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Active Investment Models

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Summary

The paper starts with an outline of modelling techniques used for the fundamental analysis of share values.

The authors located over one hundred computer based investment models and analysed and collated those for which the organisations using them were prepared to provide sufficient detail. With a single exception, all the models analysed were found to be screening processes to assist in the ultimate selection of a portfolio of investments by judgemental processes rather than an expert computer system for selecting the final portfolio by objective formulae without any subjective overrides.

A library of all known models for which sufficient detail exists to describe them is being established with the assistance of the Library of the Institute of Actuaries.

Résumé

Modèles de Placement Actifs

L'article débute par une esquisse des techniques de modélisation utilisées pour l'analyse fondamentale des valeurs d'actions.

Les auteurs localisèrent plus de cent modèles de placement informatisés et analysèrent et collectionnèrent ceux pour lesquels les organisations les utilisant étaient prêtes à fournir des détails suffisants. A une seule exception près, tous les modèles analysés s'avérèrent être des procédés de sélection destinés à aider le choix ultime d'un portefeuille de placements par des procédés impliquant un jugement, plutôt qu'un système informatique expert pour sélectionner le portefeuille final par des formules objectives sans aucune intervention prioritaire subjective.

Une bibliothèque de tous les modèles connus pour lesquels des détails suffisants existent pour les décrire est en cours d'élaboration avec l'aide de la Bibliothèque de l'Institut des Actuaires.

1. INTRODUCTION

1.1 Early in 1989 the Financial Management Group (FIMAG) of the Institute of Actuaries and the Faculty of Actuaries established five groups to study and report on different aspects of investment. The group examining stock selection systems (under the Chairmanship of L P Tomlinson) divided into several working parties to examine different types of models. This Working Party's main brief was to identify and investigate computer based investment models currently used in the process of active investment management.

1.2 The Working Party proposes to establish and maintain a library of investment models and actuaries are invited to submit models to us for inclusion in the library. The initial entries are available as an addendum of this paper. Each entry consists of:

- A brief description of the model
- A bibliography from which further references can be obtained.

1.3 We intend to provide an analysis of the strengths and weaknesses each group of models by type, in the light of the investment conditions over the period. In particular, we will seek to investigate those investment models that have been used in the past and which, for one reason or another, have been discarded. It is felt that an investigation of such models will add a greater insight into the durability of investment models in general, in different economic and market conditions.

1.4 The authors recognised that the prevalence of investment models was greater in the US than in the UK, and they therefore extended their researches to both countries.

2. MODELLING

2.1 It is important to note that modelling techniques have been used in investment management for many years and some techniques predate the digital computer. Before proceeding to portfolio investment models it is worth examining the role of modelling in the fundamental analysis of single shares or market sectors.

2.2 In order properly to evaluate a share, the analyst must construct a suitable model to assist in placing the price of that share into context. In his joint paper with Clarkson (JIA 115) Plymen drew attention to the similarity between the procedures used in air to air combat with computerised gunsights and with the application of a Market Model to the analysis of a particular share. For the 1944 gyroscopic gunsight, the pilots had to track the enemy aircraft closely and accurately for five seconds so that the internal computer could measure the rate of angular movement and speed and calculate the "aim off" required for success. Successful tracking required that the target could be clearly seen and was pursuing a consistent path. If the target was going in and out of clouds, was obscured by strong sunlight, or was taking violent evasive action, obviously the tracking process did not work. The modelling process has just the same requirement, that is to say the analyst must be able to track the progress of the profits and dividends over a significant period so as to pick up the trend of profits and dividends and to assess the likely long term growth rate, from which a valuation of the share can be determined by using a discount model.

2.3 Before specifying the conditions for successfully constructing such a model, it is best to set out certain categories of shares, for which a particular type of modelling approach may not be generally applicable. For example there are groups of businesses where the price of the share depends more on the net asset value rather than the earnings and, hence, earnings and dividend discount models would not be appropriate in isolation. These include investments trusts, composite insurance, and property companies. Similarly service companies such as stockbrokers, estate agents, insurance brokers, employment agencies, all of which have high overheads from expensive salesmen and executives and whose profits depend on trade and market conditions outside the control of their principals may not be

suitable for modelling by dividend or earnings discount models.

