Stock Market Prices: Determinants and Consequences

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Abstract

This thesis concludes that aggregate stock market prices are significantly linked to the real economy. The thesis does, however, find a number of instances of non-efficient market behaviour, in terms of unexplained stock returns prior to financial crises, the predictability of the equity premium, and, possibly, the weak statistical relationship between stock market prices and corporate investment.

Chapter I examines stock price behaviour prior to the stock market crash of 1987. Using data from 23 stock markets, there is little support for the view that the recent crash was caused by a bursting bubble. However, there is evidence that equity prices have recently moved in a non-random manner on some of these exchanges.

Chapter II investigates the movements of stock prices in the United Kingdom from 1700 to 1987. A strong nominal interest rate effect on excess returns is found for the entire period, but it appears that inflation has a consistent, negative effect only after 1950.

Chapter III analyzes major British financial crises since 1700. Using efficient and non-efficient market models, it is found that fluctuations in macroeconomic variables account for up to one half of equity price variation. As well, relatively few crises have been preceded by the excessive positive returns consistent with rational bubbles.

Chapter IV finds that Tobin's Q in OECD countries is inappropriately modelled within a static framework but is improved markedly using a dynamic error correction model. The Q measures are also superior to real stock prices as predictors of investment.

Chapter V compares the effects of equity prices on corporate investment and output in Japan, West Germany, the United Kingdom and the United States. It seems that the effect of the equity market is greater in the latter two countries for various institutional reasons associated with managerial autonomy.

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Corrigenda

Page 13 - Delete the last sentence of the first paragraph. Insert the following sentence at the end of the second paragraph: "Finally, the wide dispersion of alternative Q measures within each country is suggestive of inherent problems in the construction of the measures, and not simply a function of noise in the data." Also, substitute "unexplained" for "non-efficient" in the second sentence of the last paragraph.

Page 14 - Delete "and are, for this reason, inherently unpredictable" from the first paragraph.

Pages 18 and 19 - Replace $(1+r_t)$ with $(1+r_t+\alpha_t)$ in Equations (7), (8) and (9) and adjacent paragraphs.

Page 20 - Z_K in Equation (10) is correctly calculated as the maximum (over every K year subperiod) of the absolute value of the terms on the right hand side of the equation.

Page 30 - Insert the following at the end of the first paragraph: "Schachter et al (1985) provide indirect evidence for this relationship by showing that American bull markets in the post-1960 era are characterised by positive mean returns, i.e. the markets went up too much in those periods, and positive directional movements in returns, i.e. the markets moved in an upward direction too many times, in excess of random walk expectations. Therefore, the probability of a bubble is positively correlated to the strength of the bubble, and this, in turn, is negatively correlated to the degree of decline when the bubble bursts."

Page 43 - Delete "although there exists sufficient evidence of non-random price behaviour to bring into question the assumption of efficient markets" from the first paragraph.

Page 97 - Insert the following at the end of the first complete paragraph: "The strong negative correlation between inflation news and real stock returns in the first two rows of Table 2 does not contradict the assertion of the previous chapter that inflation had no such relationship with excess equity returns before 1914. Inflation was difficult to predict prior to 1914; therefore, the inflation news variable is highly correlated with the ex post inflation series, since the former is the residual from an estimated equation which poorly explains the latter. Given that real stock returns are calculated as nominal stock returns less *ex post inflation*, it is not surprising that a negative correlation emerges between this variable and the inflation news variable on the right hand side of the Table 2 regressions."

Page 137 - Insert the following after the first word on the page: "The F-tests in rows 1, 3, 5 and 7 of the two tables test whether lagged and current values of d(R) are jointly significant in this equation, while rows 2, 4, 6 and 8 test the same null hypothesis for lagged and current values of d(Q)."

Page 184 - Substitute Gordon for Gorden in the last sentence of the page.

Page 215 - Delete the third sentence of the first paragraph and the last sentence of the last paragraph.

Page 216 - Insert the following at the end of the first paragraph: "Finally, the wide dispersion of alternative Q measures within each country is suggestive of inherent problems in the construction of the measures, and not simply a function of noise in the data." Also, replace "The instances of non-efficient market behaviour" with "Various instances of market behaviour" in the last sentence of the last paragraph.

Bibliography - Add the following references:

Gordon, R.H. and Jorgenson, D.W. (1976) "The Investment Tax Credit and Counter-Cyclical Policy", in O. Eckstein (ed.), Parameters and Policies in the U.S. Economy, pp. 275-314, North-Holland: Amsterdam.

Hall, R.E. and Jorgenson, D.W. (1967) "Tax Policy and Investment Behavior - Reply and Further Results", American Economic Review, 59 (3), pp. 388-401.

Introduction

This thesis makes a contribution to explaining aggregate stock prices within an econometric framework by examining correlations between such prices and standard macroeconomic variables. Chapters I and II investigate two recent puzzles concerning movements in share prices: the market crash of 1987 and the relationship between inflation and equity prices. Chapter III extends the analysis of these chapters by investigating British financial crises in historical perspective. Shifting attention to the consequences of share price fluctuations, the last two chapters present correlations between such prices and aggregate output and corporate investment.

The investigation is comparative in nature, using varying data frequencies, examining different time periods from 1700 to the present, and employing a wide range of national data sources. The econometric analysis is augmented by institutional detail, where relevant, and employs standard statistical techniques. The unique aspects of the thesis lie in its data sources and the statistical facts which emerge from the analysis.

