evidence on the importance of internal mechanisms of control, and on the effects of takeovers and of going private transactions such as leveraged and management buyouts, on performance.

These studies concentrate mainly on the stock price reaction on the day of the announcement of a particular restructuring. To the extent that the stock market reacts instantly and without bias to all newly available information, correctly discounting to the present all the consequences of the restructuring, these studies provide a way of judging the desirability of particular types of restructurings. Very few studies concentrate their attention on the actual changes in the profitability or productivity of companies following a restructuring.

2.2.2.1. Internal Mechanisms of Control

We start by reviewing studies which attempt to test the importance of mechanisms, internal to the firm, for monitoring management. Warner, Watts and Wruck (1988) study the relationship between stock price performance and top management replacements. They find an inverse relationship between the probability of a management change and stock price performance, which suggests that poorly performing managers are indeed replaced: the actual monitoring mechanism which is at work may come either from the board of directors, mutual monitoring among the managers, or by the presence of large shareholders. However, the model estimated by the authors has predictive ability only for extremely good or bad performances (within the lowest decile of performance the probability of turnover is only 0.06) and the change in management can occur up to two calendar years after the bad performance is observed.

Lewellen, Roderer and Rosenfeld (1985) study the relationship between managerial ownership of acquiring firms and abnormal stock returns at the announcement of a merger, and find that it is positive and significant. Given that some mergers may be expression of agency problems (as suggested above), the higher abnormal stock returns obtained with higher management ownership is the

expression of the lower probability of a value-decreasing merger. To the extent that higher management ownership decreases agency problems, the results suggest that internal mechanisms of control are inefficient in preventing managers who own little stock in their companies from undertaking value-decreasing mergers.

The role of large shareholders as a partial solution to the free-rider problem has been explored by Shleifer and Vishny (1986). From their work it emerges that the main role of large shareholders is to facilitate takeovers, rather than to overcome agency problems. Large shareholders are mainly investment funds and insurance companies which hold large portfolios and are generally well diversified: they lack the incentive to supervise closely the activities of companies in their portfolios since it would take them a substantial amount of time and energy to do something which is not related to their main business.

Outside directors have probably a bigger role to play in the monitoring of the management, but their presence is seldom encouraged in reality. Weisbach (1988) examines the relationship between the presence of outside directors and the turnover of chief executive officers. Controlling for ownership structure, industry, and size, he finds that in outsider-dominated boards there is a stronger association between prior performance and the probability of resignation. Nevertheless, outside directors often have interests in the continuation of the present management, and lack the information necessary to judge the actions of the management. To have an effective role, outside directors should be chosen by shareholders, should have no interest in the company, and their incentive to provide efficient monitoring should be given by the desire to maintain their reputation as good non-executive directors. Kaplan and Reishus (1990) find that reputation is indeed important for directors by estimating that top executives of companies that reduce their dividends are less likely to receive additional outside directorships.

Concluding, while empirical studies find some evidence that stronger internal mechanisms of control, such as the presence of outside directors or of a large shareholder, are associated with higher monitoring of managers, they do not show that the level of monitoring is sufficient, suggesting instead the contrary.

2.2.2.2. Hostile and Disciplinary Takeovers

A distinction which has become frequent in the literature is between hostile and friendly takeovers: a friendly takeover is not opposed by the incumbent management at its announcement, making it very similar to a merger, while a hostile one generally encounters resistance from the incumbent management, which often adopts defensive measures. By reviewing the empirical evidence, we want to see to what extent hostile takeovers have succeeded in increasing the efficiency and profitability of the companies involved, in order to judge whether insulating from the market for corporate control can be positive (short-termism argument) or negative (entrenchment argument) for the shareholders. The motive behind the takeover determines what changes we can expect to observe: if takeovers are prompted by efficiency considerations, they should result in a more productive firm; if the objective of the merger is, instead, market power, then we should see an increase in industry concentration. Finally, if takeovers are prompted by agency problems, then we would see either a decrease in productivity or no change at all.

We are interested in the relationship between hostile takeovers and stock price performance, as well as in changes of productivity and profitability of firms taken over. Unfortunately, no single empirical study, or group of studies, can provide a coherent picture on the effects of takeovers since conflicting results are often obtained for different samples. We will therefore present the main studies and their conclusions indicating, wherever possible, what can account for differences in results.

Morck, Shleifer and Vishny (1988a) examine ownership and financial characteristics of the firms in the 1980 Fortune 500 sample, 82 of which were either acquired by a third party, or underwent a management buyout. The authors classify the target firms as either friendly or hostile, depending on the reaction of the incumbent management to the tender offer, and look at the differences among these two groups and the average firm in the sample. Boards of directors of friendly targets owned on average over 20% of the company, significantly more than the 10.9% of the whole sample and the 8.3% of the hostile targets. Also, the

incidence of a member of the founding family on the management team was significantly higher for friendly targets (40%) than for the average firm in the sample (24%), and this was significantly higher than for hostile targets (10%). These differences could be due to two effects of high management ownership of shares: difficulty of completing a hostile takeover when managers own a substantial amount of shares, and lower agency costs due to stronger convergence of interests. An additional possible explanation for this result is that, given that a bid is made, managers who own a big amount of shares have a strong financial incentive to accept the tender offer at a premium, so may not resist it. The authors warn that the differences that they find between friendly and hostile targets could also be caused by other characteristics of the firms which are not controlled for, such as size.

The authors also look at the values of Tobin's Q - defined as the ratio of the market value of the firm to the replacement cost of its tangible assets - and find that hostile targets have a significantly lower Q than both the average firm in the sample and friendly targets. The lower Q, which is taken to imply that the company is undervalued with respect to the rest of the economy, may be due either to mismanagement, or to the low value of the assets caused by technological progress and increased foreign competition; the last reason is consistent with the finding that hostile targets were older and growing more slowly than the average firm in the sample. A related result is that firms which divest part of their businesses and those acquired in hostile takeovers are underperformers in their industries, while companies making acquisitions do not seem to be outperformers. By running probit regressions, the authors also find that the probability of a friendly takeover is not influenced by the market value of the company or by Q, while the probability of a hostile takeover is negatively related to both of them[35].

Concluding, hostile targets were smaller, older, growing more slowly, had lower Tobin's Q, more debt, and less investment, compared with the average

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35 The regression includes both the industry Q and the deviation of Q from the industry average, but the first one is more important and statistically significant.

Fortune 500 company. Friendly targets had a board with higher ownership, but did not share the same characteristics of hostile targets, suggesting that there could be a relationship between the reasons for the takeover and whether it is a friendly or a hostile one. Morck, Shleifer and Vishny (1988a), in fact, interpret these findings as evidence that friendly takeovers are motivated by the exploitation of synergies, while hostile ones are of a disciplinary nature.

A potentially more useful classification of takeovers is the one by Martin and McConnell (1991) who classify them as disciplinary if there is top management turnover after the takeover. By looking at a sample of 253 successful tender offers occurring between 1958 and 1984, they find that disciplinary takeover targets had a stock market performance significantly lower than other targets; when the authors divide the sample into friendly and hostile takeovers, they find no difference in turnover rates or in stock market performance prior to the takeover. Furthermore, the authors find that the abnormal returns for both bidders and targets, and the probability of multiple bids, are not influenced by whether the takeover was disciplinary, or friendly, suggesting that competition for target firms does not depend on the motive of the takeover.

We now look at the evidence on the consequences of takeovers. One consistent result about mergers and takeovers is that shareholders of acquired firms gain a premium of about 20%[36], while bidder's shareholders break even or have very small gains (Caves, 1989). Since the acquirer is generally bigger than the acquired company, the combined share value increases by 7-8% on average after the merger. In their review of the early evidence on the performance of takeovers as expression of the market for corporate control, Jensen and Ruback (1983) report that shareholders of target firms realise on average 20% gains in mergers and 30% in takeovers, while bidding firms on average do not lose[37]. The

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36 This shows a rising trend with values around 40% for the latest acquisitions.

37 The authors view the market for corporate control "as a market in which alternative managerial teams compete for the rights to manage corporate resources" (Jensen and Ruback, 1983, p. 6).

authors report evidence that, after one year, the share price of the bidding firms drops, which suggests that, at the time of the merger, the market overestimates the future efficiency gains (Jensen and Ruback, 1983, p. 20). The authors claim that the source of the short-term gains does not appear to be an increase in market power, but in efficiency, even though they are not able to identify it.

Very few studies relate the stock market gain to real performance improvements; one such study is Healy, Palepu and Ruback (1990) who analyse the post-merger changes in operating performance by looking at the 50 biggest takeovers in the period 1979-1983. Using company accounts data they find that operating cash flow performance, relative to the industry, increases in the five years after the merger, due to improvements in asset productivity. The improvement in cash flow performance is not achieved by cutting capital expenditures or R&D, even if the industry-adjusted growth rate per employee declines significantly in the post-merger period; an increase in asset turnover rather than in operating margins is responsible for the higher operating returns.

Since shareholders of the target firms in this sample earn on average a 45% return, the authors look at the relationship between this abnormal stock return and the increase in cash flow performance, and find a significant and positive correlation. They claim that "the abnormal equity returns ... are broadly consistent with the value increases implied by the post-merger cash flow return increases" (Healy, Palepu and Ruback, 1990, p. 21). In contrast to this positive performance effects, Caves in his review of the evidence on realised profits and productivity after mergers concludes that business units involved in mergers "on average suffer substantial declines in profitability and losses in market share" (Caves, 1989, p. 170). The differences among the two studies may be due to the different sample period (more recent in the former) and to different data source and measures of performance employed.

Since most studies of performance after mergers have failed to explain the positive stock market reactions with improvements in efficiency, other possible sources of gains to shareholders of takeover targets have been investigated. One of these alternative sources of gains can be transfers from other parties, such as employees, customers, and the Treasury (in the form of tax savings). These

transfers may be important in explaining the premium paid in a takeover: several studies have attempted to measure them and some have found that in a few cases the redistribution of wealth after a takeover can alone explain the whole premium paid. However, no significant pattern has emerged and, although redistributions may have important effects, they are rarely believed to be the main determinant of a takeover.

The last issue that we discuss in this review is the evidence on short-termism: this can be caused by myopia on the part of the market, or on the part of the managers. Jensen (1988) reports empirical findings which he interprets as evidence against short-termism on the part of the market. These are that: 1) price-earnings ratios differ among companies; 2) stock prices respond positively to increased investment expenditure announcements; 3) higher institutional holdings are not associated with decreases in R&D expenditure; and 4) firms with high R&D expenditure are not more vulnerable to takeovers. Also, he argues that if the market undervalues a company, maybe because it does not value correctly long-term projects (short-termism argument), then the acquiring company can offer a premium over the current price to the shareholders, and still have an incentive for the takeover. This argument has testable implications: companies which succeed in resisting a takeover should improve their performance in the long-run, and after the failed tender offer - once the information on undervaluation has been revealed - the price should not revert to pre-bid levels[38]. These predictions are the empirical implications of market myopia, or short-termism on the part of the stock market and have been tested in various empirical studies and rejected overwhelmingly[39].

The other, and possibly more important, form of short termism is managerial myopia, and this may be a consequence of takeover pressure: if shareholders are imperfectly informed, and form earnings expectations by looking at the current level of earnings, it is in the interest of managers who want to

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38 This holds only if the reason why the bid has subsequently failed is not the arrival of new information which shows that the firm is overvalued at the new price.

39 See Jarrel, Brickley and Netter (1988, p. 57) for references.

avoid a takeover at a low stock price, to invest in projects with lower net present value, but shorter horizon. Unfortunately, to date, there is no direct empirical evidence on the importance of managerial short-termism, also because the nature of the problem itself makes it difficult to observe: as noticed by Stein (1988, p. 76)

> "whether takeover pressure makes managers work harder or makes them behave more myopically, it must be true that a lot of the action, for better or for worse, occurs rather invisibly in companies that are never actually subject to bids".

The implications of managerial myopia are different from those of stock market myopia. With managerial myopia, long term projects and R&D would be performed, and valued, but only investment projects with high net present value (not just positive) would be undertaken.

2.2.2.3. Going Private Transactions, LBOs, and MBOs

Going private transactions are carried out by a group of investors, generally including the incumbent management, which buys all the shares of a company and withdraws it from public trading. Going private transactions which are financed by large amounts of debt are known as Leveraged Buyouts (LBOs), or Management Buyouts (MBOs) when the incumbent management takes part in the transaction.

The possible sources of gains in going private transactions are less evident than for mergers and takeovers. For example, synergy gains cannot be obtained by going private since only the ownership structure of the company is affected by the transaction; moreover, in an MBO the management of the company is not replaced, and any gains involved cannot be due to the replacement of an inefficient management. Wealth redistributions from bondholders, the Treasury, and employees could have an important role as they do for takeovers, as also savings from registration and listing fees: costs involved in shareholders' services may be substantial and include also the time that top

managers have to spend in activities related to publicly traded corporations. However, the main argument generally given of why MBOs result in a more profitable company are the improved managerial incentives.

We now look at the characteristics of companies proposing to go private, and at the consequences of their decisions on stock prices, productivity, and possible wealth transfers. In their sample of 72 firms which proposed to go private during the '70s, DeAngelo, DeAngelo and Rice (1984) find that the median management stake before the buyout was high (above 50%), the ratio of long-term debt to assets was low (12.6%), and the companies were fairly small. At the announcement of the buyout, the share prices increased by 22.3% on average, but companies withdrawing the going private proposal experienced later a stock price decrease of 8.9%[40].

The gains from an LBO may come from improved management efficiency for four reasons: 1) the substantial amount of debt can prevent misuse of free cash flow for projects with negative net present value; 2) managers have increased stakes in the company, and therefore more incentives not to shirk; 3) private companies may find it easier to adopt substantial compensation packages; 4) higher concentration of ownership increases the incentive for closer monitoring. All these reasons point to an increase in the performance of the company following a buyout.

Various studies, reviewed below, have found improvements in operating cash flow (before interest) and on returns on asset and cash flow per employee, both on a before and after tax basis.

Lichtenberg and Siegel (1990) study productivity changes after LBOs at the manufacturing establishment level. They identify 1108 LBOs which took place between 1981 and 1986 (35% of which are MBOs) out of the 20,493 establishments for which they have data, and look at total factor productivity, which is often regarded the most neutral measure of performance for a firm.

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40 The difference between the decrease and the previous gain may reflect a higher expectation of a new bid.

Plants involved in LBOs were more efficient than non-buyout plants, and continue to be more efficient for at least three years after the LBO; also, the difference between LBO plants and non-LBO plants is higher in the three years after the buyout than in three years preceding it, suggesting that buyouts are associated with increases in productivity. Moreover, the subsample of MBOs shows greater short-run productivity increases than LBOs.

Similar results are found by Smith (1990b) who investigates performance after 58 MBOs completed in the period 1977-1986; she finds that operating returns increase significantly from the year before to the year after the MBO. The author cannot relate increases in operating returns with cuts in employment or in R&D expenditure, but finds significant reductions in the industry-adjusted accounts receivable collection period (time allowed for paying bills) and the inventory holding period. She interprets the change in performance as due to the incentive effects of the change in ownership structure but offers an alternative explanation (which parallels a similar one about mergers): since managers have private information about the company's prospects, they exploit favourable information by buying the company before the information is revealed in the market (undervaluation hypothesis).

In her sample, management ownership and concentration of ownership increase substantially after the buyout: the median holding of officers, outside directors and other major shareholders changes from 35.5% to 95%; also financial leverage increases with the ratio of debt to book value of tangible assets increasing from a median of 0.59 pre-buyout to a median of 1.01 after the buyout. The incentive effect of an increased management ownership does not find support from the results reported in a previous version of the same paper where she regresses changes in performance on the change in the percentage of common stock held by outside directors, and finds no relationship among the two variables.

Hall (1991) has reviewed a series of empirical studies on the effects of two types of restructurings on the horizon of the investment decisions (short-termism). She focuses on two types of corporate restructuring: substantial increases in leverage (with or without a change in control), and takeovers. As a

measure of investment horizon, she employs the level of R&D expenditure and concludes that: 1) a large fraction of restructurings have little to do with investment horizons, and especially those which do not involve changes in financial structure have no effect on investment; 2) increases in debt are associated with decreases in investment of all kinds (not just R&D), but this decreased investment expenditure is an optimal response to the higher cost of capital given by the smaller free cash flow, and the necessity of raising capital at the higher real interest rates in the 80s.

Concluding, the evidence on LBOs shows that shareholders of LBO firms earn substantial returns; productivity and operating performance increase in the years immediately following a buyout and reductions in all types of investment occur in leveraged transactions, but this seems to be the optimal response to the higher cost of capital. The main reason for the improvements after an LBO is regarded to be the increased management ownership, but the proposition that management ownership *per se* increases productivity or profitability has never been tested: we will provide below *prima facie* evidence that the postulated positive incentive effects of managerial ownership are not easily found in the data.

In this review, we have seen that the available empirical evidence does not provide a clear picture of the relationship between managerial ownership of shares and performance: instead, it is often assumed that higher managerial ownership is associated with improved incentives, but no direct empirical evidence on this issue is provided. In the next sections we aim to provide such evidence by analysing the empirical relationship between managerial ownership of shares and votes and corporate performance.

2.3. Methodology and Data

In the present study, we focus on the empirical relationship between variables which capture special aspects of the separation between ownership and control and performance. The two measures of performance which we analyse are: market valuation, as expressed by Tobin's Q, and total factor productivity growth.

We use a panel dataset of 389 UK quoted companies[41] observed during the years 1972-86; the panel is unbalanced and comprises 3993 observations[42]. Firm-level data originates mainly from company accounts to which information on share prices is added; all companies in our sample have observations for the years 1979-81. Data were originally obtained by merging information from the Exstat dataset and the Datastream on-line service, and has undergone a thorough process of "cleaning" by various members of the Centre for Economic Performance. This original dataset has been supplemented by us with data on managerial ownership of equity and votes, and on voting concentration (collected by the author from various sources), and with the calculation of Tobin's Q for which data on market value of common equity and loan capital was also added.

The first variable which we have collected is the percentage of shares owned by the management of a company. Since in the UK there is no dataset which has consistent historical information on this variable, we had to obtain it from company accounts directly, or through old Extel cards[43]. Company accounts report the holdings of each director of the company (whether or not they are managers of the company), but, given the difficulty of identifying which of the directors were also managers, we adopted the assumption that

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41 This is a subset of the dataset collected at the Centre for Economic Performance, London School of Economics and Political Science.

42 For the sample selection procedure, the exact definitions of the variables used and the sources of the data, see the Data Appendix.

43 Extel is a private service which provides, at annual frequency, a series of cards summarising the information contained in company accounts.

management ownership could be effectively proxied by the ownership of the whole board of directors. For all 389 companies, we have collected data on the percentage of shares (OWNE) and votes (OWNV) owned by managers in the year 1981 or 1982, depending on availability. We report the frequency distributions of OWNE and OWNV in table 2.1.

The average (median) managerial ownership of shares in this sample is 16.8% (8.6%), while the average (median) managerial ownership of votes is 18.0% (10.0%). In companies with differential voting rights there is in general a substantial difference among managerial ownership of equity and votes, confirming for the UK the results found for a sample of 45 US companies by DeAngelo and DeAngelo (1985). In their sample, the median ownership of corporate officers and their families in companies with dual-classes of shares is 56.9% of votes and 24% of equity. In our case the values are 18.4% and 11.2%.

The second variable which we have constructed is the concentration of voting power in the 389 companies in our sample for each year that they appear in the dataset. In companies which have a one share-one vote equity structure, the concentration of voting power among equity holders is at its lowest, since a holder of equity claims has an equal percentage of votes. However, there are a number of companies which have an equity structure which departs form one share-one vote.

The possible sources of departures form one share-one vote that we have identified are:

1) the presence of two or more types of ordinary shares with identical rights to dividends and seniority, but with different voting rights (generally one class of shares has no voting rights at all), or shares with similar voting rights, but different rights to dividends;

2) the presence of preference shares with voting rights attached to them.

Table 2.1 Distribution of the percentage of shares and votes owned by management

Percentage	Frequency of OWNE	Frequency of OWNV
0-1	92	92
1-5	74	71
5-10	37	32
10-15	24	24
15-20	27	22
20-25	22	23
25-30	25	24
30-35	13	14
35-40	16	20
40-45	15	15
45-50	14	17
50-55	13	15
55-60	10	11
60-65	4	4
65-70	1	1
70-75	1	3
75-100	1	1
Total	389	389

Table 2.2 Number of companies with departures from one share-one vote

	1975	1980	1985
Non voting or differential voting equity	77	65	46
Voting preferred capital	71	68	61
Total number of companies	115	108	85

Note Some of the companies have both non-voting and voting-preferred equity capital.

In order to give an idea of the extent of the presence of differential voting rights among UK manufacturing companies, we report in table 2.2 the total number of companies in the EXSTAT dataset which had equity with differential voting rights in three years, 1975, 1980 and 1985, together with the source of the departure from one share-one vote.

The presence of shares with voting rights which causes departures from one share-one vote is a relatively common phenomenon in UK quoted companies. One of the reasons why in the UK the number of companies with differential voting rights appears to be higher than in the USA may be that in the UK a rule similar to the one which prevented companies without one share-one vote from listing their shares on the New York Stock Exchange, has never existed.

We now describe the construction of the variable VCON which measures the concentration of votes with respect to the equity capital of a firm. The concentration index has a value of zero for companies with one share-one vote, and a value of one if votes and equity are completely separated; for companies with departures from one share-one vote the index has been computed by means of a Lorenz Curve, as previously done in a similar context by Levy (1982).