2.4 It is assumed that eligible companies will have been operating in something like their present form and business coverage for the last five years. Obviously any major takeovers or mergers during this period call for special examination. Any significant changes in the type of business undertaken, major ventures into new areas and major changes in the demand and price of the product need to be considered. Clearly it is better if regular dividends have been paid over the whole period than if the profit record includes any years with significant losses or dividend cuts. Companies whose earnings and dividend record is wildly erratic so that no long term trend can be discerned, are clearly unsuitable for modelling by discount methods.

2.5 This quantum of ineligible companies at first sight seems formidable, giving the impression that a particular modelling technique is of only limited application. This is not correct. Many of the ineligible categories are often represented by relatively small companies. For the main body of manufacturing, trading and retailing businesses discount modelling techniques may be applied and are particularly valuable in discovering special situations and undervalued and overvalued shares.

3. OUR APPROACH

3.1 The working party was able to identify more than a hundred investment management organisations in the US and the UK who claim to use, or to have used, quantitatively based investment techniques including computer based models. Unfortunately, for proprietorial reasons, the majority of those organisations were not prepared to discuss how they worked. This paper has, therefore, been based on the models of those organisations which have been prepared to release sufficient information to describe the model and on various papers describing investment models published in JIA and other journals.

3.2 We were able to identify only one purely objective investment model based on historical data, rather than just computer based screening processes or models that were used in conjunction with judgemental input. This experience led us to consider further what constituted an active investment model. The conclusion reached was that screening processes were a type of investment model falling within our brief, and that it did not matter whether or not judgement was used in conjunction with the model.

4. THE US EXPERIENCE

4.1 The bulk of the work in developing stock selection models has been carried out in the US where the availability of market data and the level of academic interest in the stock market as a statistical test-bed have combined to generate a wealth of identified apparent correlations between market factors. This process has been further assisted by the large asset pools in existence and the willingness of US pension plans to allocate these assets to portfolio managers with clearly defined investment styles.

4.2 Thus it is quite common to find that a US plan will have allocated funds to domestic fund managers espousing growth, value, small capitalisation and large capitalisation styles. The argument in favour of this approach (and indeed in favour of further subdivision into additional styles) is simple. In aggregate the total portfolio is diversified across the whole of benchmark universe (S&P 500 for example). Each manager, however, has been selected on the basis of his real or imaginary ability to outperform the sub-universe which comprises his normal portfolio. It is important to note that each manager is not expected to outperform the portfolio benchmark, the S&P 500. His job is to outperform the sub-universe of stocks which qualify under his style definition. It is equally important to note that the portfolio manager may only buy stocks which belong to this sub-universe. Thus the plan sponsor can expect, over a normal market cycle, that, in aggregate, the total fund will outperform the benchmark as each of the individual managers outperforms in their own specific area of exposure.

4.3 The major approaches that have been encountered in our researches of the US market place are described below. We are aware that a significant amount of additional work is being undertaken at an academic level and that a number of quantitatively driven trading models as opposed to investment models are in operation. Since these focus specifically on perceived very short-term pricing anomalies we have not analysed them in any detail. It should also be noted that we have only covered in broad outline the nature of many of the models and screens in existence. There are an almost infinite number of ways in which the component parts of some of these models can be defined and it is in this area that the conversion of naive models into effective management tools becomes reality.

4.4 It is only through the harnessing of large databases and computing power that any of these approaches become feasible approaches to the management of large actively managed equity portfolios.

5. SINGLE FACTOR HISTORIC DATA MODELS

5.1 The approach outlined in 4.2 seems an appropriate place to begin looking at the nature of equity selection models in today's environment. The very identification and definition of 'style' portfolios, of itself, leads to a selection process. Examination of the cumulative relative advantage charts for large and small cap, growth and value portfolios (Appendix A) reveals clear bias over a considerable period, for excess returns to be achieved by concentrating on 'value' oriented portfolios.

5.2 Similar outperformances arise from using low P/E and low Price/Book ratios as indications of value. (Appendices B and C show data from non US markets.) Equally long run data suggests a clear positive small capitalisation benefit in the UK, Japan and France (Appendix D). Similar long run results pertain in the US although the "small cap" effect has been a strongly negative input to performance over the last 6 years.