In order to construct the index we have followed this rule: we have identified all sources of equity capital (rights to dividends) and all sources of

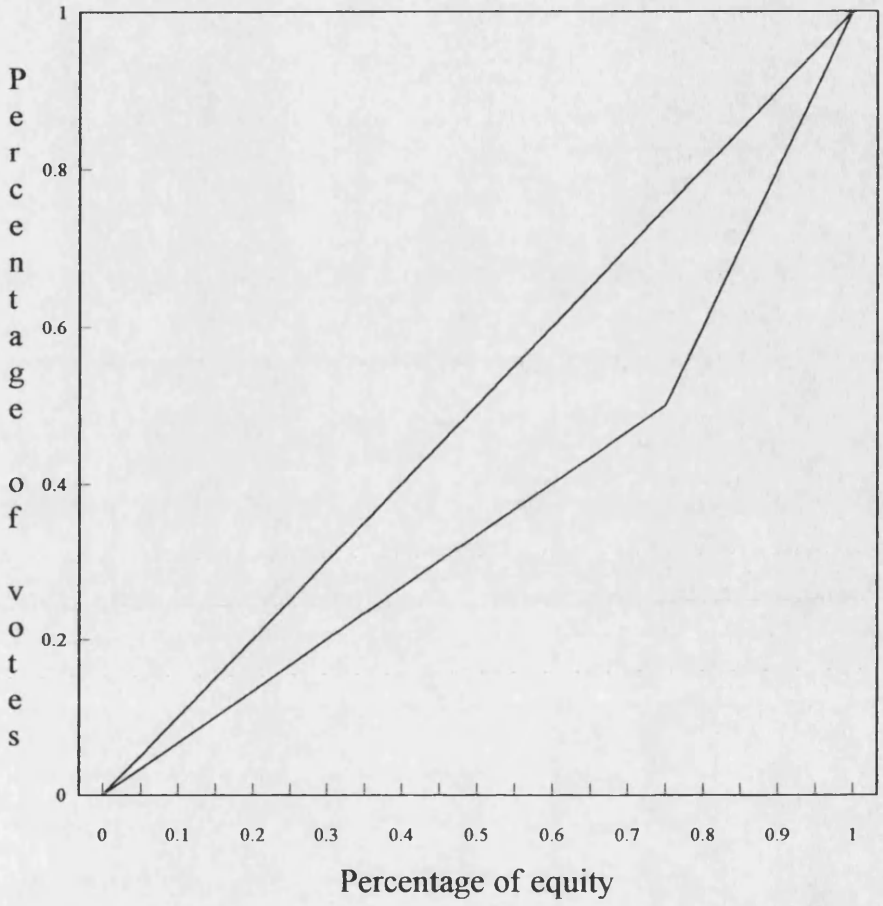
votes (excluding those voting rights which are exercisable only in certain circumstances) and have computed for each class of capital the percentage of the total votes and equity which it represents.

In the following cases we had to employ special assumptions: in the case of share capital with different dividend rights (such as deferred shares) we have imputed the amount of equity represented by such shares by comparing the share price of two classes with different dividend claims. For example, if a deferred share has a price equal to half of an ordinary share, the deferred share is considered equivalent, in amount of equity, to half of an ordinary share: if, as is often the case, deferred shares have the same voting power than ordinary ones, these would have higher voting rights per equity capital.

For preferred capital, which carries a fixed dividend, we have adopted the assumption that it does not represent equity, and is just like debt. This is in conformity with the practice in the UK where preferred capital is valued like debt, and not like equity. Although preferred capital may have some elements of equity, since part of it may be converted into ordinary shares at a later date (or if special circumstances arise), or may include some elements of participation in high earnings of a company, we believe that ignoring these equity elements introduces a smaller error than if we tried to account for them in an *ad hoc* way.

Once all the sources of equity and votes were identified, we constructed a concentration index by using the Lorenz curve method which involves constructing a curve as in Figure 2.1 (starting from the origin of the axis with the lowest votes-per-equity ratio) and then computing the ratio of the area between the curve and the 45° line, to the maximum area, which is 0.5. Figure 2.1 reports the construction of VCON for an hypothetical company which has two asset classes: one with 50% of the votes and 25% of the equity and the other with 50% of votes and 75% of equity. The voting concentration index in this example is VCON = (0.125/0.5) = 0.25.

Figure 2.1 Construction of VCON



The distribution of the voting concentration index (VCON) for our 389 companies is reported in table 2.3.

As can be seen from this table, although the great majority of companies have a concentration index equal to zero, 51 of them have a value higher than 0.001 and 32 have a value greater than 0.1[44]. We have also subdivided the companies with a voting concentration greater than zero into two groups: those

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44 Two companies in our sample, although with departures from one share-one vote, have a value of VCON less than 0.001.

Table 2.3 Distribution of the voting concentration index

VCON	Companies
0-0.001	338
0.001-0.01	9
0.01-0.1	10
0.1-0.2	5
0.2-0.3	3
0.3-0.4	4
0.4-0.5	3
0.5-0.6	2
0.6-0.7	0
0.7-0.8	5
0.8-0.9	6
0.9-1	4

with non-voting equity (NVOT=1), and those with voting preference (NEQ=1)[45].

In table 2.4 we report the median managerial ownership of shares and votes for companies in the whole sample and those with VCON>0. As can be seen from the table, companies with departures from one share-one vote have higher managerial ownership of shares and votes than the average company in our sample: this is due to the higher ownership stakes of managers of companies

45 There are two companies in our sample which have both non voting equity and voting preference shares.

with non voting shares. We would like to point out that the variable VCON is not in any way related to individual holdings: a value of VCON greater than zero allows the possibility that some shareholders own different proportion of shares and votes, but it does not say anything about actual holdings. What VCON determines, though is the upper limit to the separation of ownership of shares and votes.

Table 2.4 Median ownership of equity and votes held by management

Sample	Median OWNE	Median OWNV	Number of companies
VCON>0	11.22	18.43	53
NVOT=1	17.13	34	31
NEQ=1	3.48	3.84	24
Whole Sample	8.59	9.98	389

The companies in our dataset are classified according to 14 industry groups according to the 1980 SIC codes: these industries are reported in the Data Appendix. In table 2.5 we report the distribution of our companies in these industry groups and the distribution of those companies with departures from one share-one vote: we can see from this table that the phenomenon of departures from one share-one vote does not seem to be industry specific.

Finally, in table 2.6 we report some descriptive statistics for the companies in our dataset: the values refer to the year 1981 or 1982, depending on availability[46].

46 In all our cross section equations we include a dummy to allow for differences between 1981 and 1982.

Table 2.5 Industry distribution of companies

Industry	N companies	N companies with VCON>0	Percentage of companies
1	36	8	22.2
2	35	4	11.4
3	10	3	30
4	84	11	13.1
5	3	0	0
6	39	5	12.8
7	14	2	14.3
8	37	3	8.1
9	29	4	13.8
10	33	5	15.2
11	24	3	12.5
12	11	1	9.1
13	31	3	9.7
14	3	1	33.3
Total	389	53	13.6

Table 2.6 Descriptive statistics

	Employment	Capital	Value Added	Market Value
Sample Mean	4452	43391	40878	75530
Sample Median	842	4643	6417	7070

Note **Employment** is measured as number of employees, **Capital**, **Value Added**, and **Market Value** are expressed as thousands of 1972 UK pounds.

For the analysis of the effects on market valuation, we have estimated a cross-section regression, using for all 389 firms either the year 1981 or 1982, depending on availability, with Tobin's Q as the dependent variable. For the construction of the value of Tobin's Q we have followed Blundell, Bond, Deveraux and Schiantarelli (1988) and defined it as:

$$Q = \left[\frac{(MVE + TLC)}{((1 - DEP)RCC)} - 1 \right] \frac{PIPM}{WP}$$

where

MVE the market value of ordinary shares (voting and non-voting);

TLC the book value of debt;

RCC the replacement value of the capital stock

DEP depreciation (set here equal to 8%).

For the computation of the market value of a company, we have valued all ordinary capital at market prices[47]; debt has been entered at book prices, given

47 When prices were not available for non-voting shares, we have assumed that ordinary shares with the same rights to dividends had the same value. This is equivalent to assuming that voting rights do not have value in themselves.

the non-availability of market prices for it; and the replacement cost of capital has been computed with the technique explained in Wadhwani and Wall (1986)[48].

For the study of the effects on total factor productivity growth, we have estimated, on the whole panel, a productivity function of the Cobb-Douglas type, whose residual represents the relative productivity of the companies in the sample. Since companies may show different productivity levels for reasons that we cannot control for, such as the quality of the labour force employed, we decided to eliminate these firm-specific effects by estimating our equation in first differences: to the extent that these firm-specific effects are constant, they will disappear with the first differencing of all variables.

The production function which we have estimated has as the dependent variable the logarithm of the real value added, and as regressors the logarithm of employment and capital stock, with the addition of an industry-level variable representing the average hours worked during the year[49]. All the equations include, unless otherwise specified, industry and time (year) dummies. The value added variable has been proxied by adding the remuneration of the employees with the interest payments, the depreciation and amortization, and profits. Employment is the number of employees (domestic and overseas) and the capital stock is the same variable used for the replacement cost of capital.

Since the employment and capital variables are jointly determined with value added, causing a simultaneity problem for the estimation procedure, we estimate the equations using the generalised method of moments, described in Arellano and Bond (1991), which exploits the moments restrictions implied by the lack of correlation between lagged values of all the variables and the error term in the levels equation[50]. The lack of correlation is crucial to the estimation

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48 Details on all variables can be found in the Data Appendix.

49 The reason for the inclusion of this variable are detailed in Muellbauer (1987), together with an explanation of why we may expect a higher coefficient on the average hours worked than on the employment variable.

50 The estimations were carried out by using DPD (Dynamic Panel Data), a program written by Arellano and Bond (1988) in the Gauss programming language, which is available from Dr. S. Bond, Institute of Economics and Statistics, University of

procedure since this relies completely on that assumption: there are two possible tests for detecting such correlation. The first one, the m2 test proposed by Arellano and Bond (1991), is a test on the actual measure of second-order serial correlation of the residual in the differenced equation (we should have first order serial correlation in the differenced equation if the levels equation has an uncorrelated error); the second test is an indirect one since it tests the validity of the instruments (Sargan test) and so tests the consequences rather than the serial correlation itself.

Unfortunately, as we will see below, our basic equation exhibits second-order serial correlation, according to the m2 test, so there is the possibility of our estimates being inconsistent. We have dealt with this problem in two ways: one is to make sure that the instruments are not "invalid" according to the Sargan test, and the second is to estimate the same equation with a lagged dependent variable, and see if any of the conclusions differ, once the second order serial correlation disappears.

When presenting the results, we will report the two-step estimates, which is the most efficient of those proposed by Arellano and Bond (1991), and the corresponding heteroskedasticity consistent t-statistics. Arellano and Bond (1991) show, though, that the estimates of the standard errors obtained with the two-step estimates are biased downwards, so that the t-statistics tend to be biased upwards. We will indicate all the occasions in which the inference from one-step estimates (with heteroskedasticity consistent t-statistics) differ from the one presented.

We treat employment and capital stock as endogenously determined, and instrument them with their lagged values; for the employment variable, we employ all the moments restrictions implied by the lags from 2 to 5, while for the capital stock we employ only the lags 2 and 3 as instruments. All other endogenous variables, such as the lagged dependent variable and other firm-level variables, are instrumented with their second and third lag.

Oxford.

Table 2.7 Basic production function

Dependent variable LRVAD	Unrestricted	Constant returns to scale	Lagged dependent variable	Share of labour
Constant	-0.015 (-1.11)	-0.021 (-1.50)	0.019 (0.94)	-0.021 (-1.5)
LEMP	0.764 (11.36)	0.856 (15.49)	0.353 (6.04)	0.857 (2.27)
LCAP	0.040 (0.59)	0.144	0.063	0.143
LAHR	0.712 (2.57)	0.678 (2.32)	0.893 (2.01)	0.682 (2.32)
LRVAD(-1)			0.584 (18.56)	
SHARE				0.010 (0.02)
Serial correlation	-2.74	-2.81	-1.31	-2.81
Instrument validity	56.47 (45)	56.53 (46)	59.79 (47)	56.68 (47)
Number of Observations	2835	2835	2835	2835

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

In table 2.7 we report the results of the estimation of the basic production function, with and without the constant returns to scale restrictions, and with a lagged dependent variable. The dependent variable is LRVAD, the logarithm of the real value added, the regressors are time and industry dummies, LEMP, the logarithm of total employment, LCAP, the logarithm of the capital stock, and

LAHR the logarithm of the average hours worked.

As can be seen from the column 1 of table 2.7, the unrestricted production function shows decreasing returns to scale, with the sum of the coefficients of LEMP and LCAP equal to 0.804. This is surprising since the majority of empirically estimated production functions exhibit increasing returns to scale (König, 1992). A similar result has been obtained by Nickell, Wadhwani and Wall (1992) who employ a sample of 122 companies from the same dataset. We share their belief that the result of decreasing returns to scale is probably due to a poorly measured capital stock; in this case it is preferable to impose constant returns to scale at the outset. We impose constant returns to scale in column 2 of table 2.7, and this becomes our basic production function. In column 3 we add the lagged dependent variable which removes the second order serial correlation without altering the (long-run) coefficient on employment. Finally, in order to account for the possible heterogeneity among companies, which could result in different values of the elasticities, in column 4 we include the variable SHARE which represents the share of labour in value added. The coefficient on this variable is very small and insignificant, so we shall ignore it in the following analysis.

Essentially, we will test the importance of variables for productivity growth, by including them in the estimation of the production function. We could think of this "augmented" production function as the reduced form of a system of equations which includes a technological relationship (the production function) and other (unspecified) behavioural equations which are then substituted out.

2.4. Managerial Ownership of Shares and Performance

Managerial ownership of shares in the company they manage generates two important but contrasting incentive effects: on the one hand, it makes managers bear the consequences of their actions directly, while on the other, it enables them to entrench and insulate themselves from the market for corporate control. The former effect is due to the ownership by managers of residual claims to cash flow (equity), while the latter is given by their effective power to control which is mainly, but not exclusively, given by the ownership of votes. These two effects have not been separately studied in the empirical literature, mainly because the great majority of companies have a one share-one vote rule so that a certain percentage of shares is tied to the same percentage of votes. In this section we focus in particular on companies which have shares with differential voting rights, in order to identify these two different effects.

We also provide additional evidence on the relationship between managerial ownership and firm value which casts doubts on the various results already obtained for the US. This is particularly important, since, as we have seen in section 2.2, several studies on takeovers and leveraged buyouts give an increase in managerial ownership as the main explanation for the increase in value of the target company at the announcement of the restructuring.

2.4.1. Market Valuation

We start our empirical analysis of the relationship between market valuation, expressed by Tobin's Q, and managerial ownership of shares, by trying to replicate the results obtained for the US by Morck, Shleifer and Vishny (1988b), McConnell and Servaes (1990) and Hermalin and Weisbach (1987). These studies find a non-linear relationship among the two variables. Morck, Shleifer and Vishny (1988b) find that the relationship is piecewise linear: positive for managerial ownerships between 0% and 5%, negative between 5% and 25%,

and positive thereafter. McConnell and Servaes (1990) use instead a quadratic specification which implies that the relationship is positive between 0% and somewhere in the region of 35-50%, and negative thereafter. Hermalin and Weisbach (1987) find a positive relationship between 0% and 1%, negative between 1% and 5%, positive between 5% and 20% and negative thereafter.

The results for the US do not therefore seem to point towards any definitive conclusion. We report in columns 1 and 2 of table 2.8, the results for the UK by using the piecewise linear specification of Morck, Shleifer and Vishny (1988) (columns 1 and 2) and the quadratic of McConnell and Servaes (1990) (columns 5 and 6), plus a specification which includes dummy variables instead of levels (columns 3 and 4). The regressions are estimated by OLS using separately both the percentage of equity and the percentage of votes owned by managers. Columns 1, 3 and 5 refer to managerial ownership of equity while columns 2, 4 and 6 refer to managerial ownership of votes: the results are very similar among the two groups given the high correlation between managerial ownership of shares and votes. All equations include industry dummies and the 1981 dummy[51]. The variables in table 2.8 are defined as:

OWN 0-5	equal to managerial ownership when this is less than 5% equal to 5 otherwise;
OWN 5-25	equal to 0 if managerial ownership is less than 5%, equal to 25 if managerial ownership is greater than 25%, equal to the percentage of managerial ownership minus 5 in all other cases;
OWN 25-100	equal to 0 if managerial ownership is less than 25%, equal to managerial ownership less 25 in all other cases;
DM	equal to 1 if managerial ownership is between 5% and 25%, 0 otherwise;
DH	equal to 1 if managerial ownership is greater than 25%, 0 otherwise;
OWN	percentage of managerial ownership;
OWN2	the square of managerial ownership;

51 These variables already account for a R^2 of 17.21.

Table 2.8 Managerial ownership of equity and votes and Tobin's Q

Dependent Variable: Q	Equity	Votes	Equity	Votes	Equity	Votes
OWN 0-5	-0.02 (-0.99)	-0.02 (-0.92)				
OWN 5-25	0.01 (1.48)	0.01 (1.39)				
OWN 25-100	-0.01 (-2.38)	-0.01 (-2.33)				
DM			-0.04 (-0.44)	-0.05 (-0.51)		
DH			-0.04 (-0.62)	-0.04 (-0.65)		
OWN					0.42 (0.92)	0.36 (0.81)
OWN2					-1.09 (-1.48)	-0.97 (-1.36)
R^2	18.2	18.16	17.30	17.31	17.74	17.73

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

The first column of table 2.8 reports the results obtained in our sample for the specification of Morck, Shleifer and Vishny (1988), but our results are exactly opposite: a negative relationship between 0% and 5%, a positive one between 5% and 25%, and a negative one thereafter. In column 2 we estimate the same specification, but now with the percentage of votes rather than equity, and we obtain a similar result to column 1. When we employ the specification with dummies the results are insignificant. Furthermore, the quadratic specification of McConnell and Servaes (1990) fails to give significant parameter estimates.

These results clearly show that none of the previous results obtained for the US is replicable for the UK, although there seems to be a tendency of Q to be smaller and decreasing for high values of management ownership of equities and/or votes. However, there are no theoretical justifications for such an effect since, for ownership levels greater than 50%, the possibly negative effect of entrenchment should already be present in full, since control is completely in the hands of management (in practice, 25-30% is the level of managerial ownership which guarantees control), while the effect of the higher association of ownership and control should be monotonically increasing.

One way of disentangling the effect of managerial ownership of equity from the one of ownership of votes, is to look at what happens when managers own a different amount of equity and votes. In order to do this we run a regression of Q on the difference between votes and equity ownership by the management divided by their equity holding (OWNDIF). table 2.9 reports the result of the simple regression of Q on OWNDIF: this suggests that there is a negative relationship between the extent to which votes owned by managers are not "covered" by holdings of equity. In order to see if this result may be due to other factors which have an influence on Q, we add to the regression other variables to try and capture these effects.

The reason for introducing other explanatory variables is that empirical measures of Q cannot easily incorporate the value of the intangible capital the company has accumulated by means of, for example, brand names and reputation, or by the development of patents and know-how. To the extent that these factors are industry-specific, they will be captured in the industry dummies, but a lot of variation is still expected to be present within industries. The variables generally used to try and capture the value of the intangible capital are advertising expenditure and R&D. Unfortunately, these data are not available for UK companies for our sample period[52], so we enter size (the logarithm of the replacement cost of assets, LRCC) as an additional regressor, in order to capture at least that part of the intangible capital which varies with size. We also enter the

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52 Only recently it has become compulsory to disclose R&D expenditure.

amount of total loan capital as a percentage of assets (PTLC) as a measure of free cash flow: a higher loan capital means that less cash is left at the discretion of the managers. In a separate robustness exercise, we include the growth rate of the labour force (GROWTH) measured as the growth in the previous three years to take into account different growth prospects which may also influence Q.

Table 2.9 Difference between equity and votes ownership and Tobin's Q

Dependent Variable: Q	Basic equation	Include controls	Include growth	PRATE as Dep. Var.
OWNDIF	-0.96 (-2.59)	-0.99 (-1.93)	-0.97 (-1.89)	-1.68 (-2.45)
PTLC		0.25 (1.81)		
LRCC		-0.11 (-2.99)		
GROWTH			0.53 (4.06)	
R^2	17.82	18.73	21.48	14.06

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

The negative effect of OWNDIF is still present even after entering size and loan capital. Size is negatively correlated with Q while the loan capital seems to have a positive effect, possibly because of the incentive effects of debt. The result is robust to the use of the profit rate (PRATE) in place of Q as the dependent variable.

Leech and Leahy (1991) find, in a sample of 470 UK listed companies, that ownership controlled firms (defined with regard to the distribution of equity

ownership) are profitable and fast growing: in particular, they find a positive relationship between ownership control and profit margins, the rate of returns on shareholders' capital, rate of sales growth and the rate of growth of assets. Leech and Leahy, however, do not identify whether managers own shares or not, indeed they define as management controlled firms those which they cannot classify as ownership controlled, so a direct comparison with our results is not possible.

Managerial ownership of shares, when accompanied by an equal percentage of votes, does not seem to matter for market valuation; this casts doubts on the usual explanation given for the increase in market valuation following a takeover or a buyout. Our results suggests that it is not so much the amount of equity in the hands of managers that is important, but the inequality in the amount of equity and the amount of votes owned or controlled by them. Our econometric analysis suggests that the value of Q in our sample is lowered by an amount of up to 0.17 due to the disparity between equity and votes.

2.4.2. Productivity Growth

We now look at the effects of managerial ownership of equity and votes on productivity growth. In table 2.10 we report the estimates of our basic production function with the addition of variables measuring the amount of equity and votes owned by managers.

It should be stressed that a limit of this analysis is that data on management ownership has been collected for only one year so that implicitly we are assuming that management ownership has remained constant at the 1981-82 level for the whole time a company is present in the sample. This may seem a strong assumption and is likely to introduce noise in the results; however, managerial ownership is generally believed to be quite a sticky variable, and one study by Mikkelson and Partch (1989, p. 287) for the US finds that in a sample of 240 firms

> "[t]here is considerable variation in managers' voting stakes across firms: but little variation over time for most firms. The absolute value of the change over five-year intervals in the proportion of votes controlled by

officers and directors is less than 10% of outstanding votes for approximately 85% of our observations".

The variables that we use to capture the effects of managerial ownership are: first, the percentage of ownership of equity (OWNE), and then two dummies (DME and DHE) respectively 1 if OWNE is between 5% and 25%, and 25% and 100%. The results show that there is a positive, although not significant effect of managerial stakes between 5% and 100%, with the significance of the coefficient reduced substantially in the one-step estimate (not reported) for both column 1 and 2[53].

In column 3, we look at the disparity between equity and vote ownership by including in the basic equation the variable OWNDIF. The results suggest a strong (up to 3% per annum in our sample) and significantly negative relationship between OWNDIF and productivity growth. The result is still present when we also include OWNE (column 4) and when we interact OWNE and OWNDIF (not reported).

We now perform a variety of robustness tests of our functional specification to see if the result still holds when we relax certain restrictions, and when we include other variables which have been shown to have an effect on productivity growth: these are variables which represent product market, labour market, and financial effects.

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53 Results for the ownership of votes are very similar to the previous ones, since OWNE and OWNV are highly correlated, and are not reported.

Table 2.10 Managerial ownership of equity and productivity growth

Dependent Variable: LRVAD				
LEMP	0.844 (15.3)	0.827 (14.7)	0.850 (15.4)	0.838 (15.2)
LCAP	0.156	0.173	0.150	0.162
LAHR	0.676 (2.30)	0.675 (2.30)	0.679 (2.32)	0.674 (2.30)
OWNE	0.0001 (0.84)			0.0001 (0.76)
DME		0.008 (1.73)		
DHE		0.004 (0.81)		
OWNDIF			-0.222 (-2.52)	-0.215 (-2.42)
Serial correlation	-2.81	-2.81	-2.82	-2.81
Instrument validity	57.5 (46)	57.6 (46)	56.6 (46)	57.7 (46)

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

In table 2.11, we report various robustness exercises: in column 1 we report the estimation of our basic equation with the lagged dependent variable; in column 2 we relax the constant returns to scale assumptions; in column 3 we estimate the equation without industry dummies, while in column 4 we include three digit industry dummies[54], and in column 5 estimate the equation with OLS.