5.3 Definitions for value screens are perhaps simplest to derive with

low p/e
low price/book
high yield
low price/sales
low price/cash flow

being the significant factors. The latter two factors are often more useful for screeninng financial and cyclical companies.

5.4 Growth screens also offer a variety of approaches.

Earnings growth rate
Return on equity
Return on Capital Employed

are all relatively simple historic or naive measures which can be used to identify the growth universe. However the bulk of active growth screens include an allowance for future growth rates with the majority placing strong reliance on consensus forecasts.

6. TRADITIONAL MODELS

6.1 More than fifty years ago Graham & Dodd developed the Central Value Theory to generate a theoretical value for each stock in the market place. The model is still in use. The formula is

$$\text{Central Value} = \frac{E\ (a + bG)}{D}$$

Where E = Trailing 12 months earnings (LIFO basis)

G = Anticipated 7 to 10 year Earnings growth

D = AAA Bond yield

The formula is highly sensitive to changes in E and a normalisation process is usually applied. Graham & Dodd derived, by regression analysis, values a = 37.4 and b = 8.8 which worked in US markets but not in other stock markets.

6.2 A wide variety of Dividend and Earnings Discount Models have been published. The basis for all of these is clearly actuarial; the present value of the company is the discounted value of the income stream. The traditional approaches assume one of the following:

a) a constant payout ratio and a growth rate based on the expected earnings growth path.

b) a steady dividend growth rate and a realisation of the stock at the end of a fixed period, the current dividend yield is used to fix the termination price based on the projected dividend at that time.

c) a variable dividend rate tending asymptotically to a market norm after 5 years.

Many have required slightly artificial constraints - particularly for high growth companies as infinite valuations are otherwise produced.

The basic formula, assuming constant growth and a single underlying discount rate, simplifies to:

$$P = \frac{D_1}{K - g} \qquad \text{or} \qquad P = \frac{E_1 \times R}{k - g}$$

Where

P = Price

D_1 = Dividend in year 1

k = Discount rate

g = Growth rate

R = Payout ratio

E_1 = Earnings in year 1

An alternative approach is to compute the implied net discount rate at which the net present value of all future dividends equates to the current price. This discount rate is compared to the rate for the market as a whole to determine relative values.

Although Dividend and Earnings Discount models are relatively easy to describe, the accuracy of the dividend/earnings growth rates is critical to their success or failure in the price determinant process and considerable research is concentrated on this aspect.

6.3 The Cash Flow Ploughback approach determines relative value based on cash flow, dividends, price, assets and liabilities.

$$\text{Ploughback Multiple} = \frac{\text{Price/Cash Flow}}{\text{Ploughback Percentages}}$$

$$\text{Ploughback Percentage} = \frac{\text{Cash Flow - Dividends}}{\text{Gross Assets - Current Liabilities}}$$

A relative multiple against the market is computed for each stock considered. This gives a measure of the relative cost of self generated growth. Stocks can therefore be ranked in order of attractiveness with lowest scores being the most attractive.

The model does have implicit biases towards low gearing and low price/cash flow companies.

7. EXPECTATIONAL DATA MODELS

7.1 The establishment of the IBES (Institutional Brokers Estimate System) database has provided a rich source for analysis of correlations between earnings growth and pricing levels.

7.2 Much of the research has indicated no obvious link between forecast earnings growth and subsequent equity returns. This very much supported the conclusions of Little and Brearley within the UK. However there is strong evidence to suggest that changes in earnings forecasts and 'earnings surprises' have a continuing ex-post effect. This is because changes in consensus forecasts exhibit a degree of serial correlation over a period of weeks following a first revision or earnings surprise. The price of the stock adjusts similarly.

Analysis in the US also shows that the price impact of most 'earnings surprises' occurs before the actual announcement, but that this is often followed by a second 'surprise' at the next results date, which justified the price movement between the two announcements. It should be borne in mind that US companies report quarterly and thus provide a significant number of data points for monitoring this effect.

7.3 A second area of research in earnings data has identified the 'torpedo effect'. This relates to stocks where analysts become increasingly over-optimistic in their forecasts and thus create potential for severe disappointment. The torpedo is thus the stock which you do not see coming until it blows a hole in your portfolio. The risk of this happening can be monitored by screening out all stocks where the forecast gain in EPS, as a percentage of the stock price, becomes excessive when compared against market or sector norms.

7.4 The use of consensus data has drawbacks as the IBES database uses an equal weighting for all analysts contributing to the sample and the coefficient of variation needs to be monitored (ie the degree of variability of the forecasts). There has been some work done in this area which suggests that the equal weighting approach is sub-optimal. No obvious replacement to this approach (other than a judgemental one) appears to have been tested.

7.5 Similarly stock sponsorship (no. of analysts/stock capitalisation) is a useful measure of the level of knowledge that is likely to be in the market for a given company. There is clear evidence that the low sponsorship stocks are under-represented in institutional portofolios and less efficiently priced as a result, thus offering scope for excess gains.

8. MORE COMPLEX MODELS

8.1 Much of the research carried out has identified potential short term anomalies, often with comparatively small relative gains attached but some are producing significant results.

8.2 In the same mould are price momentum or relative strength models. These can, however, suffer quite sharp reversals from time to time and require a strong judgemental input.

8.3 A development of these is the Specific Return Reversal approach. This operates on the basis that at a point in time a stock has an expected return relative to the market based on a set of relevant factors. If a stock deviates significantly from the expected return during one time period (say one month), then there is a significant probability that the stock will recover that differential during the next two time periods. This technique appears to be statistically valid when used with an appropriate set of factor inputs.

8.4 The Barra factor model, which provides the input for a significant number of Index portfolios built on optimised factor analysis, also provides a complex model approach to active stock selection. The model is believed to have more than forty factors in addition to growth, value, size and yield, so that stocks can be screened for financial leverage, foreign exposure, labour intensity and earnings variability as a means of selecting stocks which have the appropriate characteristics for inclusion in the portfolio.

8.5 It is understood that Professor Barr Rosenberg, the original author of the Barra system now uses a Specific Return Model for portfolio selection. This model is the sole example, which we have identified, of an expert computer system which selects shares without human help. Published results indicate that cumulative returns over the last three years have been significantly better than the Standard and Poor Index.

8.6 Another multifactor model developed by Professor Harold Dulan, who has a long history of exceptional performance in the US markets, combines a risk reward index based on weighted data from multiple valuations with a securities quality index based on fundamental analysis. The buy/sell program generated by the model is fitted into the strategic allocations previously determined by economic and monetary research and portfolio constraints. Although more complex than in most models, the interplay between objective and subjective is typical of the more successful models.

9. MODELS IN USE/APPROACHES

9.1 Screening and valuation models in the main are applied to generate results in one of two forms.

a) an expected relative return against the market
b) a grouping order of attractiveness (ranked in deciles for example).

As indicated earlier in this note, in many instances where anomalies could be identified, the actual returns were relatively small and hence were more useful in trading portfolios.

9.2 Work in the area of assessing information coefficients (the correlation between ranking by characteristic and ranking by actual returns) of the different approaches led to the realisation that in many cases the combination of two separate screening models increased the information coefficient to a significant level so that transactions were justified.

9.3 Examples of these approaches are as follows

i) Value/growth screens

Stocks are ranked in deciles on both a value screen and a growth screen and a value/growth matrix constructed. Stocks are selected across the spectrum of stocks falling in the triangle below the Value = Growth line.

ii) Price/Book vs Return on Equity

$$\frac{P/B}{R} = \frac{P}{B} \times \frac{B}{E} = \frac{P}{E} \quad \left(\text{Since } R = \frac{E}{B} \right)$$

Where P = Price
B = Book Value
E = Earnings
R = Return on Equity

By plotting P/B against RoE on a scatter graph for all stocks a market P/E line on a 'best fit' basis can be derived. Stocks falling below the line appear undervalued on a P/E basis and can be ranked accordingly.

iii) P/E vs Growth

In a similar approach to the above, P/Es can be plotted against earnings growth rates for each stock and a 'best fit' quadratic can then be plotted for the current market trade off between growth and multiple.

iv) Relative P/E + Earnings Expectations

Stocks can be screened on a relative P/E basis and those appearing cheap on historic basis can be screened again to identify prospective earnings growth above the market average based on consensus earnings forecasts. Stocks are ranked on the basis of an expected regression to the mean relative P/E over the ensuing 12 months.

v) Value & Momentum

A proprietary model which uses a four quadrant approach to analyse stocks on a value basis and on an earnings momentum approach. Stocks appearing in the appropriate quadrant are bought.