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54 These classify our sample into 42 different industries. See the Data Appendix for

Table 2.11 Robustness tests of basic specification

Dependent Variable: LRVAD	Add lagged dependent variable	No constant returns to scale	No industry dummies	Three digits industry dummies	OLS
LRVAD(-1)	0.585 (18.6)				
LEMP	0.348 (5.92)	0.751 (11.1)	0.703 (11.5)	0.883 (16.4)	0.813 (22.9)
LCAP	0.067	0.040 (0.589)	0.297	0.117	0.187
LAHR	0.877 (1.97)	0.715 (2.59)	0.886 (3.11)	0.664 (2.25)	0.848 (2.46)
OWNDIF	-0.175 (-3.13)	-0.261 (-3.17)	-0.305 (-3.36)	-0.220 (-1.60)	-0.238 (-2.26)
Serial correlation	1.30	-2.784	-2.493	-2.947	-2.815
Instrument validity	58.7 (47)	56.4 (45)	57.1 (46)	56.7 (46)	

Note t-statistics are computed with heteroskedasticity consistent standard errors.

In table 2.12 we report a further series of tests. In column 1 we add to our basic specification variables which represent the market structure in which the company operates[55]: MKSH is the market share of the company, which is included both as a level and in difference form (DMKSH); CONC is the 5-firm concentration ratio; and IMP is import penetration by industry. The controls are

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further information.

55 See Nickell, Wadhwani and Wall (1992) for a comprehensive analysis of the influences of market, labour, and financial effects on productivity growth.

insignificant with the exception of import penetration which seems to have a negative effect on productivity growth.

In column 2 of table 2.12 we report the results obtained with the inclusion of variables which pick up labour market effects and financial effects. These are respectively: UDEN which is the union density by industry, and BR, the borrowing ratio at the beginning of the period (which is also included in difference form, DBR) which measures the financial pressure and the availability of "free cash flow". We also include a small-firm dummy, SMDUM, which is equal to 1 if the average employment during the years 1979-1981 is less than 1000 employees. This regression again shows the robustness of our basic result, and also confirms previous results (Nickell, Wadhwani and Wall, 1992) that financial variables have an important effect on productivity levels and growth.

In column 3 of table 2.12 we add a term to obtain a second order approximation of a CES (constant elasticity of substitution) production function. The CES term is positive and significant, but this does not alter our basic result. In Column 4 we estimate the basic equation with instruments dated t–3 or earlier which are more likely to be uncorrelated with the error term, but this does not change our conclusions; finally, in Column 5 we use the logarithm of real sales LRSLS as the dependent variable. All the equations in table 2.12 therefore confirm our basic result.

Table 2.12 Additional robustness tests

Dependent Variable: LRVAD	Add market structure variables	Add labour and financial variables	Constant elasticity of substitution	Instruments dated t-3 or earlier	LRSLS as dependent variable
LEMP	0.851 (15.2)	0.832 (15.7)	0.987 (9.92)	0.790 (20.3)	0.850 (15.4)
LCAP	0.149	0.168	0.013	0.210	0.150
LAHR	0.679 (2.32)	0.735 (2.51)	0.705 (2.42)	0.701 (2.35)	0.679 (2.32)
OWNDIF	-0.207 (-2.32)	-0.269 (-3.01)	-0.226 (-2.63)	-0.179 (-2.39)	-0.222 (-2.52)
MKSH	-0.035 (-0.73)				
DMKSH	0.833 (0.49)				
CONC	-0.012 (-0.43)				
IMP	-0.068 (-2.47)				
BR		0.027 (4.56)			
DBR		0.021 (3.66)			
SMDUM		0.002 (0.45)			
UDEN		-0.060 (-1.53)			
CES			0.071 (2.05)		
Serial Correlation	-2.84	-2.78	-2.70	-2.84	-2.82
Instrument validity	56.8 (46)	55.7 (46)	59.3 (47)	61.39 (50)	56.6 (46)

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

As with the results on Q, we have a strong negative relationship between the disparity between shares and votes which is robust respect to a variety of tests.

We have seen that, subject to the assumption on the constancy in managerial holdings of shares during our sample period, the disparity between

equity and votes in the hands of management has a strong negative effect on productivity growth. Managerial ownership of shares also seems to have a positive effect on productivity growth, with companies which have managerial ownership above 5% exhibiting a productivity growth about 1% higher than the rest: the results are, however, not significant and deserve further investigation[56].

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56 For example, Tsetsekos and DeFusco (1990), by constructing portfolios according to managerial ownership and controlling for size, have found that managerial ownership does not have an effect on portfolio returns.

2.5. Voting Rights and Performance

Two theoretical papers (Grossman and Hart, 1988; Harris and Raviv, 1988) have recently addressed the question of the importance of one share-one vote rule for the share capital of a firm, and derived conditions for its optimality.

Grossman and Hart (1988) focus on the takeover mechanism and show that one share-one vote encourages the selection of the best team, even if in some instances departures from one share-one vote can achieve a higher return for shareholders, since this would allow them to extract a higher price from the acquiring party in a takeover. The authors argue, however, that the return of this "surplus extraction" is likely to be small so that the market value of the firm is generally maximised with one share-one vote. Grossman and Hart (1988) show also that the conditions under which one share-one vote maximises the value of the firm are that private benefits to control must be small in relation to security benefits.

Harris and Raviv (1988), employing somewhat different assumptions, show that a simple majority rule (50% of votes in a control contest) coupled with one share-one vote constitutes a socially optimal structure; dual classes of shares may nevertheless increase shareholders' wealth, since they increase the possibility of extracting the benefits of control from the winning candidate in a contest, although this may lead to an inferior management taking control. For Harris and Raviv (1988), however, the total market value of shares with unequal voting rights is predicted to be higher than with one share-one vote; in fact, the complete separation of equity and votes maximises the value of the firm in the short run.

The effect of departures from one share-one vote depends, in both papers, on the relative importance of extracting part of the benefits from the winning candidate, and the probability that a worse team wins the contest: the overall effect is essentially an empirical issue. We do not know of any previous study with empirical evidence on the relationship between the value or the performance of a firm, and the presence of dual classes of shares; as we will see later, the evidence presented here tends to favour one share-one vote structures,

and implicitly attributes to voting structures with dual classes of share the role of keeping an inefficient management in power.

We will be analysing below the relationship between voting concentration and two measures or performance, Tobin's Q and total factor productivity growth.

2.5.1. Market Valuation

We have seen in the previous section that the disparity between equity and votes in the hands of management has a negative effect on market valuation, as expressed by Tobin's Q; we want to see now if the conclusion is still present when we consider voting concentration in general, not just the stakes owned by management.

Several previous studies have estimated the value of voting rights by computing the difference between the price of shares with and without voting rights[57]; although these studies conclude that voting rights are valuable, since they generally carry a positive price, they are not able to answer the question of whether the existence of differential voting rights also affects the market value of the firm, and not just its distribution among the various types of shares.

We have, therefore, analysed the relationship between Q and the concentration of voting power in the security structure of the companies in our dataset. We have first run a regression of Q on VCON, the value of the our voting concentration index: the results in table 2.13 show that this variable has a negative and significant coefficient which suggests that a company with a complete separation of equity and votes has a value of Q which is 0.178 lower than the average company[58] (the sample average for Q is 0.24).

Subsequently, in order to allow for possible non-linearities, we have run the regression with two dummies: the dummy VDM takes the value of 1 if

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57 See Levy (1982) for example.

58 All regressions include industry dummies, unless specified.

VCON is greater than 0 but less than 0.1; while VDH is equal to 1 when VCON is greater than 0.1. The number of companies with VDM=1 is 19 and with VDH=1 is 32. The results in table 2.13 show that the two variables have negative, although not highly significant coefficients; also, as expected, the coefficient of VDH is greater in magnitude than the coefficient of VDM. In a separate regression, we include two dummies to allow for a different effect depending on the origin of the departure from one share-one vote, whether the presence of non voting equity, NVOT=1, or the presence of non equity (such as preference shares) with voting rights, NEQ=1. The results of the regression including this classification also show a negative, but not highly significant relationship.

Table 2.13 Concentration of voting rights and Tobin's Q

Dependent Variable: Q	Voting concentration	Voting concentration dummies	Source of differential voting
VCON	-0.178 (-1.96)		
VDM		-0.078 (-1.67)	
VDH		-0.118 (-1.54)	
NVOT			-0.12 (-1.53)
NEQ			-0.06 (-1.44)
R^2	17.4	17.5	17.5

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

We now add the usual regressors for robustness tests and report the results in table 2.14. The effect is still present after the inclusion of both the total loan capital as a percentage of assets (PTLC) and of the logarithm of the replacement cost of assets (LRCC). The same applies to the inclusion of the growth rate of the labour force (GROWTH).

Table 2.14 Concentration of voting rights and Tobin's Q: robustness tests

Dependent Variable: Q	Include controls	Include growth	PRATE as Dep. Var.
VCON	-0.19 (-2.13)	-0.19 (-2.11)	-0.12 (-1.27)
PTCL	0.245 (1.82)		
LRCC	-0.114 (-3.04)		
GROWTH		0.53 (4.06)	
R^2	18.95	21.70	14.10

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

In the last column of table 2.14, we have also experimented using the profit rate as dependent variable. Although the result is not significant, it points in the same direction as the previous one, with VCON having a negative effect on the profit rate.

2.5.2. Productivity Growth

We investigate now the relationship between voting concentration and total factor productivity growth. In table 2.15 we report the results for the inclusion in the production function equation of VCON; of the two dummies VDH and VDM (which are equal to one respectively if VCON is greater than 0.1, and between 0 and 0.1) and of NVOT and NEQ.

In column 1 of table 2.15 we report our basic production function with the addition of the variable VCON estimated for the sample of 389 companies; for this particular set of regressions, however, we do not need data from Datastream, so we can use the larger sample of 814 companies[59]. Therefore, in column 2 we report the results of the same regression estimated with the larger sample. The results do not differ greatly (apart from the coefficient on LAHR), and we do not report estimations with the larger sample any longer.

From the results in table 2.15 we see that all variables representing voting concentration attract negative coefficients, although they are not always significant. In particular, in columns 1 and 2 VCON has a negative coefficient, although its significance is low. In column 3 the dummy VDM, which represents intermediate concentrations not too far from zero (those between 0 and 0.1) has a coefficient bigger in magnitude and more significant than the dummy VDH. This is hard to justify in terms of voting rights concentration. Also, from column 3 we see that the stronger effect comes form companies which issue preference shares with voting rights, which are generally associated with smaller departures form one share-one vote.

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59 See the data appendix for details about the construction of the sample.

Table 2.15 Voting concentration and productivity growth

Dependent Variable: LRVAD	Basic equation	Large sample		
LEMP	0.855 (15.5)	0.894 (16.4)	0.851 (15.4)	0.851 (15.5)
LCAP	0.145	0.106	0.149	0.149
LAHR	0.673 (2.30)	1.132 (4.57)	0.675 (2.31)	
VCON	-0.009 (-1.11)	-0.010 (-1.35)		
VDM			-0.019 (-2.41)	
VDH			-0.009 (-1.69)	
NVOT				-0.009 (-1.75)
NEQ				-0.019 (-2.36)
Serial correlation	-2.81	-3.79	-2.82	-2.83
Instrument validity	56.8 (46)	52.3 (46)	56.9 (46)	56.9 (46)

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

Table 2.16 Robustness tests of basic specification

Dependent Variable: LRVAD	Add lagged dependent variable	No constant returns to scale	No industry dummies	Three digits industry dummies	OLS
LRVAD(-1)	0.585 (18.5)				
LEMP	0.352 (5.96)	0.763 (11.3)	0.708 (11.6)	0.890 (16.5)	0.813 (22.9)
LCAP	0.063	0.040 (0.59)	0.292	0.110	0.187
LAHR	0.893 (2.01)	0.707 (2.55)	0.887 (3.11)	0.660 (2.24)	0.851 (2.47)
VCON	-0.001 (-0.11)	-0.008 (-0.98)	-0.008 (-0.82)	-0.009 (-1.10)	-0.004 (-0.42)
Serial correlation	1.30	-2.7	-2.49	-2.94	-2.81
Instrument validity	59.8 (47)	56.6 (45)	57.2 (46)	57.1 (46)	

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

In Tables 2.16 and 2.17 we investigate the robustness of the result of the basic specification which includes VCON. The sign on the coefficient of VCON remains negative in all regressions without becoming significant.

In summary, the evidence of a negative relationship between voting concentration and total factor productivity growth remains very weak. This does not imply that voting concentration is not related to productivity levels. Unfortunately, it is not possible to make any inference on productivity levels with our dataset since we need to difference the variables in order to eliminate firm-

specific effects, and the first difference of VCON does not contain much information in our sample since very few firms make changes to their equity structure which influences voting concentration.

Table 2.17 Additional robustness tests

Dependent Variable: LRVAD	Add market structure variables	Add labour and financial variables	Constant elasticity of substitution	Instruments dated t-3 or earlier	LRSLS as dependent variable
LEMP	0.854 (15.3)	0.837 (15.8)	0.988 (9.93)	0.792 (20.4)	0.684 (11.3)
LCAP	0.146	0.163	0.012	0.208	0.316
LAHR	0.672 (2.30)	0.733 (2.50)	0.700 (2.40)	0.700 (2.34)	0.768 (2.98)
VCON	-0.011 (-1.31)	-0.008 (-0.97)	-0.008 (-0.95)	-0.006 (-0.89)	-0.010 (-1.60)
MKSH	-0.036 (-0.74)				
DMKSH	0.704 (0.41)				
CONC	-0.01 (-0.35)				
IMP	-0.07 (-2.56)				
BR		0.026 (4.45)			
DBR		0.021 (3.68)			
SMDUM		0.003 (0.65)			
UDEN		-0.060 (-1.52)			
CES			0.068 (1.98)		
Serial correlation	-2.84	-2.77	-2.70	-2.84	-1.53
Instrument validity	57.0 (46)	56.1 (46)	59.5 (47)	61.3 (50)	54.5 (46)

Note t-statistics, computed with heteroskedasticity consistent standard errors, are shown in parenthesis.

2.6. Conclusions

In this chapter we have analysed the incentive effects of managerial ownership of shares and votes, and of the concentration of voting rights, in a panel of 389 UK quoted companies observed in the years 1972-86, of which 53 exhibit a departure from a one share-one vote security structure. The departures from one share-one vote allow us to estimate the effects of equity and vote ownership separately: we have found that some of these effects are present and important for both measures of market valuation and productivity growth.

The result that, in our sample, managerial ownership of shares is not related to market valuation, as expressed by Tobin's Q, casts doubts on the usual explanation of greater convergence of interests given for the increase in market value following a takeover or a buyout which results in a higher percentage of shares in the hands of the management. Managerial ownership of shares seems however to have a positive effect on productivity growth, even if our estimates are not highly significant.

The disparity between equity and votes ownership has, instead, a strong and negative effect both for market valuation and productivity growth, when managers own more votes than equity claims: this is probably due to the power that vote ownership has of entrenching management and insulating it from the market for corporate control, and the lack of the convergence of interests due to the lower equity holdings. When equity and votes are held in the same proportion, the two effects on market valuation seem to balance out.

Departures from one share-one vote allow any shareholder, not just managers, to choose different proportions of equity and votes, so we have used a measure of voting concentration to assess the impact of dual-classes security structures on the total market value of the firm. Positive values of voting concentration have a negative effect on market valuation and a possibly negative effect on productivity growth, providing further evidence that the incentive effects of equity and vote ownership are present and important.

Although further work on particular aspects of the separation of ownership and control is necessary, especially about the relationship between management ownership and productivity growth, we believe that the evidence presented here allows us to conclude that managerial ownership of votes generally leads to lower market-valuation and productivity, unless it is accompanied by an equal amount of equity.

2.7. Data Appendix

2.7.1. Sample Selection

We started our sample selection from the Exstat database which, in the version available at the London School of Economics, has a sample of around 1800 UK manufacturing companies. For these companies the data has been checked and "cleaned" by various members of the Centre for Economic Performance, leaving a sample of 814 companies with at least four continuous years of data, which was our starting point. For all of these companies we checked whether they were also included in the Datastream service, where price data are available, and we found over 500 companies (Datastream has also data for dead companies). For each of those we then tried to get data on managerial ownership of shares and votes, from various sources. This left us with a sample of 389 companies for which a full dataset was available.

Below, we report the exact definitions and sources of the variables employed in this study. Items starting with a C are obtained from the EXSTAT dataset, while those starting with a D come from Datastream. Industry level variables were already included in the dataset of the Centre for Economic Performance.

BR	Borrowing ratio (D733)
CES	$(LEMP-LCAP)^2$
CONC	Five firm concentration ratio (Industry specific) Source: *Census of Production*, summary tables
DBR	First difference in BR
DEP	Depreciation for plants and machinery: set at 8%

DH	1 if managerial ownership (equity or votes) is greater than 25% 0 otherwise
DHE	Same as DH, but referred only to ownership of equity
DM	1 if managerial ownership (equity or votes) is between 5% and 25% 0 otherwise
DME	Same as DM, but referred only to ownership of equity
DMKSH	First difference in MKSH
GROWTH	Growth rate of the labour force in the previous three years
IMP	Import penetration: ratio of import to home demand (Industry specific) Source: *Business Monitor*
LAHR	Logarithm of average hours worked (Industry specific) Source: *Department of Employment Gazette*
LCAP	Logarithm of the capital stock constructed as described in Wadhwani and Wall (1986) Source: Centre for Economic Performance
LEMP	Logarithm of total employment (C15+C17)
LRCC	Logarithm of RCC
LRVAD	Logarithm of the real (deflated with WP) value added VAD defined as wages (C16+C18), plus profit sharing (C72), plus profits before tax (C34), plus depreciation (C52), plus interest payments (C53+C54)
MKSH	Market share computed as the percentage of sales (C31) of a company to total sales in the industry (the number of firms in each industry is kept constant over the years)

MVE	Market value of all ordinary equity (including non-voting) plus deferred capital (D302) and preference capital (D306) Source: Datastream, when available, otherwise London Share Price Database
NEQ	1 for those companies which have preference shares with voting rights 0 otherwise
NVOT	1 for those companies which have ordinary capital which carries partial or no voting rights 0 otherwise
OWN	Percentage of managerial ownership (same as OWNE)
OWN 0-5	Managerial ownership (in percentage) when this is less than 5% 5 otherwise
OWN 25-100	0 if managerial ownership is less than 25% percentage of managerial ownership minus 25 in all other cases
OWN 5-25	0 if managerial ownership is less than 5% 25 if managerial ownership is greater than 25% percentage of managerial ownership minus 5 in all other cases
OWN2	square of managerial ownership ($OWNE^2$)
OWNDIF	$\frac{(OWNV - OWNE)}{OWNE}$
OWNE	Percentage of equity owned by company directors Source: obtained by the author from company accounts, Extel cards, and the International Stock Exchange Yearbook
OWNV	Percentage of votes owned by company directors Source: same as OWNE
PIPM	Price index for plant and machinery Source: *Price Indices for Current Cost Accounting* HMSO

PRATE	Profit rate. Cash flow (D136+D137) divided by RCC
PTLC	$\frac{TLC}{RCC}$
Q	$\left[\frac{(MVE + TLC)}{((1-DEP)RCC)} - 1\right]\frac{PIPM}{WP}$
RCC	Capital stock (CAP) converted into nominal terms with WP
SHARE	Share of labour costs in value added defined as wages (C16+C18) divided by VAD
SMDUM	1 if average employment in the years 1979-1981 was less than 1000 employees 0 otherwise
TLC	Book value of debt; total loan capital (D321)
UDEN	Union density (Industry specific) Based on data from the Workplace Industrial Relations Survey interpolated and extrapolated using the aggregate data from the *Department of Employment Gazette*
VCON	Concentration of voting rights (construction explained in section 3) The data on all the types of shares issued by companies is taken from the D record of the Exstat dataset, together with the voting rights of each share. Prices for the securities were obtained from Datastream, when available, otherwise from the London Share Price Database. All departures from one share-one vote have also been verified in the International Stock Exchange Yearbook
VDH	1 if VCON> 0.1 0 otherwise
VDM	1 if 0<VCON<0.1 0 otherwise

WP — Wholesale prices (Industry specific): producers' price indices taken from *Trade and Industry* until 1979, thereafter *British Business* and unpublished data from the Business Statistical Office

The Exstat dataset reports the industrial classification of the Stock Exchange and the Institute and Faculty of Actuaries. The industry level data, however, is available for the classification according to the Department of Trade and Industry's Standard Industrial Classification (SIC). Therefore, we had to match the 42 Exstat industries to the SIC ones. Below we report the fourteen SIC 1980 industries and the corresponding Exstat industrial classifications used in our study.

1. Food, Drink and Tobacco (49, 50, 46, 45, 63)
2. Chemical Industry (16, 67, 68, 37, 66)
3. Metal manufacturing (26, 33)
4. Mechanical Engineering (22, 23, 24, 25, 27, 29)
5. Instrument Engineering (31)
6. Electrical and Electronic Engineering (19, 36, 39)
7. Manufacture of Motor Vehicles and Parts Thereof (41, 43)
8. Manufacture of Metal Goods not elsewhere specified (20, 21, 28, 32, 34)
9. Textile Industry (61, 61, 62)
10. Footwear and Clothing (59, 64)
11. Manufacture of Non-Metallic Mineral Products (12, 14, 15)
12. Timber & Wooden Furniture (38)
13. Paper & Paper Products, Printing & Publishing (52, 53, 54)
14. Other Manufacturing (65)

3.

Technical Analysis

This chapter comprises three essays, written by Prof. C.A.E. Goodhart[60] and myself, on the behaviour of prices in financial markets and on the ability of technical analysis to predict their future movements.

'Technical analysis' generally refers to the use of technical (mathematical) rules for the forecasting of prices, employing as only inputs past values of the price series. The main difference between technical analysis and econometric time-series modelling is the absence in the first one of any statistical test in support of the relationships uncovered, which are generally simply 'backtested' on past data[61]. Chartism, the study of charts and patterns, is also considered a part of technical analysis, although it involves subjective judgement.