10. MULTIFACTOR MODELS

10.1 The logical extension of the above is to use a greater number of factors to improve the information coefficients further. There is however an inevitable danger that a multiple screening approach will eliminate the value added by earlier screens. Most multifactor models therefore rank stocks on a number of different approaches and combine these to produce an overall ranking number. Weights are either equal or based on a regression analysis of back data to maximise predictive correlations.

10.2 Multifactor models employing up to 11 ratios/screening approaches have been encountered in the US although it is difficult to determine whether all of the factors are actually utilised at any time. More normally between 4 and 8 inputs are used.

11. THE UK EXPERIENCE

11.1 As will be seen from the following sections all the UK models of which the Working Party have been made aware are "bottom up" rather than "top down". Portfolios appear to be constructed by selecting shares which are cheap rather than by choosing sectors and then trying to find the cheapest shares within these sectors.

11.2 VALUE MODELS

Multifactor models, such as used by GMO Woolley Limited, seeks to identify the key variables that determine share price behaviour and to describe and measure the relationships between these variables and individual share prices by specifying models of price determination which are then tested for a large universe of stocks over an extended time period. The model examines the relationship between individual share prices and such variables as current earnings, earnings growth, return on equity, P/E ratio, dividend yield and growth, net asset value, company size and so forth. The relationships are investigated singly and in combination, and are also brought together to construct a present value (or dividend discount) model.

It is intended that the model should identify the underlying regularities and irregularities in the company's performance and distortions in the share price behaviour.

11.3 THE POSITIVE VALUE MODELS

Pictet International Management Limited use an alternative multifactor model which dynamically weights each of a series of variables according to its ability to explain share price movements. The model emphasises factors such as earnings yield, dividend yield, price to book, earnings growth, etc. and places heavy weight on historical data.

The model seeks to identify the relative, not absolute, attractiveness of a share within its universe.

11.4 THE CAPITAL EFFECTIVENESS MODELS

An alternative multifactor model is based on the assumption that market efficiency reflects investors' forecasts and expectations of change. MIM Limited have developped such a model. Inputs to the model consist of previously reported financial data.

Elements examined in the model are:

- the normalised return a company can earn on shareholder's equity

- the company's ability to pay out or reinvest earnings

- the financial risk incurred by a company

Financial risk is measured from two perspectives: balance sheet risk and operational risk. Balance sheet risk is the risk that expenses cannot be covered by cash flow. Operation risk has regard to a company's earnings stability.

11.5 LONG TERM EXPECTED YIELD MODEL

(i) This model was developed in detail by Hempsted in his paper to the Student Society of the Institute of Actuaries in 1961 (JSS vol 16 part 6). Following further development and computerisation, it is still used by Norwich Union Fund Managers Ltd, as a form of dividend discount analysis.

Detailed and rigorous fundamental analysis is used to study the earnings on capital employed by a computer over the previous ten years. This is combined with a study of the dividend yield in order to determine the expected yield which is defined as the rate at which the future stream of dividends must be discounted in order to equate to the current share price. The larger the stream of dividends - and hence the more attractive the shares for a given share price - the higher the discount rate (or expected yield) must be. In developing the model conditions of constant growth are assumed since both profitability and the proportion distributed are assumed to remain at constant levels.

The resultant expected yield is regarded as:

a) an indication of the return expected on the investment

b) a yardstick which may be used in comparing one share with another using a consistent approach

c) an alternative to the reverse yield gap for comparing shares in aggregate with fixed interest securities.

(ii) In March 1981 Clarkson published a very detailed study of his market equilibrium model (T.F.A. 37 pt 5). The model, developed in 1975, which discounts a combination of expected earnings growth rates and dividend payout ratios, is designed to select shares that are cheap or dear on a long-term view. It can, however, be used to generate switches between whole sectors of the market, for example, in 1976 the model prompted a switch from the engineering to the consumer goods sector with spectacular results.

11.6 DIVIDEND DISCOUNT AND PRICE-PROJECTION MODEL

A proprietory model called 'Pricepro' forecasts relative price movements twelve months ahead and then ranks the constituent shares in accordance with the forecasts. Buy and sell recommendations follow from the ranking process.

The overall forecasts are based on forecasts of a large number of factors considered, including: Earnings per share, EPS growth, P/E, Yield, Dividends, Full value price (based on discounted gross accrued dividends).

All figures produced by the model are so calculated to eliminate the impact of purely statistical events, such as share going ex-dividend or different year ends. Clean prices (the theoretical ex-dividend prices) are used in the financial ratios.

12. CONCLUSION AND PROPOSALS

12.1 The use of models is becoming more prevalent in the investment industry. Consequently it is desirable that these models be catalogued and that a library be created to which interested parties might refer. This library should be updated regularly as new models are developed and old ones fall out of use or are modified. It is proposed that the library be held by The Institute of Actuaries and the authors are seeking volunteers to assist in its maintenance.

12.2 An index will be established.

Each entry in the index will consist of:

(i) a brief description of the model.

(ii) a bibliography from which further details may be obtained.

12.3 Where a model has been used in the past and disregarded an attempt will be made to analyse the reasons for its discontinuance and these will be included with the description of the model.

12.4 In the main the models identified by the authors highlight, for investment managers, those shares upon which fundamental analysis should be concentrated. It was not possible to distinguish the success of the model from the judgemental input of the managers.

12.5 All the models were designed to search for specific anomalies in the market. They, therefore, run counter to the Efficient Market Theory in its stronger forms.

13. ACKNOWLEDGEMENTS

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The Wiltshire Company
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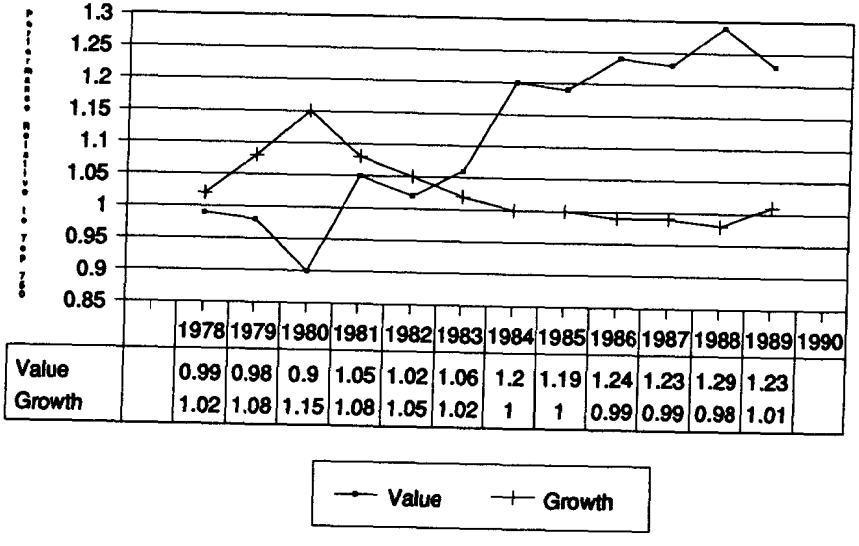
Citicorp Investment Management
DSI Inc
James Capel
County Natwest
Value & Momentum Ltd
Financial Analysts Journal
Journal of Portfolio Management
Morgan Stanley
Dimensional Asset Management

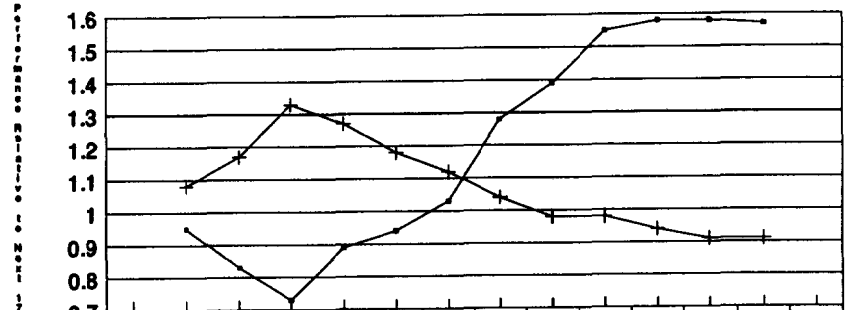
for producing advice, assistance and relevant data.