Notwithstanding the lack of statistical support for the forecasting power of technical analysis, its use is widespread in the financial community. A recent survey on the use of technical analysis and chartism in the foreign exchange market, conducted under the auspices of the Bank of England, found that technical analysis is indeed widely used in London[62] as one of the main inputs of tactical allocation decisions:

> One of the clearest results of the questionnaire survey was that chart analysis appears to exercise its greatest influence when dealers are formulating forecasts or trading decisions concerning relatively short time horizons ... At the shortest horizon (intraday to one week) approximately 90% of respondents reported using some chartist input when forming their exchange rate expectations, with 60% judging charts to be at least as important as fundamentals. At longer forecast horizons, of one to three months or six months to one year, the weight given to fundamentals increases. At the longest forecast horizons of one year or longer, the skew towards fundamentals is most pronounced, with around a third of respondents relying on pure fundamentals and some 85% judging fundamentals to be more important than charts. (Taylor and Allen, 1992, pp. 308-309)

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60 Prof. C.A.E. Goodhart is Norman Sosnow Professor of Banking and Finance and a co-director of the Financial Markets Group at the London School of Economics and Political Science.

61 Backtesting a technical trading rule means computing the net profits that the rule would have generated if applied to a historical time series of data.

62 In 1988, the time of the survey, London was, and continues to be, the largest foreign exchange market.

The potential importance for the determination of asset prices of this sizeable number of chartism followers is beginning to be appreciated. Frankel and Froot (1990a, 1990b) analyse the path of the US dollar in the 1980s as the outcome of an interplay between those following fundamental analysis and those following technical analysis; however they make no attempt in these studies to examine what technical analysts might actually have been predicting. Instead, they make the working assumption, for the purpose of their model, that technical analysts assume that foreign exchange spot prices would remain constant.

Technical analysts have, in fact, been viewed by economists as being effectively 'noise' traders, about whose effects in asset markets there is now a large amount of theoretical literature (Campbell and Kyle 1988, De Long et al 1990); virtually no empirical evidence has been collected, however, of how successfully, or badly, technical analysts perform.

How, and why then, did technical analysis continue to be used, and people make a living by developing, operating and selling it? Economics textbooks generally dismiss technical analysis as inconsistent with the working of efficient markets, and hence of no value[63], without asking how technical analysts are able to stay in business. Perhaps the most common view among economists is that there will always be openings for plausible quacks, and soothsayers, even when they really know nothing. In such cases the market price will tend to be set by rational efficient agents, though they will have to take account of the presence of such noise traders (De Long et al 1990), and technical analysts will tend to lose money on balance. Technical analysis would then continue only if its adherents want to believe or because 'there are always more fools born'.

In the present study we investigate this issue directly, by testing the ability of technical analysis to predict future price movements, in such a way as to avoid the main criticisms which have been levied against previous works in the area: that they are not acceptable for their methodology to an academic audience; and/or that they are judged irrelevant by practitioners. There is a vast literature

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63 See for example Graham, Dodd and Cottle (1962), and Copeland and Weston (1988).

which addresses market efficiency[64] and seriously questions it, but, although the results obtained in this study have implications for market efficiency, this is not the main purpose of our research. The presence of market inefficiency does not in fact necessarily imply that the rules used by technical analysts can generate profits in excess of naive rules.

In section 3.1 we introduce technical analysis and its main tools together with the recent theoretical literature on its effect on the pricing of assets. In section 3.2 we report the results of an experiment in which a commercially available technical trading system has been tested for its ability to help traders make profitable decisions, while in section 3.3 we test a trading rule based on "support" and "resistance" levels provided by technical analysis of various financial institutions. section 3.4 contains a study which is not directly addressed to technical analysis; in it we analyse the clustering of prices and spreads, and tests the prediction of two alternative theories which purport to explain the phenomenon.

64 See for example Taylor (1992) and references therein.

3.1. Introduction

Technical analysis, as opposed to fundamental analysis, aims to provide forecasts of the likely future movements of a price series based entirely on past price movements. The main assumption of technical analysis is that all factors affecting prices in financial markets are instantly reflected in the price itself[65], with new information being incorporated in the price possibly even before becoming public knowledge, due to the presence of insiders.

The difference between technical and fundamental analysis is not in the belief of what determines prices, but on what constitutes worthwhile research: while fundamental analysis studies the factors which affect prices, technical analysis concentrates its attention on prices themselves. Below, we will briefly introduce the most common technical indicators. These are:

1. chart analysis;
2. moving averages and momentum indicators;
3. support and resistance levels.

As hundreds of different approaches have developed through time for various assets and markets, we cannot be exhaustive[66]; more comprehensive surveys of technical analysis are: Edwards and Magee (1966) and J.J. Murphy (1986)[67].

The study of charts and chart formations - often referred to as 'chartism' - is probably the best known form of technical analysis. What a technical analysts looks for in a chart is a pattern which he recognises and which is associated with

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65 See J.J. Murphy (1986).

66 It is often claimed that there are as many approaches as technical analysts.

67 The use of technical analysis dates at least back to the 1800s. Charles Dow was the founder and first editor of the Wall Street Journal and he made his predictions by looking at the co-movements of two stock market indices, the Dow Jones Industrials and the Dow Jones Transportation inventing what is known today as the 'Dow theory'. See Glickstein and Wubbels (1983) for a recent test of the Dow theory.

a subsequent price development. The most common patterns are the head and shoulder, the double tops and bottoms, triangles, diamonds and channels. Each pattern, in order to be correctly identified, must satisfy certain criteria, laid down by the analyst himself, in terms of magnitudes and timing. Once identified, these patterns provide generally for an "objective", or the likely direction and magnitude of the movement of the price series.

Moving averages are the most widely used among the technical indicators. Although they certainly contain less judgmental input than chart analysis, they can be of any arbitrary length, with the most common being 20, 50 and 200 days. A moving average of a price series, when compared with the current price, is supposed to give an indication of the trend of the market. By construction, moving averages will not be able to identify turning points in a price series, since they react slowly to changes in trends, but, if trends last long enough, a rule based on moving averages can be profitable. While moving averages apply to trends and price levels, momentum indicators pertain to changes in prices and their speed.

Support and resistance levels are other widely used technical indicators. These are particular price levels (the support below, and resistance above the current price) at which it is believed to be a sufficient demand or supply in the market to stop the price from going through them. We will look at supports and resistances more in detail in section 3.3, where we will test a trading rule based on them.

Although researchers in financial markets have long recognised the widespread use of technical analysis[68] by practitioners, the lack of a theory which gives technical analysis a proper role has largely prevented analysis of the effects and implications of its use. In fact, the 'efficient markets hypothesis', in its weak-form, states that current prices reflect all available information, so that excess returns cannot be earned by looking at past prices (Fama 1970). This has been a widely held view until recently, when theoretical models have been proposed in

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68 Roberts (1959), Jensen & Benington (1970).

which technical analysis can have a role.

For example, Brown and Jennings (1989) develop a two-period dynamic model of equilibrium in which rational investors with heterogeneous information use historical prices in forming their demands. As for the implications of their work for efficient markets theory, the authors conclude:

> What is not clear from textbook discussions of weak-form efficiency is whether the statement that 'technical analysis has no value' is an implication, derived by logical reasoning, of the assumption that the market is weak-form efficient, or whether it is the defining characteristic of weak-form efficiency. If the latter is assumed, then the market discussed in this work is not weak-form efficient. Technical analysis does have value. Alternatively, in the case that 'technical analysis has no value' is an implication of market efficiency, this work demonstrates that this inference may be unwarranted, given a definition under which the noisy rational expectations equilibrium is efficient. (Brown and Jennings, 1989, p. 542)

An alternative possible explanation for the importance of technical analysis is that, once enough people believe that the market will move in a certain direction, it will do so, whether or not the original basis for the view had any basic validity. This is commonly known as the 'sunspot' theory, which states that decisions based on irrelevant data or analyses may become self-fulfilling and self-justifying if enough people believe in them. This syndrome may be more permanent when the market's horizon is short-term, as it is believed to be the case in the foreign exchange market.

Froot, Sharfstein and Stein (1992) also construct a model in which technical analysis can have value. They assume that there are at least some traders who trade over short horizons and they derive an equilibrium which can possess a particular type of informational inefficiency, even in presence of fully rational agents. Froot, Sharfstein and Stein (1992) note that in general, for a trader to profit on his information, it is necessary that there are other traders acting on the same information that he is. If traders have short horizons, they may choose to focus on completely extraneous variables which may not bear any relationship with fundamental variables:

> Yet, the very fact that a large number of traders use chartist models may be enough to generate positive profits for those traders who already know

> how to chart. Even stronger, when such methods are popular, it is optimal for speculators to *choose* to chart. ... Such an equilibrium can persist even if chartist methods contain no relevant long-term information. (Froot, Sharfstein and Stein, 1992, p. 1480)

Unfortunately, these theories which allow technical analysis to play a role are not directly testable, but they suggest interesting areas of research: first, on the weakest assumptions which are necessary to generate an equilibrium in which technical analysis plays a role; and, second, on the actual use of technical analysis in financial markets and on the results that this achieves.

In the next sections we will be addressing the second of these areas of research by testing some of the predictions made by technical analysts, and by analysing the results of an experiment designed to replicate the actual use of chartist inputs in the trading decision process. We do not have any particular theory in mind for why technical analysis should or should not work; the focus of the papers is purely empirical and its aim is to expand our knowledge of the performance of technical analysis.

One might think that chartism would leave testable imprints on the data, but there has been remarkably little testing of its economic impact. For example, if the breaking of a longer-term moving average by a shorter term moving average would be a well known buy/sell signal to technical analysts, then (non-committed) observers seeing such an event approaching should move in to buy/sell beforehand. Hence, the intersection of the moving averages should act as an attractor, causing prices to move increasingly rapidly towards that event (Bowden, 1989). Again, the clear breaking of a support or resistance line should lead technical analysts to expect a large further move in the same direction; hence support and resistance levels should act as repellors, causing prices to move rapidly away from them, especially when broken.

Previous studies of the effectiveness of technical analysis in predicting future price movements have generally concentrated on the (simulated) profitability of certain filter or trading rules: these studies have been criticised in two respects. First, showing that a trading rule has been profitable in the past is no guarantee or proof that it will work in the future; indeed, profitable trading

rules can always be found *ex post* to work in any time series, even a random walk (Tomek and Querin, 1984). Second, since there is no agreement on what constitutes a generally applicable technical trading rule, works which 'prove' that technical analysis does not work - by showing that some trading rules do not generate profits, or have ceased to generate profits - are dismissed by practitioners as irrelevant, since those trading rules may not be the ones that a technical analyst would have employed for that particular market and time period.

More important, though, is the claim by technical analysts that their job involves a lot of judgement and that it cannot be confined to a set of mathematical rules blindly applied to price series. This makes testing technical analysis in a way which is acceptable to both the people who use it and to an academic audience more difficult since it requires that the main inputs - the predictions of technical analysis models - be provided by technical analysts themselves, on an *ex ante* basis, and that these are then properly tested.

Furthermore, a major difficulty in generalising the results of empirical tests of technical analysis is that there is no such thing as the technical analysts prediction, or approach, any more than there is a single fundamentalist prediction, or approach. The forecasts of technical analysts are heterogeneous. This heterogeneity was exemplified in the second survey exercise carried out by Allen and Taylor, who telephoned a panel of chart analysts every week from June 1988 to March 1989 to find our their expectations with respect to the sterling-dollar, dollar-mark, and dollar-yen exchange rates for one and four weeks ahead. They commented as follows:

> Statistical tests of individual chartists' forecasts revealed a significant difference between individual forecasters' accuracy - chartists do not all appear to react in a uniform manner to chart formations. Indeed, one particular chartist consistently outperformed all other chartists and a range of alternative economic and statistical forecasting methods, in terms of forecasting accuracy, although the statistical significance of this finding, in what was a relatively small sample, should be viewed cautiously. (Allen and Taylor, 1989c, p. 550)

In the essays which we present below, we have limited ourselves to the

study of two specific types of technical analysis predictions: one concerns a chartist product which is marketed world-wide to over forty institutions (mainly banks with substantial trading volumes); the other involves technical indicators which are divulged to thousands of users through Reuters screens. Although the group of potential users of this product is quite large, we cannot claim. for the reasons above, that the results achieved here are representative of the whole practice of technical analysis: we hope though that our work will attract other researchers in the field.

3.2. Chartism: A Controlled Experiment

In this section we report the results of an experiment undertaken at the Financial Markets Group of the London School of Economics, in which a commercially available product has been tested for its ability to help traders make profitable decisions.

The use of such products is widespread in the London foreign exchange market, as reported by Taylor and Allen (1992, p. 306). In their questionnaire survey among foreign exchange dealers based in London, 36% of the respondents claimed to use chartist computer graphics packages and 65% on-line commercial chartist computer services; also 21% of respondents claimed to rely on advice from outside commercial organisations for technical analysis, while 42% to subscribe to chartist publications.

In the course of our attempts to do some empirical work on the effects of technical analysis, we talked to several technical analysts in London. One of these, Mr B. Georges of Fiamass Ltd., was sufficiently confident that his firm's product was capable of making money for his clients that he was prepared to make it available to us in a form which enabled us to do a controlled experiment. Sceptics will note that in the event of the experiment being unsuccessful, in the judgement of Mr Georges, his name, or that of Fiamass Ltd. would not be revealed, while if reasonably successful, it would be. This would protect the firm in case of failure, and give it, perhaps, some marketing advantage, if successful[69].

As described further in the next section, the experiment was carried out by the authors as independent observers at arm's length from the firm. We had no personal interest in the outcome, though the firm did put up half the funds to pay incentives (to be described in more detail subsequently) for the participants of our simulated trading exercises. These participants were chosen by us, had no contact whatsoever with the firm, and their names and addresses are available on request

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69 While perhaps undesirable in principle, it would have been hard to have the co-operation of a firm of that kind without such an arrangement.

from us. Most were L.S.E. students responding to an advertisement, but we also invited some professionals with experience in foreign exchange trading to participate[70].

The product that Fiamass markets is the capacity to take an asset price series, of any frequency, and calculate instantaneously as each new data point occurs, a number of lines (displayed in different colours on screen and superimposed to the price series) that describe certain aspects of the market's behaviour. Some of these lines are standard, such as moving averages of differing periodicities, while other are proprietary constructs of the firm. Since the algorithms of these are believed by Fiamass to be commercially valuable, we neither asked, nor were told, how they are formulated. Fiamass believes that the addition of all these extra lines on a screen showing the movements of an asset price series can assist any user, whether a trained dealer or not, to envisage the likely future movements of the asset price.

Fiamass also believes that training, under their own supervision, to use their product improves performance: indeed they normally hold training exercises for dealers of clients buying their product. But for those faced for the first time with their product (the additional lines on the screen) Fiamass no longer thought it worthwhile, as they previously had done, to try to explain in some detail how they might best interpret the patterns of the these lines in order to maximise trading profits. They came to feel that such interpretation was otiose for first time users, and that it was just as successful to allow, indeed to encourage, users to assess such developing patterns entirely subjectively and intuitively. We asked the firm to supply us with a written introduction to the use of their lines on screen which we could supply to all those of our participants using their lines. This is shown in the Appendix.

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70 Sceptics may still wonder whether our contacts with the firm might leave us with some predisposition to find that their technical analysis was 'successful'. Perhaps so, though we would not benefit financially from that. More to the point, a 'successful' result would surely cause other sceptical economists to contact the named company to seek to replicate the experiment independently, and failure to replicate would hardly benefit us!

Essentially, our experiment was to choose a historical asset price series, and to run this on a computer screen with one sample of participants with Fiamass' lines superimposed. Then, with another separate sample of participants we ran the same asset price series without the lines. In section 3.2.1 the exact form of our experiment is described in detail. Then in section 3.2.2 we report our results. Finally, in section 3.2.3 we outline our conclusions.

There are three important caveats that should be kept in mind throughout. First, this is a test of one particular technical analysis product, not of technical analysis as a whole. Second, none of the sample of students had any prior familiarity with technical analysis, and none of our foreign exchange dealers had used this particular product, though they will all have had some knowledge of how technical analysis was used in dealing rooms. So this is a study of the use of a specific product by untrained operators (though Mr. Georges of Fiamass was still confident that it would help). Thirdly, as reported below, our sample was comparatively small in statistical terms, though it took much time and effort to set up and complete.

3.2.1. Design of the Experiment

The Fiamass technical analysis product we tested is a software program which is capable of computing and displaying, together with an asset price series, certain lines which are then updated instantaneously on the arrival of a new data point. These lines are of various forms and colours. They require a long prior series, about six hundred observations, to construct the longer term calculations.

The purpose of the present experiment was to test whether the Fiamass product would help users to make a better guess of the future direction of a price series than not using the product. This was achieved by simulating trading by two groups of participants, half with the price series only on the screen, and half with the addition of the lines. The specific objective, to test the predictive power of the Fiamass product, required that participants took positions at certain points in time, and closed them subsequently with the intent of making a profit, subject to

some limitations which we will describe below.

In order to concentrate on the subject of predictive power only, instead of considering the overall performance of the system in a practical context, we ignored transaction costs and any restrictions on short selling: this enabled us to observe much more clearly the predictive power of the system, without biasing the results in any way. We also ignored alternative forms of investment for the participants who could only go long or short of the asset whose price series was on the screen, or simply do nothing. Moreover, the price series used were of different periodicities (with a chart representing from a single day to several months), and the participants were not told which periodicity they were looking at[71]. Because of all this, we cannot meaningfully talk of rates of return in this context and compare these across assets; although this might have been preferable in principle, it would probably not have added much here, given the specific purpose of the experiment, but it would have made it much more difficult to set up the experiment and more complex for the participants to understand.

Fiamass made available to us many potential asset price series of differing markets, frequencies and dates. On all of these their lines could be added, using up the first 664 observations, so that the participants would have a series of length of 336 observations to unroll (with or without the lines) on the computer screen before him/her. In each case the new observation appeared on the screen when the participant tapped the space bar on his/her computer keyboard. Unlike reality, this meant that the participant had command over the speed at which the data-points arrived on the screen. Each participant was told of the number of forthcoming data points in the exercise, and that the exercise would last half an hour for each series.

As noted earlier, Fiamass supplied us with a large range of potential data series, and we were free to choose which ones to use. We found it hard to see quite how Fiamass might restrict our choice to series which might be inherently more susceptible to interpretation via their line (than without). But, being

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71 Mainly in order to prevent possible identification of the series.

sceptical, we insisted that Fiamass arrange for one data series, collected and chosen by us, to be included in the asset price series put before the participants. Our own series is labelled A1.

We advertised for participants among the student body of L.S.E. We did not state, either in the advertisements or at the experiment, that the purpose was to test the comparative value of this chartist product. Instead we told all the students that the aim of the exercise was to see how well they could perform as market dealers. We had six computers (with screens) available. They were set up in the same room in such a way that the participants could not see any other screen[72], and one of us was present at all time to prevent oral communication[73]. Apart from the first occasion, when some Fiamass employees were present as silent observers and out of concern for the technical functioning of the computer programs, no-one from Fiamass attended these sessions.

We sought 60 participants from the students, with 30 working with lines and 30 without. In practice, one or two did not arrive at the appointed time, and there were also occasional cases of computer malfunction. Each session, with six participants at a time, lasted two hours. First there was half an hour of explanation and practice on the keyboard with a trial asset price series on the screen. Then there were three consecutive half-hour exercises on three different asset price series.

We also wanted to test whether experience would improve student dealing performance, so we asked our first participants whether they would be willing to try again, on new asset series, but sticking in each case to either having the extra chartist lines, or not. About half the original sample agreed to come

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72 At the outset, for the first few sittings, the computer screens were set up in such a fashion that some peeking might have been possible. Since subjects could go at different speeds, this might have allowed peekers perfect information about future prices. We tested whether there were any signs of some outliers among our subjects at these few sessions, appearing at any time to have perfect information, and we have convinced ourselves that there are no such signs.

73 It would, indeed, have been preferable to have used single, sound-proofed cubicles, but we did not have these facilities to hand.

back on two further sessions. So these participants undertook some 4½ hours of simulated screen dealing on nine separate asset series.

Many, perhaps most of the students, came primarily out of interest in how well they could perform as screen dealers. However, we devised an incentive scheme which would encourage the students to try and guess the direction of the market. We paid them £5 per session for attendance and an equivalent amount divided up depending on how well each participant performed[74]. We believe that such a payment system, a fixed wage plus a bonus for comparative profit performance, is quite close to that followed in real conditions, and provides no undue incentive for either excessively risky or cautious behaviour.

We felt, however, that any results might be ascribed to the fact that we were using a sample of students, unfamiliar not only with the chartist product but also with screen dealing. So we also sought, through personal contacts, to run the same exercise with a smaller sample of professional foreign exchange dealers, drawn from the trading rooms of two banks. All will have had some (varying) exposure to chartist techniques, but none had used this particular product. We wanted 24 participants (12 with, 12 without), but we only got, for the usual reasons, 21. In order to compare their results with the students, we gave them three of the same asset series (A1, A8 and A9) in their identical two hour sessions.

Motivation for the professional traders was more difficult, especially for the control group who were not using the lines (one of the banks was considering buying the product). Our financial resources would not stretch to meaningful sums for this group. In the event we stated that we would publish the names of the most successful in each session[75]. This may have given an incentive to excessive risk taking, and hence have contaminated our results, but, short of

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74 The method was as follows. Suppose that there were five subjects in the group. They made the following returns: -200, -100, 0, 100, 200. We gave the first nothing extra. The excess over the first's bottom result was 100, 200, 300 and 400. This totals 1000. We then gave the second subject 0.1 x 25 = £2.50, the third £5, the fourth £7.5 and the fifth £10.

75 These were Mr Trevor R. Carr and Mr Nick Lindholm.

making much larger payment to these professionals, we were not able to think of anything better.

The nine assets price series which we employed, together with their frequencies, are reported in table 3.1; these include both cash (spot) prices and futures prices[76]. Each asset series loaded into the computer had 1000 data points. The first 664 represented the 'known' history; the screens were set up initially so the participant saw the most recent 55 of these 664 data points, but the horizontal scale could be shifted by the participant by pressing the relevant control key to see, more, or fewer, prior data points, up to the whole 'known' history. These prior observations also formed the basis for calculating the lines, various shorter and longer control lines, harmonic support and resistance lines, and other proprietary constructs, which Fiamass had calculated to help indicate the flow of the market[77].

Once the initial position was on the screen, the participants could make the next data point appear by pressing the space bar. In each case there were 336 further data points in the full series. The participants were given half an hour to work through these. They were told in advance of the number of forthcoming data points in the series, and warned five and two minutes ahead of the end of the exercise. When they wanted to buy, or sell, at a particular data point, they would press the relevant control key. Each single press would buy (sell) one unit. They could press as many times as they wanted at any data point (price)[78]. The computer recorded the purchase (sale), and the price at which it was made on a computer printout that was immediately available. Each participant signed and dated their printouts at the end of each session. The computer also showed on the screen the profit/loss made in each transaction.

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76 The use of technical analysis in the futures markets is very popular. See J.A. Murphy (1986); Neftci and Policano (1984).

77 See also appendix 3.2.4.

78 Although no limit was imposed on the number of positions which could be open at any time, the fact that they had to be entered one by one with a procedure which lasted a few seconds, meant that in practice a limit existed.

Table 3.1 Asset price series employed in the experiment

Name	Asset	Cash/Futures	Frequency
A1	DM/$ exchange rate	Cash	Continuous time
A2	FTSE Index	Futures	5 minutes
A3	German Bond	Futures	15 minutes
A4	US Treasury bond	Futures	5 minutes
A5	Long Gilt	Futures	15 minutes
A6	10 year T-notes	Futures	hourly
A7	BP/$ exchange rate	Cash	15 minutes
A8	JP/$ exchange rate	Cash	hourly
A9	SF/$ exchange rate	Cash	4 hourly

At the end of each exercise, the participant's remaining net position was valued at the price of the final data point which he/she had reached, in order to calculate his/her dealing profits/losses for the exercise. Each participant was told in advance that this would be done. In several cases the participant did get to the end of the series by the end of the exercise, but many were too slow to do so[79]. We then had a record of each participant's complete transactions, showing at which data point (price) she/he transacted, number of deals, volume of each deal and price of each deal, as well as our calculation - based on price of final data point reached - of the total profit from dealing of each participant.

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79 An alternative method of valuation might have been to value the net positions of the slow (unfinished) at the price at the end of the exercise, rather than at the observation which they actually reached, but an objection to this is that they might well have wanted to adjust their positions had they observed the change in prices between their final observation and the end of the exercise.

3.2.2. Results

We have tested the predictive power of the Fiamass product, using both parametric and non-parametric tests, by looking at three measures:

1. percentage of times that positive profits were made with a trade;
2. total amount of profits/losses;
3. amount of profits/losses per trade.

Since participants could keep more than one position open at any time, the computation of the first measure is affected by the convention used. The one used here is LIFO (last in first out) which means that the position which is closed with a trade is the last one which has been entered into. The results for the percentage of profitable trades are reported in table 3.2 below. Together with the standard test for the equality of two means from independent samples, we also report the results of the Mann-Whitney test which is a distribution-free test for the equality of two medians. This can give different results due to the non-normality of the distribution of returns, especially at high frequencies, and to the small sample size; it is also preferable in presence of outliers since it uses only information on the position of the observations rather than their magnitude.

A1-S shows that this was a sample of Students on the exercise with the first asset, A1; The results for the average profits/losses per trade are shown in table 3.3 and those for the total profit/loss are shown in table 3.4. In table 3.5 we also report the results for the average number of trades made for each asset.

From table 3.2 we can see that the percentage of profitable trades is significantly higher for the participants without lines in just one case (A1-T) at the 5% significance level, and in two cases (A3-S and A7-S) at the 10% level according to the t-statistic, while is significant only for A1-T at the 5% level according to the Mann-Whitney test. Surprisingly, the number of profitable trades is always greater than 50%, both when the lines are used and when they are not: this may be due to the fact that the participants were reluctant to close positions which would result in a loss and so preferred to take fewer (and probably bigger) losses. Although this is an interesting aspect of traders'

psychology, and it deserves further attention, we believe that it does not affect the results in the next two tables, on which we will concentrate our attention.

Table 3.2 Sample statistics of the percentage of profitable trades

	lines			no lines				
	Obs	Mean	st dev	Obs	Mean	st dev	t stat	M-W
A1-S	28	84.95	12.23	29	87.23	13.45	-0.68	746.5
A2-S	28	66.53	18.04	29	68.94	20.28	-0.47	736.0
A3-S	22	77.44	14.50	29	84.45	10.51	-1.92*	464.5
A4-S	16	67.43	21.51	18	68.03	20.73	-0.08	285.5
A5-S	15	71.07	15.50	18	67.32	13.08	0.74	271.1
A6-S	16	67.05	20.60	18	66.87	18.67	0.03	280.0
A7-S	12	66.46	10.41	17	74.62	15.89	-1.67*	147.0
A8-S	12	77.12	16.17	17	77.26	16.56	-0.02	176.5
A9-S	13	77.19	19.74	17	67.92	22.84	1.19	234.0
A1-T	11	70.61	20.71	10	90.56	6.57	-3.03**	83.0**
A8-T	11	66.79	20.89	10	70.08	28.56	-0.30	113.0
A9-T	11	82.04	17.43	10	77.30	16.73	0.63	134.0

Note **Obs** is the number of participants (observations); **Mean** gives the mean percentage of profitable trades from dealing in this asset; **st dev** is the standard deviation among this set of participants; **t-stat** is the value of the t statistic for the hypothesis that the means in the two samples are equal; and **M-W** is the value of the Mann-Whitney statistic for the difference of two medians. A * (**) next to either the t-stat or the M-W value means that the statistic is significant at the 10% (5%) level.

Table 3.3 Sample statistics of average profits/losses per trade

	lines			no lines				
	Obs	Mean	st dev	Obs	Mean	st dev	t stat	M-W
A1-S	28	35.15	11.93	29	44.65	28.79	-1.64	721.0
A2-S	28	1.65	43.62	29	13.12	69.65	-0.75	761.0
A3-S	22	4.04	3.62	29	8.57	8.86	-2.49**	453.0**
A4-S	16	0.28	6.08	18	1.23	5.29	-0.48	266.0
A5-S	15	-0.31	3.11	18	-2.60	5.88	1.43	299.0
A6-S	16	-1.96	15.36	18	-0.18	13.65	-0.37	278.0
A7-S	12	3.52	7.89	17	5.80	16.24	-0.50	175.0
A8-S	12	14.82	36.78	17	15.04	42.69	-0.01	164.5
A9-S	13	37.15	76.74	17	-45.81	111.5	2.41**	248.0**
A1-T	11	20.61	13.80	10	35.34	15.29	-2.31**	88.0**
A8-T	11	26.53	65.31	10	0.34	144.2	0.53	117.0
A9-T	11	84.92	74.31	10	42.79	102.7	1.07	138.0

Note See note for table 3.2

Table 3.4 Sample statistics of total profits/losses

	lines			no lines				
	Obs	Mean	st dev	Obs	Mean	st dev	t stat	M-W
A1-S	28	2422	1621	29	2881	2574	-0.81	779.0
A2-S	28	317.7	2824	29	1507	5525	-0.98	752.5
A3-S	22	227.5	211.6	29	555.8	537.9	-2.99**	432.5**
A4-S	16	40.19	180.7	18	58.83	254.5	-0.25	263.5
A5-S	15	-0.200	140.2	18	-173.3	544.4	1.30	294.0
A6-S	16	-28.19	547.4	18	-135.3	924.4	0.42	280.5
A7-S	12	96.08	282.8	17	370.2	929.8	-1.14	170.5
A8-S	12	857.6	1425	17	977.8	2282	-0.17	166.0
A9-S	13	2353	4223	17	-2733	6319	2.64**	251.0**
A1-T	11	1650	1593	10	2500	1249	-1.37	99.0
A8-T	11	2619	6984	10	-564	13267	0.68	115.0
A9-T	11	7424	8730	10	5740	15133	0.31	138.0

Note See note for table 3.2

The results in tables 3.3 and 3.4 are similar: for the total profit/loss figures, only in two cases (out of twelve exercises) A3-S and A9-S, there was a significant difference at the 5% level between the samples with and without lines, according to both the t-statistic and the Mann-Whitney test, in one case there was a better result without the lines (A3-S) and in another a better result with the lines (A9-S). There is, therefore, no significant difference between the mean

profit/loss with, and without, the lines for this sample of students. For the average profit/loss per trade, an additional case (A1-T) is significant, with a better result obtained by participants without the lines.

Moreover, in the six cases when students and professional traders faced exactly the same exercise (A1, A8 and A9, with and without lines), there was evidence of difference between their total profits/losses only in A9 where traders outperformed students significantly (at the 10% level) both with and without lines.

In table 3.5 the average numbers of trades for all nine charts is reported[80]. In eight out of nine cases the students with lines traded less often than the students without and in two out of three cases similarly for the traders, but the difference was in most cases small[81]. In all six cases, the average number of trades for the traders was higher than for the students. For the students, the difference between the average number of trades was significant only in two cases at the 5% level (A5-S and A6-S) and in one case at the 10% level (A4-S). The Mann-Whitney test is significant at the 10% level only for A5-S.

When shown these results, Mr Georges of Fiamass made two points. First he asserted the likely value of training in the use of the system; second he noted that in 18 cases out of 24, the dealers made simulated profits on balance (five out of six for the professional traders, thirteen out of eighteen for the students). He suggested that, even though there was no significant difference (among the untrained) between lines and no lines, that any one (of university level training at least) faced with an asset price series on screen could sense the flow of the market and immediately make some money - presumably at the expense of outsiders putting in orders without the assistance of being able to do so - from following screen price series. Our experiment was not, however, structured to provide an adequate test of this last hypothesis.

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80 For the purpose of this calculation, two or more consecutive trades executed at the same data point are counted as distinct trades.

81 For both students and traders, the only exception was A1.

Table 3.5 Sample statistics of the average number of trades

	lines			no lines				
	Obs	Mean	st dev	Obs	Mean	st dev	t stat	M-W
A1-S	28	70.42	42.76	29	68.07	33.50	0.23	800.5
A2-S	28	52.29	34.21	29	60.45	28.82	-0.97	726.0
A3-S	22	58.91	26.23	29	66.03	30.77	-0.89	544.5
A4-S	16	38.00	14.31	18	48.56	19.53	-1.81*	233.0
A5-S	15	50.07	20.90	18	68.72	30.25	-2.09**	203.0*
A6-S	16	42.06	12.86	18	60.94	36.42	-2.06**	239.0
A7-S	12	39.08	17.22	17	51.76	24.46	-1.64	151.5
A8-S	12	45.50	16.47	17	50.35	23.56	-0.65	167.0
A9-S	13	48.00	19.54	17	58.00	26.20	-1.20	174.5
A1-T	11	74.45	32.26	10	69.60	22.25	0.40	126.5
A8-T	11	68.09	28.79	10	68.90	31.66	-0.06	121.0
A9-T	11	72.91	32.40	10	77.80	39.90	-0.31	116.5

Note See note for table 3.2

These results (with the possible exception of the ones on the percentage of profitable trades) are probably what most economists would have expected. The next result was, however, a surprise to us. This is that in every single case the standard deviation of the calculated profits/losses made by the students in the nine exercises was smaller with the lines than without them. In four cases (out of nine) the difference was twice (taking A2-S as twice) or more; in A5-S it was

3.88 times, in A7-S, 3.28 times. Using an F test these differences were significant in 5 exercises. It is not, however, the significance in the individual cases, but the repetition of having a smaller (though by varying degree) standard deviation in all nine student exercises that we find impressive.

This result did not however, carry through to our professional traders. In two exercises (A8-T and A9-T), they did have a broadly similar result, with those without lines having a standard deviation 1.9 and 1.73 times those with lines. But in the other exercise, those with lines had a slightly larger standard deviation (1.28 times in A1-T). Furthermore in four cases out of six, the traders had much larger standard deviations than the students (A8 and A9), and only in one case (A1 without lines) a markedly lower standard deviation. It is possible that our method of motivation of the professional traders caused them to adopt riskier strategies. Be that as it may, there is no evidence from this very small sample of professional traders that the use of this chartist product altered their usual dealing behaviour.

By contrast, we have put forward evidence that the use of this Fiamass product did cause the individual profit outcomes of the students to be more bunched together, reducing the incidence of both very bad and very good results from dealing. To the extent that dealers or their employers are risk averse and would prefer a lower standard deviation of outcomes, the use of this chartist technique would appear, on this latter sample, to be utility enhancing, given that the average (and median) results are generally not significantly different. Again our caveats must be kept in mind, especially the small samples (of students and asset price series), reinforced by the failure of the professional traders to confirm the result.

We now put together the results for the means and variances of the distributions of returns, and test for stochastic dominance among the distributions of profits/losses obtained with and without lines. The distributions on which we will perform the test are the ones obtained for the same asset by the different

participants with and without lines[82]: the result that one distribution stochastically dominates the other means that a trader would be better off using the system (with or without lines) which stochastically dominates the other, for trading that particular price series on which the test was carried out.

The mean-variance approach for comparing two distributions of returns is equivalent to stochastic dominance in the case of normality of the distributions or under other restrictive assumptions. In our case, however, we cannot rule out that the distributions of the profits/losses are non-normal and, indeed, we could reject normality in our samples in most cases (using skewness and kurtosis tests). It is worth noting that the condition needed for the validity of the mean-variance criterion, normality of the distributions, is also the condition needed in order to apply both the F test for the equality of two variances and the t-statistic test for the equality of two means: therefore, in order to derive results about mean-variance dominance we rely on these tests.

In table 3.6 we report results for the mean-variance test (EV), first degree (FSD) and second-degree (SSD) stochastic dominance. A plus sign in a column means that the distribution obtained with the lines dominates the distribution obtained without the lines according to the criterion on top of the column, a minus sign means that the distribution without the lines dominates the one with the lines, and a zero means that no distribution dominates the other.

First-degree stochastic dominance of a distribution with respect to another implies that any individual, with an increasing utility function, would prefer the first distribution to the second one. For the FSD criterion we tested the significance of the maximum differences (in either directions) in the two empirical cumulative distributions using the two-sample Kolmogorov statistic. We found that according to this criterion, the distribution without the lines dominates the one with the lines in A3-S and A1-T, at the 10% significance level.

Second-degree stochastic dominance applies to increasing and concave

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82 The test for stochastic dominance performed here is not applied to the distribution of returns obtained with and without lines on different assets, since this is not possible due to the lack comparability of profit/loss figures across assets.

utility functions. This class of utility functions includes the decreasing absolute risk aversion class, power, exponential, and quadratic utility functions. The test that we employ for SSD is illustrated in Whitmore (1978) and is valid for single-crossing distribution families, which include the normal, lognormal, gamma, and most of the two-parameter families[83]. The test procedure combines the significance of the difference of the two means, with a test on the lower tail of the distribution. We found SSD in four additional cases (A5-S, A6-S, A9-S and A9-T), and, in all four of them, the distribution with the lines dominates the one without the lines[84].

The results of the tests on stochastic dominance can be read together with the ones about EV dominance. If we accept normality of the distribution of profits/losses, the EV criterion and the tests applied, are correct; however, the FSD and SSD criteria can give us additional information. For example, a zero in A3-S under EV does not mean that an individual would be indifferent between the two distributions, but that there is not enough evidence to rank them according to the EV criterion. But since we can rank the two distributions according to the FSD and the SSD criteria, we can assert that any individual with an increasing utility function would prefer the distribution without lines to the one with the lines. The summary column combines the rankings obtained with the EV, FSD, and SSD criteria and is valid under the most restrictive assumptions of both EV and SSD[85].

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83 An exact test for second-degree stochastic dominance has been proposed by Tolley and Pope (1988) and involves looking at all permutations of the sample data. Even if this test is preferable to the one employed here since it is not restricted to distributions in the single crossing family, it does require substantial amount of CPU time.

84 Due to the lack of a suitable testing procedure, we could not test for third-degree stochastic dominance.

85 One should take into account that multiple tests have been performed, and adjust the confidence regions accordingly.

Table 3.6 Mean-variance and stochastic dominance results

	EV	FSD	SSD	Summary
A1-S	+ (5%)	0	0	+ (5%)
A2-S	+ (5%)	0	0	+ (5%)
A3-S	0	- (10%)	- (5%)	- (5%)
A4-S	0	0	0	0
A5-S	+ (5%)	0	+ (5%)	+ (5%)
A6-S	+ (5%)	0	+ (10%)	+ (5%)
A7-S	+ (5%)	0	0	+ (5%)
A8-S	0	0	0	0
A9-S	+ (5%)	0	+ (5%)	+ (5%)
A1-T	0	- (10%)	- (10%)	- (10%)
A8-T	+ (10%)	0	0	+ (10%)
A9-T	0	0	+ (10%)	+ (10%)

If we accept the assumptions of the EV and SSD criteria, we have that in 8 cases out of 12, the distribution of returns with the lines is preferred to the one

without the lines in a significant way. In only two cases out of 12 the opposite is true. For the students alone, the ratios are 6 out of 9 against 1 out of 9. The main reason for this result is that the students working with the lines had a much smaller variance in their outcomes.

Subjects to the caveat of non-normality, this evidence, therefore, seems to suggest that the use of this chartist technique does change operational behaviour and may act as a means of controlling risk, even if it does not lead to improved mean returns. How might it do so?

Before we investigate the possible reasons for this result, we report, in table 3.7 various test statistics computed on the series A1, A8 and A9 (limited to the 336 observations used for trading). These are: the skewness and kurtosis of the returns series together with the value of the Jarque-Bera normality test; the values of the Breusch-Godfrey LM tests for autocorrelation (1 and 10 lags); a test for the presence of Arch effects (significance of the lagged square residual in the regression of the square residual); and the values of the Augmented Dickey-Fuller statistics (computed by adding lags until the p-value of the t-statistic on the next lag is greater than 0.10) for the unit root test on the levels of the series.

Table 3.7 Summary statistics for the time series A1, A8 and A9

	Skew.	Kurt.	Norm.	AR1	AR10	Arch	ADF
A1	0.062	3.440	2.643	96.24**	137.3**	28.84**	-1.165
A8	-0.106	4.686	38.66**	0.347	6.620	1.210	-2.428
A9	-0.625	5.144	83.61**	0.052	17.72*	0.028	-3.81**

Note A **(*) indicates that the statistic is significant at the 5% (10%).

Significant first and higher-order serial correlation and Arch effects are present in A1, while mildly significant (10%) higher-order serial correlation is detected in A9. Normality is rejected in A8 and A9, while the null hypothesis of a

unit root in the levels series is rejected in A9 only.

Below we will look at four possible reasons for our result on stochastic dominance by analysing in detail the behaviour of both students and professional traders in the experiment with the three assets series which they both used: A1, A8 and A9. The four reasons for a lower variance in the profit/loss figures for the people using the lines which we will investigate are:

1) the possibility that participants using the lines tend to keep similar positions open because they respond to the same "hints" from the lines;

2) the possibility that people using the lines adopt broadly similar strategies;

3) the possibility that the people using the lines are less "aggressive" by keeping positions open for shorter times;

4) the possibility that the people using the lines are less "aggressive" by trading smaller amounts.

We will examine them in turn.

One possible reason why people using the lines have a lower variance in their results might be that they follow the same hints given by the system, and maintain similar positions at each point in the chart. We tested this by computing the average position profile during the 336 prices for both groups and computing correlations among the position of each individual and the average for his/her group. In table 3.8 we report the average of these correlations for students and traders for the charts A1, A8 and A9[86]. There is no evidence from this table that the position profiles of the people using the lines are more correlated than those of the people not using the lines.

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86 For those tests which require the knowledge of the exact speculative position of the trader at each point in time, we had to exclude some observations, due to the impossibility of reconstructing the position profiles. This has been due to occasional malfunctioning in computers and in printers. The percentage of observations affected is about 25%.

Table 3.8 Mean correlations with average position

	lines		no lines	
	Obs	mean correlation	Obs	mean correlation
A1-S	20	0.584	16	0.629
A1-T	8	0.408	7	0.507
A8-S	12	0.705	15	0.662
A8-T	8	0.670	5	0.622
A9-S	13	0.464	16	0.455
A9-T	7	0.263	6	0.449

The second aspect of our participants' behaviour that we examined was their strategies. We counted the proportion of occasions in which participants bought (sold) after a prior price increase, and also sold (bought) after a prior price fall[87]. We termed those who followed this strategy 'trend followers' ('contrarians'). The hypothesis in this case was that students, being unused to screen trading, might exhibit a wide variety of strategies without the lines; the lines might tend to induce such students to move towards a common strategy, thereby reducing the range of outcomes. On the other hand professional traders might have learned already to adopt broadly similar strategies, so that the use of the lines would cause no additional bunching of strategies.

In any case we were interested to see what strategies students and professional traders would adopt when faced with no information at all except an asset price path on the screen, with and without chartist lines. In so far as asset

87 We also examined the proportions of buying (selling) after two consecutive price rises, and selling (buying) after two consecutive price declines. The results are qualitatively similar to those shown above, and are not reported.

prices follow a random walk, neither a trend-following nor a contrarian strategy should dominate. Our hypothesis was that generalised concepts about equilibrium and the fact of watching a series within physical bands imposed by the screen itself would cause most participants to impose a contrarian strategy upon the asset price series, and that this would be more marked in the case of students than of professional traders.

A common prejudice among economists is that chartist techniques cause dealers' behaviour to be more trend-following, extrapolative. Thus Frankel and Froot (1990a, p. 183) write: "Many so called 'chartist' forecasters, or technical analysts, are thought to use rules that are extrapolative, such as, 'Buy when the 1 week moving average crosses above the 12-week moving average'." Chartists, however, contend the accusation that they are just extrapolators, and the formal test by Allen and Taylor (1989c, p. 550) bears out their case: "This last point - the inelasticity of expectations - was reinforced by formal econometric analysis of the survey data: chartists' advice does not appear to be intrinsically destabilising, in the sense that chartists' expectations do not appear to overreact systematically to changes in the current exchange rate". There are, therefore, conflicting hypotheses about how the introduction of chartist lines might influence strategies.

Our expectation was that they would reduce the extent of contrarian bias in the trading undertaken by our participants, but our results must be described as mixed.

In table 3.9 we report the mean degree of contrarianism for each group. The degree of contrarianism is defined as the percentage of contrarian trades on all trades. A value of 1 represents extreme contrarianism - every buy was preceded by a price fall and every sell by a price rise - while a value of 0 the opposite. For the students, with the exception of A1, the lines are associated with a higher degree of contrarianism, while for the traders, the converse is true. For the students, the lines are associated with a lower dispersion of strategies, but for the traders this is true only in two out of three cases.

Table 3.9 Degree of contrarianism

	lines		no lines	
	Mean	st dev	Mean	st dev
A1-S	0.877	0.104	0.896	0.123
A1-T	0.811	0.149	0.839	0.180
A8-S	0.662	0.190	0.515	0.269
A8-T	0.604	0.253	0.719	0.242
A9-S	0.693	0.218	0.491	0.291
A9-T	0.586	0.250	0.655	0.289

Note **Mean** is the mean number of contrarian trades in each sample. **St dev** is the standard deviation.

The tentative conclusions are as follows: first, strategies without the lines are more diverse than those with the lines; second, without the lines the traders in all three cases showed a tendency to follow extreme contrarian strategies whereas the students only followed their example in the A1 case. The availability of lines tended to cause both students and traders to move to a less extreme, contrarianism.