Large Stock Portfolios
Cumulative Relative Advantage

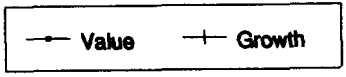


	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Value	0.99	0.98	0.9	1.05	1.02	1.06	1.2	1.19	1.24	1.23	1.29	1.23	
Growth	1.02	1.08	1.15	1.08	1.05	1.02	1	1	0.99	0.99	0.98	1.01	

Small Stock Portfolios
Cumulative Relative Advantage

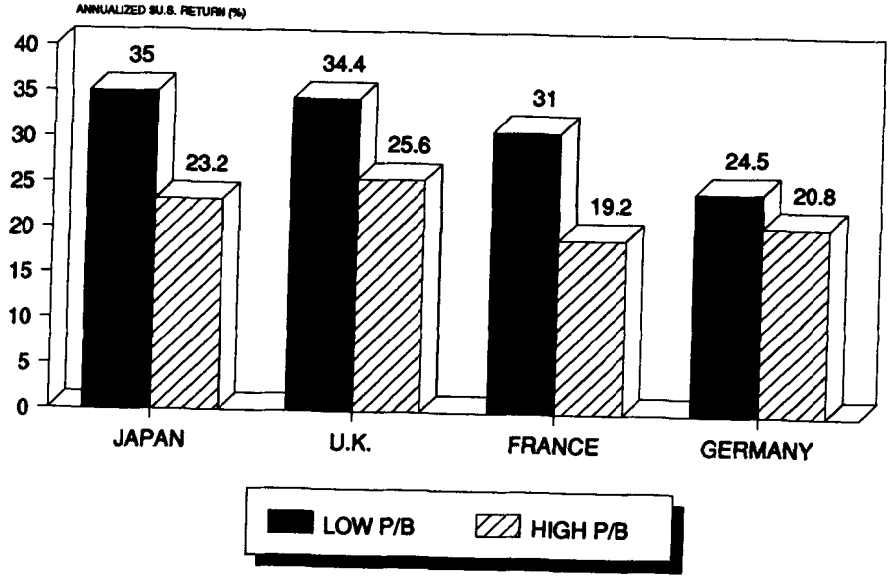


	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Value	0.95	0.83	0.73	0.89	0.94	1.03	1.28	1.39	1.55	1.58	1.58	1.57	
Growth	1.08	1.17	1.33	1.27	1.18	1.12	1.04	0.98	0.98	0.94	0.91	0.91	



THE LOW P/B EFFECT IN 4 MAJOR MARKETS

DECEMBER 31, 1974 - DECEMBER 31, 1989



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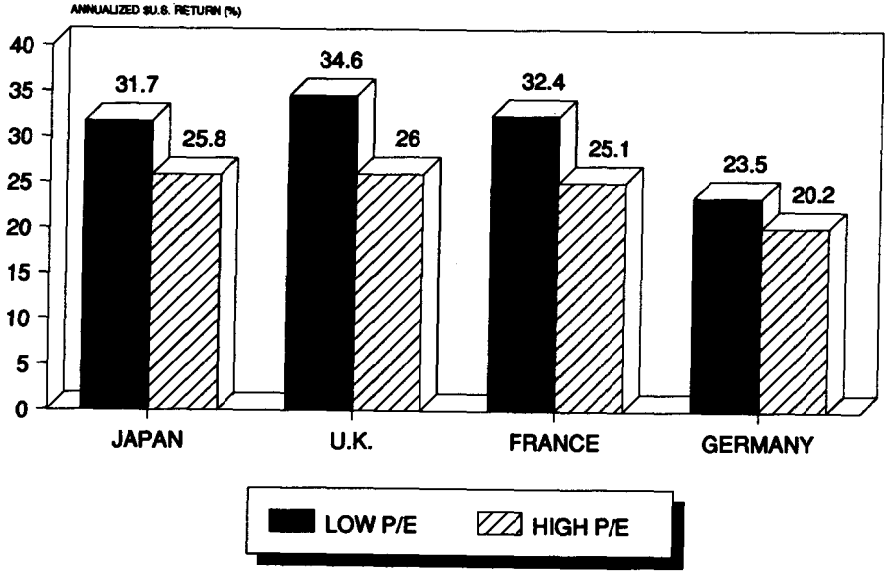

THE SMALL STOCK EFFECT IN 4 MAJOR MARKET

DECEMBER 31, 1974 - DECEMBER 31, 1989