It is possible that the use of chartist techniques can correct a common misperception (even, perhaps especially, among professional traders) that asset prices are more stationary than is the case in reality. Examples of such apparent misperceptions have been noted in several other experimental cases[88]. While the Fiamass product, in the case of the traders, tended to shift strategies more towards trend-following, in all but one case the mean value remained contrarian.

88 See for example Thaler, 1987.

There is no support here for (some) economists' prejudice that chartism can be equated with destabilising extrapolation, and some suggestion that it may help to cure an otherwise common misperception. But in view of the very small size of the sample, these suggestions must be treated with extreme caution, and not taken as statistically established.

Therefore, while there was some indication that the use of lines caused a bunching of strategies among the students, we doubted whether this was sufficiently marked to explain the lower variance of their trading profit outcomes. So we turned to examine the third aspect of our participants' behaviour: their total outstanding speculative position during the exercise. This was obtained by multiplying the number of positions (long or short) open at any time, by the number of periods for which they were kept open. This measure gives an indication of the total exposure during the whole exercise. table 3.10 reports the average total positions obtained with and without lines, together with the value of the t-statistic and the Mann-Whitney statistic for the hypothesis that the mean and medians of the two samples are equal.

Essentially this test suggests, subject to the caveat about small sample size, that the use of this set of chartist lines was associated with students more cautious in their adoption of speculative positions, although in only one case A9-S the average is significantly different. We already know, from table 3.5, that the student participants using the lines traded slightly less frequently.

The fourth aspect that we now examine is whether the actual average size of trade was smaller with the lines. The results are reported in table 3.11 and indeed show (especially for the students) that the presence of lines is associated with a smaller average size of trade. However the results are again not highly significant and are not confirmed by the Mann-Whitney test.

Table 3.10 Total positions open during experiment

	lines		no lines			
	Mean	st dev	Mean	st dev	t-stat	M-W
A1-S	1086	1353	2163	2928	-1.36	112
A1-T	3040	6387	1324	1032	0.75	24
A8-S	1358	534.0	2515	3280	-1.34	101
A8-T	2214	1377	2454	2608	-0.19	23
A9-S	1144	725.0	3079	3184	-2.36**	75
A9-T	1077	667.0	1454	1528	-0.56	26

Note **Mean** gives the average; **st dev** the standard deviation among this set of participants; **t-stat** the value of the t statistic for the hypothesis that the means in the two samples are equal; and **M-W** the value of the Mann-Whitney statistic for the difference of two medians. A * (**) next to either the t-stat or the M-W value means that the statistic is significant at the 10% (5%) level.

Since the total outstanding is a function of the interaction of three factors, the average number of trades, the average size of trades and the length of time with which speculative positions are maintained, we can deduce that these three factors jointly explain the lower variance among students using the lines.

Thus the conclusion here is that the use of these chartist lines is associated with a more cautious behaviour with students making slightly fewer and smaller trades and establishing speculative positions which were closed out sooner. This latter tendency was not, however, apparent in the case of the professional traders. In both cases, the results should be treated with extreme caution because of the small size of the sample and the limited number of price series used. Moreover, the Mann-Whitney statistics is never significant in these tests.

Table 3.11 Average size of trade

	lines		no lines			
	mean	st dev	mean	st dev	t-stat	M-W
A1-S	2.87	3.23	3.65	5.15	-0.53	141
A1-T	4.56	5.76	3.36	2.57	0.53	24
A8-S	2.01	0.90	3.53	3.13	-1.79*	78
A8-T	5.38	4.85	6.08	6.01	-0.22	23
A9-S	2.44	1.40	4.08	3.60	-1.67*	82
A9-T	4.13	3.66	8.37	10.4	-0.95	24

Note See note for table 3.10.

Finally, in order to obtain a measure of profit/loss adjusted for the overall exposure of the trader during the exercise, we compute for each participant the ratio of his/her profit/loss to the total position held during the experiment: we report the results in table 3.12.

These results show some differences to the ones in table 3.3 for the absolute profit/loss: for example, student using the lines in A1 do better than those without lines in terms of 'exposure-adjusted' profit/loss, while they do worse in absolute terms; the opposite is true for the professional traders in A1 and A9. These differences, however, do not alter our main conclusions which we summarise below.

Table 3.12 Average profit/loss per unit of total position

	lines		no lines			
	mean	st dev	mean	st dev	t-stat	M-W
A1-S	4.15	4.23	2.26	2.43	1.68*	215*
A1-T	4.26	5.06	4.15	4.68	0.08	26
A8-S	0.87	1.35	1.04	1.27	-0.30	82
A8-T	-0.07	1.15	0.05	1.69	-0.14	20
A9-S	2.09	3.39	1.06	2.75	0.88	127
A9-T	2.30	3.60	4.27	3.22	-1.04	13

Note see note for table 3.10.

3.2.3. Conclusions

Our first set of conclusions does not suggest that the Fiamass product is able to improve performance. We would, however, stress that there was no prior training in this chartist technique for any of our participants, and that this is only one among many such techniques. Subject to that, our results indicate that:

1) there was no evidence that participants using the Fiamass lines could obtain better mean returns than those without;

2) there was only weak evidence that professional traders could use our screens to predict the future path of prices any better than students either with or without lines;

3) both students, and traders, made profits more often than not in these tests, but our experiment was not designed to study whether screen

trading (without any other extraneous information, such as order flows and news announcements) would be profitable.

We did, however, find that the use of lines was associated with a different behaviour of the students. This was not, however, confirmed by our sample of professional traders, perhaps partly because their motivation was different. Also the sample is too small for comfort, and the distributions possibly non-normal. Even so, there did seem a strong tendency for the following:

4) in 8 out of 12 cases the distribution of profits/losses obtained with the lines dominates (at the 10% significance level) the one obtained without the lines on the same price series; while in only 2 cases out of 12 the opposite is true;

5) the use of lines seemed to make student participants more cautious, and the dispersion of their outcomes was smaller;

6) student participants generally took smaller speculative positions overall. This was a combination of fewer trades, smaller trades and shorter holding periods for their positions.

We also examined whether, and how, the use of lines might cause participants to change their trading strategy, specifically that the use of lines would induce participants to follow a more trend-following, extrapolative strategy. Our results were, subject again to the caveat about small samples:

8) students followed, as we had expected, more diverse strategies, varying among students and exercises. There was some faint indication that the use of lines caused strategies to standardise around a mild contrarian mean;

9) our participants, especially when without lines, followed extreme contrarian strategies;

10) whereas the use of lines did seem to induce the participants to follow slightly less contrarian strategies, there was no evidence at all that this chartist technique induced extrapolative, trend-following behaviour.

Whereas there is no evidence here that this chartist technique can allow

untrained users to predict the future course of prices any better than those just looking at the price series by itself, it may be that the shifting pattern of lines can induce greater caution, at least among some groups in particular, persuading participants to close out speculative positions quicker, and can reduce the dispersion of outcomes, effectively reducing risk.

While this was the result of this study, we would not however be confident that the same results would be repeated on other samples, on participants with more training in this technique, or on other forms of chartist methods. We do, however, believe that these results are sufficiently interesting to warrant ourselves, and we would hope others, to do such further research.

3.2.4. Appendix

GUIDELINES

1) Keep the FLO chart horizontally scaled with enough prices to see the recent past but few enough to see a strong image of the current state in detail (between 50 and 100 prices).
Use the ← and → to adjust.

2) Keep the Harmonic Support/Resistance Lines (Blue Envelopes) properly vertically scaled by using ↓ and ↑.

3) Go with the flow of the market. Use the multicoloured FLO lines as indications of cyclic currents. Use the blue envelopes as indications of discreet level of resistance that hold/reverse market movements.

4) Trust your intuition as it is fed visually by the computer image.

5) To avoid too much conscious analysis keep advancing the simulation process, doing as many trades as possible.

FLO from FIAMASS

3.3. When Support/Resistance Levels are Broken, Can Profits be Made? Evidence from the Foreign Exchange Market

In this section we report the results of a study of the behaviour of three exchange rate series (Dm/$, $/£, and Yen/$) around their support and resistance levels, and of the profitability of technical trading rules based on these levels. In academic circles, there has recently been a renewed interest on technical analysis and the ability of technical trading rules to generate profits. The latest studies in the field (Brock, Lakonishok and LeBaron, 1992; Levich and Thomas, 1991; our study on chartism in section 3.2) have tried to remedy two main weaknesses of previous empirical tests of the effectiveness of technical analysis: first, the absence of a proper determination of the significance of the results obtained; and second, the fact that profitable strategies, which cannot be expected to work out of sample, are bound to emerge in a finite sample even in the presence of a random walk (Tomek and Querin, 1984).

In order to avoid both the assumptions of normality of returns (which is easily rejected by formal tests) and the specification of the data generation process, Levich and Thomas (1991) use a bootstrap technique to measure the significance of their results. They find that certain technical rules can earn abnormal profits, but their work falls, though, under the second criticism since their rules have been arbitrarily chosen. The same applies to Brock, Lakonishok and LeBaron (1992) who also use the bootstrap technique while considering the possibility that the data generating process is an AR(1), a Garch-M process or an E-Garch process. They also find that the abnormal profits which they detect cannot be explained by the possibility that their price series follows any of these processes.

Our experiment described in section 3.2 avoids the criticism that the particular product tested uses techniques that technical analysts may not believe appropriate, since the test mimicked the way in which the product is marketed to

be used. The main limitation of our experiment is that it is a test of a single product so that the (mixed) results obtained cannot be generalised to the whole market of chartist products. In fact, technical analysts do not go as far as to claim that their rules, in so far as they can be expressed in the form of an algorithm, can be profitable for all time periods and for all assets; their claim is that some rules work for some assets in certain periods of time, and that they can predict which rule is going to work in a specific situation. It is therefore important to rely on the subjective input of technical analysts for the particular price series and periods considered.

In the present section we test one prediction which most technical analysts tend to accept: this is that particular levels of the exchange rate, called supports and resistances, can provide useful buying and selling signals. In particular, it is believed that once a support or resistance level has been broken, this is a sign that a trend in that direction has started and that it is likely to continue[89].

The literature on technical analysis reports several possible ways of computing where support and resistance levels are going to appear, but no definition of support and resistance exists which can identify these levels unequivocally. In fact, technical analysts use subjective inputs to locate these levels of the exchange rate. In order to test the significance of support and resistance levels is therefore necessary to rely on inputs from the technical analysts themselves.

We are able to use data on support and resistance levels provided by technical analysts and we apply simple trading rules based on the crossings of these levels - which we believe would be accepted by the majority of technical analysts - to three exchange rate series. We hope to minimise in this way the criticism from economists that we use arbitrary rules among a potentially infinite set, and from technical analysts that we do not use models and data that they themselves believed to be relevant.

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89 See Edwards and Magee (1966) and J.J Murphy (1986).

The data on supports and resistance levels is obtained from Reuters' screens, which are continuously updated with what their panel of advisers in each of the three main foreign exchange markets, London, New York and Tokyo believes to be the support and resistance levels of these three spot exchange rates. Supposing such panel estimates to be both reasonably representative of market opinion, and indeed helping to form market opinion through publicity on Reuters screens, we investigate the profitability of signals generated by the breaking of such levels of support and resistance and compare it to the one obtained with similar technical rules which involve breakings of certain levels of the exchange rate. We confirm previous findings that trading-range breaks generate profitable signals, even after the inclusion of transaction costs, and we show that signals originated from chartists' inputs are more frequent and profitable.

In the section 3.3.1 we introduce the concepts of support and resistance as they appear in the technical analysis literature and present the data we use, while in section 3.3.2 we describe the test devised and present the results. section 3.3.3 contains our conclusions.

3.3.1. Support and Resistance Levels

One branch of technical analysis is concerned with support and resistance levels and trading ranges. In the work of Edwards and Magee (1966), which is considered by many as the "bible" of technical analysts, we find a definition of support and resistance which we believe is widely accepted by the profession:

> [W]e may define support as buying, actual or potential, sufficient in volume to halt a down trend in prices for an appreciable period. Resistance is the antithesis of support; it is selling, actual or potential, sufficient in volume to satisfy all bids and hence stop prices from going higher for a time. (Edwards and Magee, 1966, p. 211).

Support is found under the current price of an asset, while resistance above it; a breaking of a support or resistance level occurs when the price of an asset penetrates through one of them. Given the above definition of support and

resistance, a breaking of either of them can be interpreted as a sign that the demand or the supply of that particular asset has shifted substantially and that the new equilibrium level is to be found beyond the previous support or resistance level.

One of the fundamental claims of technical analysis is that investor psychology is important and that the level at which an investor has bought an asset is an important determinant of the level at which he will sell it. We will try to illustrate this with a typical example:

> Imagine yourself, for the moment in the place of those new owners [who bought at 50]. They see prices turn up, reach 55, 58, 60. Their judgement appears to have been vindicated. They hang on. Then the rally peters out and the prices start to drift off again, slipping to 57, 55, 52, finally 50. They are mildly concerned but still convinced that the stock is a bargain at that price. Probably there is a momentary hesitation in the decline at 50 and then prices break on down. Briefly there is a hope that the break is only a shake-out to be recovered quickly, but that hope vanishes as the down trend continues. Now our new owners begin to worry. Something has gone wrong. When the stock gets down below 45, the former bargain doesn't look so good. "Well, I guess I picked a lemon that time but I won't take a loss in it. I'll just wait until it gets back up to 50 some day where I can get out even (expect for expenses) and then they can have it. (Edwards and Magee, 1966, p. 213)

This quotation is an example of the type of reasoning frequently given as an explanation for the asserted effectiveness of technical analysis. This type of reasoning is generally not compatible with utility maximisation and efficient markets, but its validity is not crucial for the profitability of technical trading rules. First, a trading rule may be generating profits simply because it is taking a greater risk that is involved in the benchmark with which the rule is being compared. Second, time-varying risk premia may be altering the expected returns on both the benchmark and the trading rule portfolio, making any comparison worthless[90].

A concept related to that of support and resistance is the trading range;

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90 Although this explanation is very difficult to prove wrong, it is not generally found plausible given the magnitude of the risk premium necessary to explain the results (Taylor, 1992; Sweeney, 1986).

this may be defined as the price range within which an asset has traded in the past and can be characterised by the maximum and minimum of the series (of various length) of latest prices. Although support and resistance levels bear some relationship with the boundaries of a trading range, they are not the same thing. Supports and resistances arise at levels where a substantial volume of transaction has taken place: it is this high turnover which creates what are sometimes called by technical analysts "vested interests" at that level of price.

3.3.2. Methodology and Data

As we mentioned above, one of the technical rules which seems to be accepted by all technical analysts is that the breaking of a support or a resistance level, or of a trading range, represents the beginning of a trend in the same direction. In the present study we test this prediction by simulating a trading strategy based on such breakings.

We use hourly data on the exchange rate of three currencies, the Deutsche Mark, Sterling and Yen, against the dollar, over a period of 12 weeks (less one day) from 10 April 1989 to 29 June 1989. The data are mid-points (average of ask and bid prices) of the latest prices which appeared in the page FXFX of Reuters screens at the end of each hour during our sample period[91]. The data employed in this study is part of a larger dataset, which spans the 12 week period, collected by Prof. Goodhart[92].

From a different page (FXNB at that time) on Reuters screens, we also have data on support and resistance levels for the three exchange rates, as well as their likely future trading ranges, according to the panel of technical analysis advising Reuters. The values of the support and resistance levels are obtained by Reuters through a telephone survey of a small number of major institutions (around five, but not always the same ones) and are updated two or three times a

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91 Due to the thinness of the market at weekends, only weekdays are considered.

92 A description of the dataset can be found in Section 3.4.1.

day: at the opening of the London and Tokyo markets, plus occasionally during the day if some event (in the judgement of Reuters) has significantly changed expectations. The values reported on the screen are the modes of the distributions of the survey values.

The methodology employed here involves computing the returns from a strategy which holds $s if the exchange rate (expressed in foreign currency per dollars) breaks above the resistance and holds the foreign currency if the exchange rate breaks below the support. The strategy remains neutral in other periods. Since we also compute the returns from breakings of supports and resistances separately, we can think of this strategy as the sum of two strategies: the first holds dollars unless the exchange rate breaks below the support level, and the second holds the foreign currency unless the exchange rate breaks above the resistance.

We will be ignoring issues connected with the tax treatment of gains from foreign exchange trading, and we will be assuming that trades can take place at the advertised price on the screen (bid or ask). This last assumptions is not strong since financial intermediaries quoting their prices on Reuters' screens are expected to be able to trade standard amounts of currency at those prices[93]. An additional assumption which we are also implicitly making is that the buying and selling generated by the rules do not affect the exchange rate.

In this study we ignore interest rate differential and the possibility of earning interests by depositing the currency holdings. This is done for two reasons: first, since we use hourly data, few are the occasions in which the portfolio is invested in the same currency for a long enough period to earn a meaningful interest; second, in a study by Sweeney (1986) in which he takes into account interest rate differentials, he finds that excluding them does not cause the results to change significantly.

In the same study, Sweeney (1986) proposes a test statistic for the existence of excess profits which takes into account that risk is being taken when

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93 A more detailed discussion of this point can be found in Section 3.4.1.

switching between currencies. His statistic is easy to compute and has the property of being compatible with versions of the Capital Asset Pricing Model or the Arbitrage Pricing Model, when risk premia are constant. We have computed also the values of his X statistic, which is approximately normally distributed, for the two benchmarks ($s and foreign currency) for each exchange rate. We will not be reporting these results since they do not differ significantly from the simple t-statistics for the average excess return. The main difference between the two statistics is that Sweeney's X statistic takes into account how many hours a $ based investor has not been into the foreign currency, so avoiding the risk connected with its fluctuations.

3.3.3. Results

In order to test for the possibility of earning abnormal profits by looking at breakings of support and resistance levels we have devised 6 technical trading rules and applied them to our three hourly exchange rate series for the Deutsche Mark (DEM), Sterling (GBP) and Yen (JPY), all against the dollar; table 3.13 contains summary statistics for these series, while plots of the hourly data are in the Appendix. In table 3.13 we report the skewness and kurtosis of the returns series together with the value of the Jarque-Bera normality test; the values of the Breusch-Godfrey LM tests for autocorrelation (1 and 10 lags); a test for the presence of Arch effects (significance of the lagged square residual in the regression of the square residual); and the values of the Augmented Dickey-Fuller statistics (computed by adding lags until the p-value of the t-statistic on the next lag is greater than 0.10) for the unit root test on the levels of the series. Normality, as expected, is rejected for all three series and, in two series (GBP and JPY), Arch effects seem to be present.

Each of the 6 trading rules devised consists of a range within which the exchange rate is expected to fluctuate: if the exchange rate moves above the higher end of the range, a buy signal is generated, while a sell signal is generated if the exchange rate moves below the lower end of the range. The position opened following a signal is then kept open until either the exchange rate moves

back into the range, or the range is revised to include the actual value of the exchange rate.

Table 3.13 Summary statistics for daily returns

	DEM	GBP	JPY
Mean	0.003151	-0.0065054	0.0057267
St dev	0.158396	0.172137	0.171235
Variance	0.025089	0.029631	0.029321
Skewness	0.13422	0.12888	-0.75413
Kurtosis	11.04728	7.88556	13.22628
Normality	7143**	3640**	10368**
AR1	2.548	2.599	0.314
AR10	10.90	8.674	13.43
Arch	1.396	21.3**	8.158**
ADF	-1.705	-2.388	-1.728
Obs	1415	1415	1415

Note **Mean** is the average return of the series; **St dev** is the standard deviation of the return. **Normality** reports the value of the Jarque-Bera normality test; **AR1** and **AR10** are the values of the Breusch-Godfrey LM tests for autocorrelation (1 and 10 lags); **Arch** is a test for the presence of Arch effects (significance of the lagged square residual in the regression of the square residual); and **ADF** shows the values of the Augmented Dickey-Fuller statistics (computed by adding lags until the p-value of the t-statistic on the next lag is greater than 0.10) for the unit root test on the levels of the series. A * (**) means that the statistic is significant at the 10% (5%) level.

In the first rule we use the values of the support and resistance levels as they appear on Reuters screens as the lower and upper bounds of the range, while in our second rule we apply an outer band of 0.1% to these values in order to take into account the possibility that the exchange rate has to fall outside of the range by a substantial amount in order to be perceived as a break. The third rule uses forecasts of the likely trading range as reported by Reuters as our lower and upper bounds, and in the fourth rule we apply a 0.1% band to these values. The fifth rule requires the exchange rate to fall outside both of the ranges of the first and third rule in order to generate a signal, and the sixth rule applies a 0.1% band to the boundaries of the previous one.

For each of the rules we separately compute the average returns earned by following the buy and sell signals, and we test whether the difference between the average return obtained following the signals and the average return during the whole sample period is significant (we do not test whether the average return earned by following signals is greater than 0).

In tables 3.14, 3.16 and 3.18 we report the results obtained by applying the six rules to our three exchange rate series. A few interesting results can be immediately noted by looking at these tables:

1) the average returns from following both buy and sell signals are always positive and higher than the average returns for the whole series (the t-statistic for the hypothesis of equal returns varies from 1.27 to 2.85);

2) the average returns from following both signals are substantially higher than the average returns of the whole series by an order of magnitude of at least 5 for the DEM series, positive instead of negative for the GBP series, and between 3 and 8 times higher for the JPY series;

3) for the DEM and the JPY series, only the buy signals are profitable while for the GBP series only the sell signals are profitable;

4) the number of total signals generated varies from a minimum of 149 for the JPY series to a maximum of 527 for the GBP series out of a possible maximum of 1408.

Brock, Lakonishok and LeBaron (1992) test the significance of trading-ranges breaks by using as upper and lower bounds of the ranges the maximum and minimum of the previous 50, 150 and 200 daily values of the Dow Jones Industrial Average with and without a band. We test similar rules on our data for two reasons: one is to confirm their results by using a different asset class (exchange rates instead of a stock market index), the other is to compare the performance of these technical rules with that obtained by using data supplied directly by technical analysts.

In tables 3.15, 3.17 and 3.19 we report the results obtained by following the technical rules suggested by Brock, Lakonishok and LeBaron (1992). The results from applying these rules can be summarised as follows:

1) the average returns from following both the buy and sell signals are always positive and higher than the average returns of the series, but with generally lower t-statistics (ranging from 0.41 to 2.21) than those obtained with rules constructed with Reuters data;

2) the average returns per signal are substantially higher than the average returns for the whole sample and also somewhat higher than those obtained with our rules above;

3) again, for the DEM and JPY series only the buy signals are profitable, while for the GBP series only the sell signals are;

4) the number of total signals is much lower than that obtained with the previous rules, ranging from 39 to 208[94].

Consequently, despite the somewhat higher return per signal obtained with these rules, the total return from following the signals is likely to be greater with the previous rules which generate a higher number of signals.

These results clearly show that on average positive abnormal returns can be made by opening and closing positions according to signals generated by

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94 The maximum number of possible signals with these rules is also lower since we lose the first 50, 150 and 200 observations in order to compute the ranges.

range breaks, with more significant results obtained by using chartists' predictions rather than technical rules. There is, however, an important asymmetry to consider: breakings of supports and resistances do not seem to give similar results. In our sample period, all three exchange rates trended considerably, with the dollar appreciating by between 5% and 10% against the other currencies. Remembering that the Sterling exchange rate is quoted in the opposite way as the other two currencies, so that an appreciation of the dollar is reflected in a lowering of the exchange rate, it appears that in our samples upper bounds tend to work with rising prices and lower bounds with falling prices. This is not merely a tautology since we always compare returns obtained by following signals with the average returns of the series; in other words, if the exchange rate was generated by a random walk with drift process, we would obtain, by following any of the previous rules, average returns per signal equal to the drift parameter, which is also the average return of the series.

Table 3.14 DEM: mean returns from following rule

Rule	N. buy	N. sell	buy	sell	buy-sell
SUP-RES	189	181	0.025912 (1.85)	0.011772 (0.69)	0.018995 (1.71)
SUP-RES 0.1	140	120	0.035046 (2.27)	0.004012 (0.06)	0.020722 (1.64)
LR-HR	190	170	0.033105 (2.45)	-0.00114 (-0.33)	0.016936 (1.47)
LR-HR 0.1	147	126	0.039692 (2.66)	0.005647 (0.17)	0.023979 (1.99)
BOTH	120	122	0.035519 (2.15)	0.010781 (0.51)	0.023048 (1.81)
BOTH 0.1	91	89	0.035268 (1.91)	0.010422 (0.42)	0.02326 (1.62)

Note in the column labelled **N. buy** (**N. sell**) we report the number of buy (sell) signals generated by the rule, while under the **buy** (**sell**) column we report the mean return from following the buy (sell) signals together with the t statistic for the test of the hypothesis that this mean return is equal to the mean return of the whole series. The **buy-sell** column reports the mean return and t statistic obtained by following both the buy and sell signals

Table 3.15 DEM: mean returns from following rule

Rule	N. buy	N. sell	buy	sell	buy-sell
50	118	73	0.020498 (1.14)	-0.00082 (-0.21)	0.01235 (0.75)
50 0.1	44	35	0.04934 (1.90)	-0.03975 (-1.52)	0.010665 (0.41)
150	96	30	0.019993 (1.01)	-0.02501 (-0.96)	0.009278 (0.42)
150 0.1	33	14	0.081672 (2.81)	-0.05668 (-1.41)	0.04046 (1.59)
200	78	22	0.016711 (0.74)	0.002209 (-0.03)	0.013521 (0.63)
200 0.1	27	12	0.082637 (2.58)	-0.01523 (-0.40)	0.052525 (1.92)

Note See note to table 3.14

Table 3.16 GBP: mean returns from following rule

Rule	N. buy	N. sell	buy	sell	buy-sell
SUP-RES	204	251	-0.01062 (-0.32)	0.018151 (2.09)	0.005251 (1.27)
SUP-RES 0.1	147	188	-0.00099 (0.37)	0.019187 (1.92)	0.010333 (1.61)
LR-HR	221	306	-0.01007 (-0.29)	0.015394 (2.02)	0.004714 (1.28)
LR-HR 0.1	227	165	-0.00894 (-0.17)	0.01758 (1.96)	0.006419 (1.32)
BOTH	152	189	0.00058 (0.48)	0.019729 (1.97)	0.011193 (1.70)
BOTH 0.1	113	140	0.014448 (1.24)	0.028777 (2.31)	0.022377 (2.46)

Note See note to table 3.14

Table 3.17 GBP: mean returns from following rule

Rule	N. buy	N. sell	buy	sell	buy-sell
50	56	125	0.018616 (1.07)	0.022766 (1.82)	0.021482 (2.06)
50 0.1	26	54	0.016879 (0.69)	0.021134 (1.16)	0.019751 (1.33)
150	10	103	0.038276 (0.82)	0.028314 (1.98)	0.029195 (2.12)
150 0.1	6	42	-0.0798 (-1.04)	0.046288 (1.96)	0.030527 (1.47)
200	6	94	-0.00422 (0.03)	0.029426 (1.96)	0.027407 (1.90)
200 0.1	4	40	-0.09912 (-1.07)	0.04831 (1.99)	0.034908 (1.57)

Note See note to table 3.14

Table 3.18 JPY: mean returns from following rule

Rule	N. buy	N. sell	buy	sell	buy-sell
SUP-RES	179	111	0.032337 (1.96)	0.005298 (-0.03)	0.021988 (1.47)
SUP-RES 0.1	121	86	0.066373 (3.74)	0.007993 (0.12)	0.042119 (2.85)
LR-HR	188	121	0.038528 (2.47)	0.010541 (0.30)	0.027568 (2.03)
LR-HR 0.1	127	100	0.051268 (2.87)	-0.00371 (-0.53)	0.027049 (1.74)
BOTH	120	75	0.052711 (2.88)	0.015384 (0.48)	0.038355 (2.49)
BOTH 0.1	88	61	0.063721 (3.08)	0.022457 (0.75)	0.046828 (2.79)

Note See note to table 3.14

Table 3.19 JPY: mean returns from following rule

Rule	N. buy	N. sell	buy	sell	buy-sell
50	145	63	0.032823 (1.81)	-0.01832 (-1.09)	0.017331 (0.91)
50 0.1	60	36	0.064038 (2.58)	-0.02741 (-1.15)	0.029745 (1.33)
150	111	21	0.038047 (1.91)	0.004158 (-0.04)	0.032656 (1.73)
150 0.1	48	16	0.063098 (2.28)	-0.01487 (-0.48)	0.043606 (1.73)
200	102	13	0.0398 (1.94)	0.005589 (0.00)	0.035933 (1.83)
200 0.1	48	16	0.063098 (2.28)	-0.022 (-0.56)	0.046079 (1.79)

Note See note to table 3.14

It is important, from the point of view of market traders, for trading-range breaks to give the correct buy signal in rising markets and the correct sell signal in falling ones since it can enable them to avoid being systematically on the wrong side of the market. In order to illustrate how rules based on trading-ranges breaks can help in this, we compute the returns generated by both the buy and sell signals; this gives the excess returns of a strategy of holding an equal amount of a portfolio in two currencies and switching into one only if a signal is generated. In tables 3.20, 3.21 and 3.22 below, we report the returns obtained by applying all the trading rules considered above to this strategy[95].

As can be seen from tables 3.20, 3.21 and 3.22, on average the returns obtained by each strategy for the whole sample is greater than zero on a before transaction costs basis (this is simply the result that the returns in the buy-sell columns of tables 3.14-3.19 are positive), with the rules based on Reuters data producing generally higher excess returns.

We now take into account transaction costs to see if the strategies are still profitable after including them into the computation of the returns. We assumed, conservatively, that transaction costs are 0.03% of the amount of the transaction and that these are paid every time that a position is changed. In tables 3.20, 3.21 and 3.22 we also report the returns from following each strategy, net of our transaction costs: the results are not altered in their substance, and the returns from following our six rules are still positive on average.

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95 In order to ensure comparability among the rules, we have used the same sample for this computations, thus ignoring the first 200 observations.

Table 3.20 DEM: total returns from following strategies

	before transaction costs			after transaction costs		
Rule	Whole sample	First subsample	Second subsample	Whole sample	First subsample	Second subsample
S-R	13.497	1.279	12.603	8.967	-0.626	9.730
S-R 0.1	11.161	2.417	8.947	7.563	1.164	6.433
LR-HR	12.251	-2.810	15.121	8.111	-4.382	12.354
LR-HR 0.1	12.286	-1.749	14.069	9.226	-2.921	12.019
BOTH	10.348	-1.084	11.400	7.048	-2.250	9.115
BOTH 0.1	8.946	-0.546	9.456	6.426	-1.301	7.591
50	3.436	3.285	-0.105	-1.724	0.895	-2.827
50 0.1	1.256	4.359	-3.405	-2.104	3.304	-5.692
150	2.360	4.418	-2.306	-1.180	2.321	-3.666
150 0.1	3.803	5.122	-1.585	1.943	4.187	-2.523
200	2.704	4.029	-1.473	-0.296	2.222	-2.577
200 0.1	4.097	4.832	-0.943	2.657	4.130	-1.693

Table 3.21 GBP: total returns from following strategies

	before transaction costs			after transaction costs		
Rule	Whole sample	First subsample	Second subsample	Whole sample	First subsample	Second subsample
S-R	5.755	2.871	3.093	1.165	1.275	0.046
S-R 0.1	7.703	1.970	5.964	4.389	0.928	3.691
LR-HR	6.187	-1.512	7.551	1.957	-3.173	4.916
LR-HR 0.1	5.531	-1.395	6.862	1.904	-2.888	4.686
BOTH	8.687	2.490	6.510	5.597	1.465	4.364
BOTH 0.1	11.437	2.658	9.358	9.247	1.980	7.740
50	7.801	5.087	3.192	2.881	3.062	0.383
50 0.1	3.082	4.698	-1.087	-0.042	3.642	-3.066
150	6.532	5.987	0.843	3.412	4.383	-0.511
150 0.1	2.853	5.315	-2.263	1.026	4.496	-3.165
200	5.481	5.483	0.235	2.721	4.166	-1.002
200 0.1	2.532	5.292	-1.967	1.452	4.589	-2.809

Table 3.22 JPY: total returns from following strategies

	before transaction costs			after transaction costs		
Rule	Whole sample	First subsample	Second subsample	Whole sample	First subsample	Second subsample
S-R	14.687	2.514	12.765	11.086	0.956	10.502
S-R 0.1	19.099	2.110	17.830	16.519	1.313	15.175
LR-HR	18.362	-0.271	19.215	14.222	-1.794	16.643
LR-HR 0.1	13.862	-0.625	14.633	11.162	-1.685	12.819
BOTH	16.418	1.343	15.542	13.898	0.413	13.768
BOTH 0.1	15.612	0.198	15.922	14.052	-0.209	14.651
50	10.181	3.391	6.806	4.841	0.918	3.865
50 0.1	7.429	4.887	2.571	4.192	3.822	0.280
150	8.437	4.449	3.965	4.897	2.387	2.526
150 0.1	5.627	4.915	0.688	3.467	3.973	-0.517
200	8.265	4.449	3.807	5.145	2.445	2.746
200 0.1	5.529	4.915	0.582	3.489	3.973	-0.493

Under the joint hypothesis of market efficiency and no foreign exchange risk premium, the whole of the additional return given by a trading rule is an excess return; if instead the efficient markets hypothesis is coupled with the existence of a risk premium associated with currencies, then in order to obtain the excess return of a trading rule, this risk premium has to be taken into account. The X statistic developed by Sweeney (1986) takes into account the possible existence of a constant risk premium compatible with either the CAPM or APM frameworks. We have computed the X statistic for all our rules, but this adjustment for risk does not alter significantly our results, so we do not report them. The limited effect of the adjustment for risk is not surprising, given the magnitude of the excess returns generated by the rules and given that the evidence on the existence of a risk premium in the foreign exchange market is still mixed (Levich and Thomas, 1991). Although our results could also have been generated by a time-varying risk premium, we believe that the magnitude of the returns generated would imply an implausibly big risk premium.

The split sample analysis, also reported in tables 3.20, 3.21 and 3.22, shows some interesting results: these are that most of the excess returns to the strategies which employ Reuters data are generated during the second subsample, while during the first subsample, among these, only the rules based on support and resistance generate excess returns (with one exception). The rules based on past maxima and minima, instead, generate most of their excess returns in the first subsample. We can only speculate on the reason for this since we do not have a theory of why these rules should work at all; this should, however, warn us about the robustness of the results so far obtained.

Finally, we want to compare our results with those of De Grauwe and Decupere (1992) who claim, by using 11 years of daily data for the DEM and JPY exchange rates, that barriers, which behave as supports and resistances, exist at round numbers. They look at the frequency of observations around decimal and unit barriers, which are defined respectively as levels of the exchange rate with the last 3 and 4 digits (out of 5) equal to zero, and they reject the hypothesis that the frequency of the distribution is uniform, concluding that this anomaly might be profitably exploited by foreign exchange dealers. Their interpretation of

the results would imply that whenever an exchange rate crosses through a psychological barrier, it is more likely that the next move is in the same direction as the previous one, away from the barrier.

We, therefore, used our own data to test this hypothesis by applying our trading rule to decimal and hundredth (last two digits equal to zero) barriers and our results are reported in tables 3.23 and 3.24; we were not able to test what happens with breakings of unit barriers since there are too few of them in our samples. As can be seen from tables 3.23 and 3.24, rules based on decimal and hundredths barriers are not profitable in general, and generate losses in the case of the JPY, which had showed the strongest effect in De Grauwe and Decupere (1992).

Table 3.23 Mean returns from following rule

Rule	N. buy	N. sell	buy	sell	buy-sell
DEM 100	136	122	0.014418 (0.79)	0.000976 (-0.15)	0.008062 (0.46)
DEM 10	7	7	0.124744 (2.03)	-0.03945 (-0.71)	0.042649 (0.93)
GBP 100	107	119	0.008006 (0.84)	0.035005 (2.53)	0.022222 (2.33)
GBP 10	7	10	0.11768 (1.90)	-0.04276 (-0.66)	0.023304 (0.71)
JPY 100	113	101	0.002365 (-0.20)	-0.02449 ('1.71)	-0.01031 (-1.28)
JPY 10	7	6	0.03316 (0.42)	-0.07677 (-1.18)	-0.01758 (-0.49)

Table 3.24 Total returns from following rule

Rule	holding $	holding FC	holding $	holding FC
DEM 100	4.956	-1.473	-1.764	-9.003
DEM 10	4.778	-3.584	4.358	-4.004
GBP 100	10.68	-1.936	4.992	-8.476
GBP 10	11.28	-11.34	10.98	-11.82
JPY 100	5.828	-7.874	0.608	-13.87
JPY 10	7.952	-8.049	7.232	-8.469

Although the results presented here are strong in statistical terms, we would like to caution about their robustness. In particular, our tests rely on the asymptotic normality of the distribution of the statistics employed. It would be preferable to employ statistical techniques which do not rely on distributional assumptions, but a bootstrap technique, such as the one employed by Levich and Thomas (1991) and Brock, Lakonishok and LeBaron (1992) is not appropriate here. The values of support and resistance levels are in fact associated with contemporaneous levels of price and would be meaningless in a scrambled series, such as the ones employed with bootstrap techniques. On the other hand, if we were to scramble the series with the support and resistance levels attached to the contemporaneous price, then we would obtain the same results reported here since there is no dynamic involved in our trading rules. In addition, although the sample size is big in statistical terms, it is not in economic terms since it covers a period of only twelve weeks.

3.3.4. Conclusions

In this study we use data on support and resistance levels provided by chartists and made publicly available by Reuters, in order to test the profitability

of rules based on them. Our test is, therefore, replaceable, potentially extensible to other time periods, and cannot be rejected by chartists as an invalid measure of their approach.

We find that abnormal returns could be made in our sample period by following such technical signals. However, all these abnormal returns were obtained with a relatively small sample from following the signals on one side of the market (buy signals for the DEM and JPY series, sell for the GBP series) in a time period during which the dollar was trending quite strongly. By comparing the results of following these signals with a simple buy and hold strategy, it appears that supports and resistances work to warn traders against holding currencies subject to adverse trends.

Support and resistance levels are found to produce higher returns than other rules based on trading-range breaks, while rules based on round numbers are shown to produce no excess returns. The split sample analysis casts doubts on the robustness of the results by showing that the biggest part of the excess returns from following a rule based on supports and resistances is generated in the second subsample: a discussion of why this might be the case requires a theory, not yet developed, of why supports and resistance levels should work.

Our results do not appear to be generated by the presence of a constant risk premium required for holding foreign currency, and are unlikely to be generated by a time-varying risk premium. Although the results suggest a form of inefficiency in the foreign exchange market, its particular form is not investigated; the profitability of trading rules is compatible with a wide variety possible inefficiencies, such as those given by the presence of rational bubbles or of fads, by central bank interventions to lean against the wind, or the presence of noise traders.

3.3.5. Appendix

Figure 3.1 DEM: Hourly values: 10 April-29 June 1989

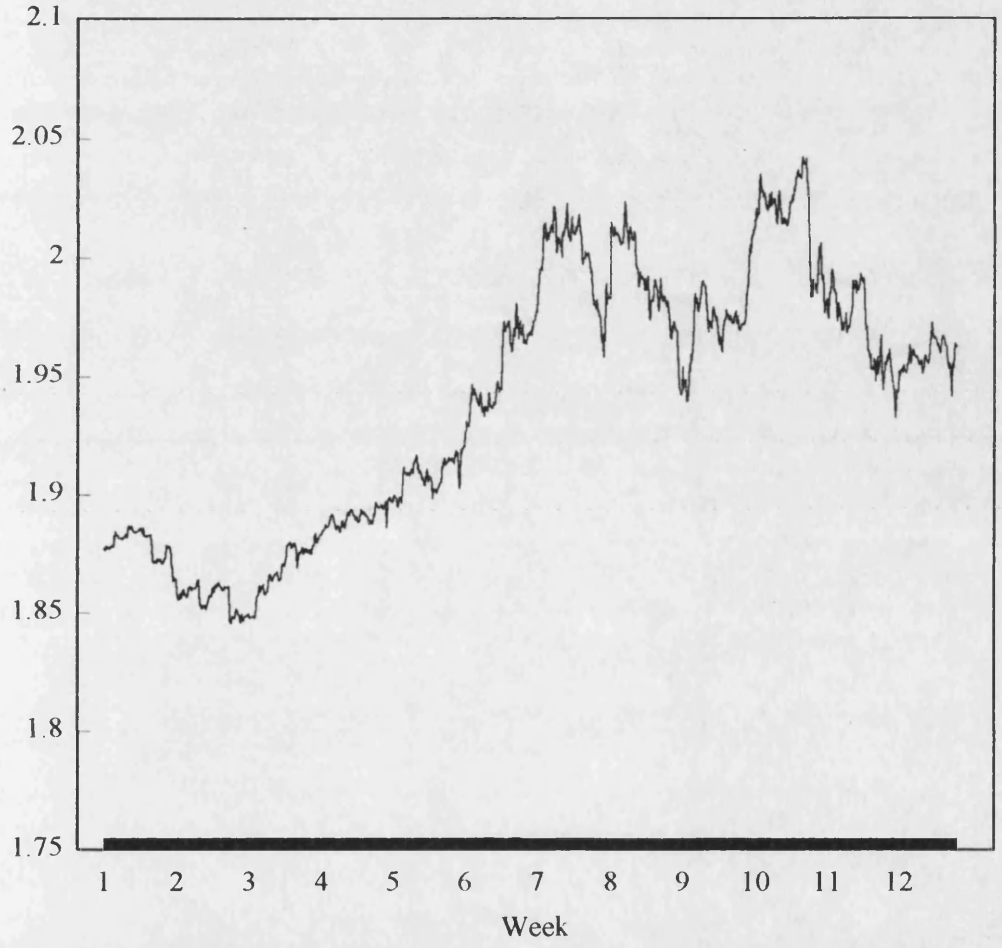


Figure 3.2 GBP: Hourly values 10 April 29 June 1989

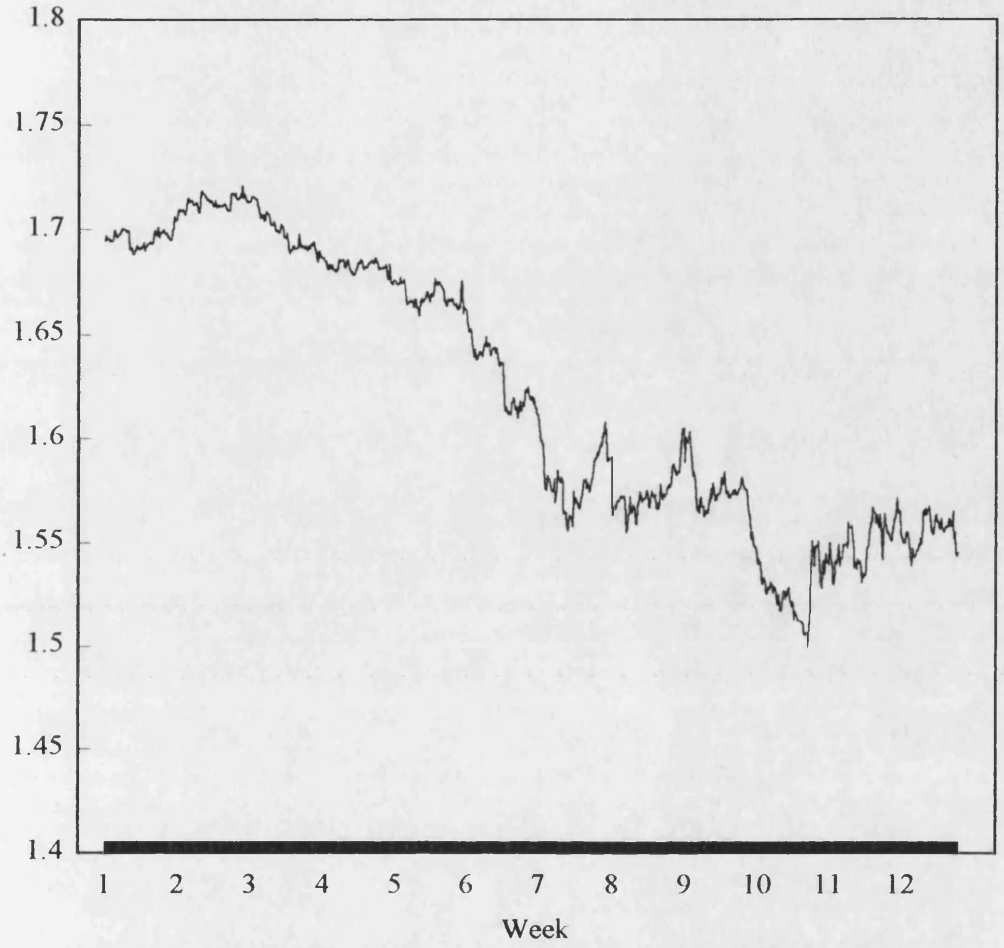
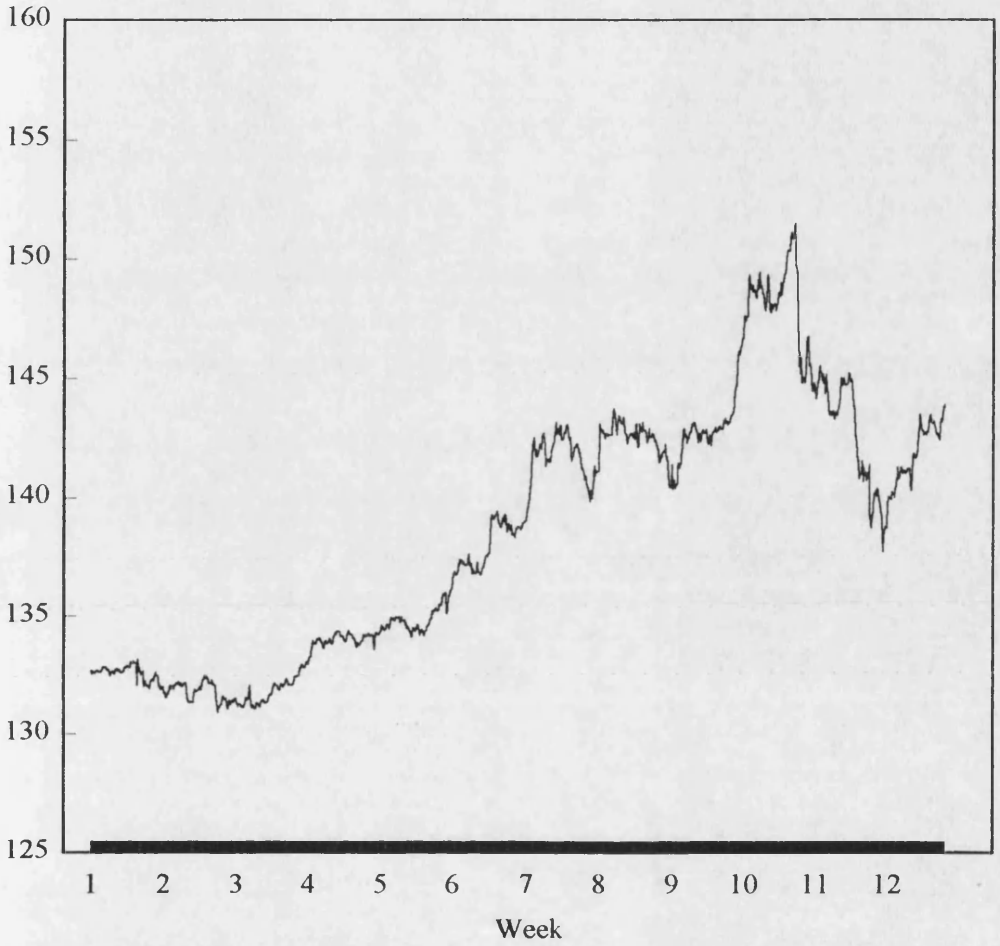


Figure 3.3 JPY: Hourly values 10 April-29 June 1989



3.4. The Clustering of Bid/Ask Prices and the Spread in the Foreign Exchange Market

Following Harris' (1991) study of price clustering in stock prices, we examine the same phenomenon in the foreign exchange market. We show that the pattern of clustering in the final digit of bid/ask prices depends on the desired degree of price resolution. The selection of spreads also involves clustering, but this is driven by a different behavioural pattern, consistent with the pure 'attraction' hypothesis. The combination of the two patterns can explain the differing frequencies of final digits in the bids as compared with the asks.

Harris (1991) notes that the phenomenon of price clustering on round numbers is pervasive. In his study on stock price clustering he notes that:

> Stock prices cluster on round fractions. Integers are more common than halves, halves are more common than odd quarters, odd quarters are more common than odd eighths; other fractions are rarely observed. The phenomenon is remarkably persistent through time and across stocks. ... Clustering is found in quotes almost to the same extent that it is found in transaction prices; it is found in intradaily prices and in closing prices. (Harris, 1991, p. 391)

This feature of asset prices has been noted for some time, and questions have been raised on its consistency with the random walk hypothesis and on its relevance when analysing the effects of price discreteness on estimators (Osborne, 1962; Niederhoffer, 1965; Harris, 1990), but only recently there have been attempts to give behavioural explanations of this pattern.

Perhaps the simplest possible explanation might be called the 'attraction' theory, or round number syndrome. Suppose that discrete trading prices, bids and asks, are obtained from continuously distributed underlying values by rounding to the nearest available final unit, as hypothesised by Gottlieb and Kalay (1985), but that, in addition, nearest does not only depend on linear distance, but also on an 'attraction' of each particular round number. Then, in a price system based on eighths, one would expect to see the following ranking of the distribution of

prices with respect to the final fraction, 0, 1/2, (1/4=3/4), (3/8=5/8), (1/8=7/8). In a price system with integers as final units, one would expect to see the ranking, 0, 5, (7=3), (8=2), (4=6), (1=9).

An alternative theory, which has more behavioural content, has been developed by Ball, Torous and Tschoegl (1985) and refined by Harris (1991), and suggests that clustering is a consequence of the achievement of the optimal degree of price resolution. According to this theory no-one would find the extra time and effort of specifying the bid price of, say, the spot Dm/$ rate to eight decimal places worthwhile, e.g. 1.71465238. On the other hand, three places of decimals might be too coarse, e.g. 1.715. Indeed, as it happens, the Dm/$ spot rate is conventionally traded to four decimal places and we would expect that if that did not achieve the optimal degree of price resolution, the convention would change. But there is no reason to expect that all traders want exactly as much resolution as provided by the full set of decimals in that final unit (.0001 to .0009). Some may not need any resolution beyond the third decimal and leave the final, fourth decimal always at zero. Some would be happy with halves (i.e. .0000 to .0005 to .0010); some would ideally like quarters but cannot obtain .00025 or .00075, and so will choose either .0000, .0002/.0003, .0005, .0007/.0008 or .0010. Others may appreciate the narrower resolution provided by the complete range of the final decimal place; and those who would prefer an even tighter resolution have to make special arrangements. If such price resolution theory were correct, one would find that, aggregating all the traders, the ranking of the final decimal units would be: 0, 5, (2=3=7=8), (1=4=6=9). Thus there is a testable difference in predictions.

Harris (1991) finds that the attraction theory is not supported on his data set, since, according to it:

> the 1/8 and 7/8 price frequencies, which are adjacent to the attractive 0/8 should be less than the 3/8 and 5/8 price frequencies, which are adjacent to the less attractive 4/8. The data provide no support for these additional implications. There are no systematic differences among the four odd eighths. (Harris, 1991, p. 395)

Harris then goes on to estimate the factors causing the desired resolution

to become more coarse, and hence the extent of clustering to increase. These are that price clustering increases with the price level (for example, if the Dm/$ went from 1.7000 to 10.7000, fewer traders would need to use the fourth decimal place), and with asset price volatility, and decreases with the average size of the transaction involved, and with the extent of competition and dealing frequency.

In this study, we shall look at the evidence on price clustering in the foreign exchange market. We describe the data set that we use in section 3.4.1. We will show then in section 3.4.2 that in our data there are two different kinds of clustering, which interact. The first is a price resolution mechanism, as outlined above, which, once again, proves superior to an attraction hypothesis; but the second is a separate, distinct form of clustering for the choice of the spread itself, which does depend on the attractiveness of certain key numbers. We argue that the psychology is quite different. When deciding which final fourth decimal unit to choose, the final number has no importance in itself; but the situation is different when deciding on the number to use for the size of the spread itself, as will be seen.

3.4.1. Methodology and Data

Between April 9th and July 3rd 1989, Goodhart (assisted by R. Lloyd) made a record of every single foreign exchange spot price exhibited on Reuters' FXFX and FXFY screens. The busiest market is that for the Dm/$ for which there are approximately 5000 new quotes exhibited on Reuters screens each working day, thus making for a consecutive time series of about 1/4 million, irregularly spaced, observations. Goodhart and Demos (1990, 1991 and references therein) have produced a series of papers describing the characteristics of these series.

The last quote of Dm/$ on Sunday April 9th, 1.8780/90, was made by BQ Worms in Hong Kong, at 23-59-29 (quotes recorded to nearest second). All quotes for spot rates on Reuters screens, including the DM/$, are in this form, with first the lower number, at which the bank will sell Deutsche Marks for

Dollars (we call this here the bid price), and then the higher number (the ask) at which the bank will sell Dollars for Deutsche Marks; the banks are identified with their name and with the location of the branch making the quote[96].

The price quotes exhibited on Reuters screens are indicative; the actual trading is done by telephone, and there are no regular data available on actual transaction prices or volumes[97]. There are, however, pressures to prevent banks from quoting false prices on Reuters (prices at which it would not subsequently be prepared to deal), in the hopes of stampeding the market. Dealers' and banks' reputations would suffer, and Reuters itself keeps a watchful eye to prevent misuse of its information system. Indeed - and this will become important later on - practitioners have regularly told us that price resolution in the subsequent telephonic dealing is generally finer (within) that quoted on the screens.

The Reuters system works as follows. Those banks which are linked into the Reuters system display their own individual bid/ask prices for a selection of spot and forward rates on their own individual electronic page, which can be accessed by anyone on the Reuters FX network. Whenever one such bank changes its bid/ask quote for a spot rate (exhibited on FXFX for the main currencies, all bilateral with US$, and on FXFY for a number of minor currencies), the new quote is not only shown on its own individual page, but is also flashed up on the FXFX (or FXFY) screen[98]. Thus the FXFX price series provides a series of consecutive individual bank price revisions[99].

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96 In this exercise, we will ignore weekend price quotes since the markets on Saturdays and Sundays, although open, notably in mid-Eastern centres (e.g. Bahrain), are thin, at least until about 22.30 GMT on Sundays when the Antipodean markets come into full activity.

97 Occasionally, Central Bank surveys are made, such as the one described in Press Releases by the Bank of England, Federal Reserve Bank of New York and Bank of Japan on Sept. 13, 1989.

98 The entry procedure to FXFX and FXFY takes a fraction of a second, but, if a second bank revises its quote while the first bank is still having its quote entered, the second bank's quote will not appear on the screen.

99 This series does not represent the 'touch', the finest bid or ask available at any time, nor would it be possible to estimate the 'touch' from these data.

For this exercise we shall look at all the prices quoted on the weekdays of the first week of our sample for the DM/$ spot rate, a set of about 20,000 observations from over 200 banks[100]. This is a small selection of our over-all sample for all currencies over 12 weeks, but, with one exception (described further below), statistically sufficient for our present purpose.

3.4.2. Results

In table 3.25 we record the percentage of observations with which the final digit in the low (bid) price took on each numerical value, from 1 to 0, over 5 trading days, and for the whole sample. The extent of clustering is clear: 0 is regularly somewhat more frequent than 5, but not by much; the frequency of 2, 3, 7 and 8 is broadly similar, though 8 appears noticeably more frequent than 7, and 3 slightly more frequent than 2, (it should be noted that the former is contrary to the 'attraction' hypothesis). Next, the frequency of observations of final digits, 1, 4, 6 and 9 again form a set with a broad similarity, though 1 appears rather more frequent than 4, 6 and 9, in contradiction to the pure 'attraction' hypothesis.

Then in table 3.26 we examine the associated distribution for the higher (ask) price. The main characteristics, the division into three groups ([0,5], [2,3,7,8] and [1,4,6,9]), remain the same, but the distribution in the second group shifts, thus now 7>8 and 2>3, whereas the inequalities had the reverse sign in table 3.25.

Naturally, when we take all price quotes, both bids and asks, in table 3.27, the results average out. As expected 0>5: otherwise the frequencies in the other two groups are quite closely similar ([2,3,7,8] and [1,4,6,9]), except for the higher value of 8.

We now test the equality of the frequencies in the three groups, having

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100 In this exercise, branches of the same bank located in different centres are considered as different banks.

noted that the variance in the percentage frequencies from day to day is greater than the one consistent with an identical multinomial distribution for the 5 days. This suggests that the same model with identical percentages for all digits is not valid for the whole sample; we should keep this in mind when interpreting the statistical tests[101].

Table 3.25 Frequencies of final digit: bid price

Day	1	2	3	4	5	6	7	8	9	0	Obs
10	4.60	9.03	9.93	3.58	20.3	3.03	8.8	11.5	4.30	24.9	4584
11	5.23	9.30	10.6	4.71	20.7	3.86	8.2	11.6	3.74	22.1	4012
12	4.78	8.50	7.44	2.62	21.7	4.76	8.8	14.1	4.27	23.0	3470
13	2.81	7.56	8.61	2.43	26.2	2.88	7.1	10.4	2.16	29.9	4482
14	3.47	7.05	9.84	2.85	25.8	2.75	6.9	9.51	2.56	29.2	3860
Avg.	4.18	8.29	9.29	3.24	22.9	3.46	7.9	11.4	3.41	25.8	20408

101 We are aware that the distribution of final digits generated by the cumulation of a random walk departs slightly from the uniform one, as Ley and Varian (1991) have shown. This, however, cannot explain the big departures that we see here.

Table 3.26 Frequencies of final digit: ask price

Day	1	2	3	4	5	6	7	8	9	0	Obs
10	3.38	9.80	9.03	5.48	22.2	4.54	12.4	9.2	4.23	19.8	4584
11	4.16	10.3	9.25	5.06	19.6	5.08	10.6	9.5	4.71	21.7	4012
12	4.70	10.7	11.0	5.01	24.1	3.72	9.14	7.9	3.17	20.7	3470
13	2.90	8.95	8.05	2.92	26.5	2.63	9.42	8.4	2.79	27.4	4482
14	2.31	8.21	8.24	3.73	25.5	3.50	7.23	9.4	3.37	28.5	3860
Avg.	3.49	9.60	9.09	4.44	23.6	3.89	9.75	8.8	3.65	23.6	20408

Table 3.27 Frequencies of final digit: bid and ask prices

Day	1	2	3	4	5	6	7	8	9	0	Obs
10	3.99	9.41	9.48	4.53	21.3	3.78	10.6	10.4	4.26	22.4	9168
11	4.70	9.82	9.93	4.89	20.2	4.47	9.37	10.6	4.22	21.9	8024
12	4.74	9.60	9.16	3.82	22.9	4.24	8.98	11.0	3.72	21.9	6940
13	2.86	8.26	8.33	2.68	26.4	2.76	8.23	9.4	2.48	28.7	8964
14	2.89	7.63	9.04	3.29	25.7	3.12	7.07	9.47	2.97	28.9	7720
Avg.	3.84	8.94	9.19	3.84	23.3	3.67	8.84	10.2	3.53	24.7	40816

In table 3.28 we test the equality of the frequencies of 5=0, 2=3=7=8 and 1=4=6=9, for the tables 3.25-3.27, first for the whole sample, and then independently for each day, using a X^2 test. Note that the main reason for rejecting 2=3=7=8 in tables 3.25 and 3.27 is the surprisingly high frequency of finding a final 8 digit.

Table 3.28 Tests for equality of the frequencies

	whole sample			separate days		
	X^2	D. F.	Accept or Reject	Accept at 5%	Accept at 1%	Reject
5=0						
Table 1	37.3	1	Reject 0.1%	2	0	3
Table 2	0.01	1	Accept	1	3	1
Table 3	19.7	1	Reject 1%	2	1	2
2=3=7=8						
Table 1	157	3	Reject 0.1%	0	0	5
Table 2	13.2	3	Reject 0.1%	2	0	3
Table 3	43.9	3	Reject 0.1%	1	2	2
1=4=6=9						
Table 1	28.8	3	Reject 0.1%	2	0	3
Table 2	27.8	3	Reject 0.1%	2	0	3
Table 3	6.84	3	Accept	4	1	0

In order to throw more light on some of the above findings we turn to an examination of the size of the spreads (between the bids and asks) quoted by the banks.

In table 3.29 we report the percentage of observation of all spreads in our sample. This table suggests the presence of clustering of a different type than the one found in tables 3.25-3.27.

Table 3.29 Frequency of the spread

Date / Spread	10	11	12	13	14	Tot Obs.
<3	0.24	0.42	1.73	0.09	0.23	101
3	0.46	2.02	2.05	0.83	1.30	260
4	1.55	1.92	1.35	0.38	0.67	238
5	41.58	44.72	44.96	36.23	38.68	8377
6	0.37	0.62	0.29	0.27	0.13	69
7	17.10	14.11	11.73	12.29	9.27	2666
8	1.88	0.65	1.10	1.29	1.55	268
9	0.15	0.10	0.00	0.02	0.00	12
10	36.56	35.32	36.60	48.08	46.55	8315
11-14	0.02	0.02	0.03	0.04	0.03	6
15	0.04	0.10	0.09	0.42	1.04	68
16-30	0.04	0.00	0.09	0.04	0.54	28
Tot Obs.	4584	4012	3470	4482	3860	20408

The spread allows banks to recoup expenses composed of transaction costs and inventory costs, and is affected by the extent of informational asymmetries and the degree of competition. Different banks may have different cost structures and these could be responsible for the distribution in table 3.29. Our data set contains information on the bank which quoted each price, so we are able to investigate the matter in more detail.

In order to have a reasonable number of observations for each bank with which to estimate the distribution of the spread, we have selected the ones which

quoted more than 100 prices during the week of our sample. These are 56 banks out of 212 and account for over 3/4 of the observations. With regard to the choice of the spread, these banks behaved quite differently, with some of them always quoting the same spread, while others chose 2 or more different spread sizes throughout the week. We have therefore subdivided the banks according to the minimum number of different spreads used in at least 90% of their quotes. The distribution is given in table 3.30 below.

Table 3.30 Frequency of the spread

Number of spreads used	1	2	3	4	5	6
Number of Banks	26	18	8	2	1	1

Among the 26 banks using only one spread, the size adopted was 5 in 9 cases, 7 in 2 cases and 10 in the remaining 15 cases. The remaining 30 banks use at least 2 spreads in most of their quotes, so we can infer something about the distribution of the spread. Banks change their quoted spreads because of changing costs and conditions in the market; there is no theory, though, on how the these should evolve, and in general, we would not expect the spread to follow a random walk process. Nevertheless, the following observations strongly suggest the presence of clustering in the spread:

1) the most used spreads of the 18 banks using mainly 2 spreads are never adjacent, with spreads of 4, 6, and 9 never among them;

2) the 8 banks using mainly 3 spreads always have 5 and 10 among them, but never 6, 8, or 9;

3) a spread of 5 and/or 10 is always present among the most used spreads of all 30 banks (both in 17 cases), while 6, 8, and 9 are rarely present (respectively only twice, once, and never).

These observations suggests that clustering is present in the choice of the spread, but, in contrast with the bid and ask prices, the pattern of clustering is

Table 3.31 Frequencies of final digit

Spread	1	2	3	4	5	6	7	8	9	10	Obs.
5	5.69	9.57	10.8	5.33	18.7	5.69	9.57	10.8	5.33	18.7	16754
7	3.32	12.5	10.2	5.18	17.2	2.27	15.2	10.1	4.01	20.0	5332
10	1.52	7.07	6.95	1.56	31.0	1.62	6.36	9.28	1.17	33.5	16630

consistent with the pure 'attraction' hypothesis.

We now combine our findings of price resolution in the final digits with pure 'attraction' in the choice of spread. Assume that the trader starts with the choice of the lower bid price; 0 and 5 are the most common. But related to these, a spread of 7 dominates 8 (to a far greater extent than 3 dominates 2). So in the asks (higher price), we should expect to see 2 (given by 5+7) and 7 (given by 0+7) more frequent than 3 or 8. This is what appears in table 3.26. Next assume that the trader starts with the choice of the higher ask price: again the combination of 0 or 5 with 7 will imply that 3 (0-7) or 8 (5-7) will be greater than 2 or 7 in the bid price, as indeed appears in table 3.25. The combination of these two distinct behaviour patterns can explain the major shifts between the results for these two tables, except that the doublet (8 bid / 5 ask) occurs more frequently than this line of analysis can readily explain.

With many of the bank traders exhibiting a spread of 5, the entry of a spread of 10 can, perhaps, be seen more as a general indication of a willingness to trade, rather than a commitment to those particular bid/ask quotes in subsequent haggling over the telephone. Consequently we hypothesised that the extent of price clustering among those entries involving a spread of 10 would be significantly greater than those involving the lower value of 5. The results for spreads of 5, 7 and 10 are shown in table 3.31, using bid plus ask prices.

Observe that in 64% of the prices quoted, those using a spread of 10 remain at 0 or 5, compared with 37% for those using the lower spread of 5.

Those with the larger spread (10) only quote the marginal numbers (1,4,6,9) on 5.87% of all quotes compared with 22% for those with a spread of 5. For those with the lower spreads (5 and 7), the sum of 2+3 and 7+8 is greater than either 0 or 5, while it is less than half in the case of those with the higher spread. The conclusion is that the desired extent of price resolution for those with the larger quote (10) is nearer to 1/2 than to 1/4, while it is less than 1/4 for those with the narrower spreads (5 and 7).

Finally, given the above conclusion that even those using the highest spreads desired a price resolution less than 1/2, it follows that there should be no clustering, at least from this source of influence, in the penultimate digit. We examine this in table 3.32. This does reveal a complete absence of the kind of clustering exhibited in tables 3.25-3.27; indeed a number (1) that was marginal there is the most common here. However, the frequencies are not approximately equal. On some days, such as April 11, 12 and 13, the extent of price movement in the market is so sluggish that there is a clear tendency for the digits to cluster around a given mean level[102].

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102 In view of this, one would either need some complex statistical adjustment process (as applied by Harris, 1991) or a longer series to establish that the expected frequency of all digits in the penultimate digit was equal. We are confident, however, that Table 3.32 shows clearly that the pattern apparent in numerical clustering in the final digit does not carry over to the penultimate digit.

Table 3.32 Frequencies of penultimate digit: bid price

Day	1	2	3	4	5	6	7	8	9	0	Obs
10	2.23	3.25	2.12	0.37	2.16	21.3	44.9	18.4	4.47	0.85	4584
11	44.0	4.25	4.54	2.92	7.10	4.26	0.15	0.00	0.10	12.7	4012
12	4.41	7.61	18.6	44.0	23.7	1.61	0.06	0.00	0.00	0.06	3470
13	28.3	25.1	3.19	0.56	0.18	3.08	7.72	5.06	7.79	19.0	4482
14	9.43	9.61	11.4	7.49	5.34	10.5	32.1	7.33	3.24	3.65	3860
Avg	17.9	14.1	7.37	9.67	6.96	8.55	17.9	6.63	3.35	7.56	20408

3.4.3. Conclusions

We have shown that the pattern of numerical clustering in the final digit exhibited for foreign exchange spot bid and ask quote prices depends on the desired degree of price resolution by traders. Traders quoting larger spreads seek a coarser price resolution than those using finer spreads.

The selection of spreads also involves clustering, but this appears to be driven by a separate behavioural pattern, which appears consistent with the pure attraction hypothesis. The combination of these two behaviour patterns can explain most of the difference between the numerical frequencies of the final digits in the bids as compared to the asks.

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