In brief, the following conclusions emerge from the thesis.

Chapter I examines stock price behaviour prior to the stock market crash of 1987. Using monthly and daily data from 23 stock markets, there is little support for the view that the recent crash was caused by a bursting bubble. However, there is evidence that equity prices have recently moved in a non-random manner on some of these exchanges.

Chapter II investigates the movements of stock prices in the United Kingdom from 1700 to 1987. A strong nominal interest rate effect on excess returns is found for the entire period, but it appears that inflation has a consistent, negative effect only after 1950. The changing influence of inflation on equity prices may be linked to Britain's adherence to the gold standard.

Chapter III analyzes major British financial crises since 1700. In the first part, using efficient and non-efficient market models, it is found that fluctuations in macroeconomic variables account for up to one half of equity price variation. In the second part, these models reveal that relatively few crises have been preceded by the excessive positive returns consistent with rational bubbles. The success of non-efficient market models in explaining equity returns does imply, however, that the efficient markets hypothesis does not strictly hold for this data set.

Chapter IV finds that Tobin's Q, the ratio of the market value of the corporate sector to the replacement cost of its capital, is inappropriately modelled within a static framework but is improved markedly using a dynamic error correction model. The Q measures are also superior to real stock prices as predictors of investment in the OECD countries under investigation. These results imply that Q, and hence stock prices, are correlated to investment. However, the relationship is relatively weak and depends on the exclusion of other relevant explanatory variables from the investment equation.

Chapter V compares the broader effects of equity prices on corporate investment and output in Japan, West Germany, the United Kingdom and the United States. It seems that the effect of the equity market is greater in the latter two countries for various institutional reasons having to do with the degree of managerial autonomy from stock price fluctuations.

Overall, it appears that aggregate stock market prices are significantly linked to the real economy. The thesis does, however, find a number of instances of non-efficient market behaviour, in terms of unexplained stock returns prior to financial crises, the predictability of stock returns, the influence of lagged and nominal variables on the equity premium, and, possibly, the weak statistical relationship between stock market prices and corporate investment. All of these results offer support to a view of the stock market influenced not only by fundamental factors, but also possibly by social and psychological elements.

Chapter I: Stock Prices and Rational Bubbles

I. Introduction

The efficient markets hypothesis posits that equity prices incorporate all information known to market participants at any point in time and are, for this reason, inherently unpredictable. A further extension of the theory relates such prices to expectations of the present discounted value of all future dividends attached to the stocks in question. This suggests that equity prices are intimately related to underlying real economic processes and are, therefore, rationally based.

The crash of 1987 and the mini-crash of 1989 suggest to others, however, that stock prices are divorced from economic reality. From this perspective, these events were caused by the bursting of a speculative price bubble over a short period of time. Coming to such a conclusion suggests that the stock market is appropriately studied within a multidisciplinary framework incorporating economic, psychological and social elements.

This chapter therefore explores one explanation of the crash that has been put forward from many quarters, namely that the events of October 1987 were the end result of a speculative bubble, in order to comment on these two views of stock market pricing.[1,2] While such bubbles may be rationally or irrationally based, the necessary condition for linking them to the crash is prior existence. To sum up the chapter's basic conclusion, it is found that this necessary condition is not satisfied. In addition, although there is evidence for bubbles occurring in some of the countries examined here, it is difficult to provide a comprehensive explanation for the international differences.

The chapter applies a variant of the traditional runs test on asset prices to reach these conclusions and the result is therefore dependent on the ability of such tests to measure bubble like activity. The novel aspects of this investigation are, firstly, the extension of the particular runs methodology used here to the equity markets of a number of different countries and, secondly, the application of the bubble view to an explanation of the market crash.

Section II describes previous theoretical and empirical work on speculative bubbles and outlines the empirical method used here. In Section III, the bubble probabilities are presented and Section IV discusses the bubble question from the perspective of option pricing theory and evidence. Section V provides an investigation of the cross country differences. The conclusions of the chapter follow in Section VI.

II. Theoretical and Empirical Issues

The notion that economists typically try to capture with work on bubbles is that market behaviour may be self-fulfilling and therefore divorced from standard economic considerations of valuation. On the theoretical side, bubbles may be classified as rational, non-rational or based on asymmetric innovations in fundamentals.[3] On the empirical side, bubbles have been tested using variance bounds tests, runs tests, price/fundamentals correlation tests, variance ratio tests and tests based on fundamentals.[4]

IIa. Theoretical Bubble Specification

The first theoretical category, rational bubbles, refers to the compensation expected by investors when the probability of a market crash increases over time; in order to compensate for the expected loss, investors rationally demand a sustained increase in asset prices. The second category, irrational bubbles, refers either to investment decisions divorced from rationality or else to the existence of biased expectations. The former are impossible to model using the rationality assumptions underlying the neoclassical paradigm while the latter may be a function of imperfect information flows or adjustment costs to changing portfolios in response to new information. The third category, asymmetric fundamentals, refers to market responses under the efficient markets hypothesis where bubbles exist due to continued bouts of unexpectedly good or bad news.

In order to discriminate between the various explanations, a full theoretical specification must be constructed which offers testable hypotheses. Additionally, some assumptions must be made about the relative information flows that the investor and the econometrician observe. We will now examine how the existence of rational bubbles affects the properties of asset prices and discuss a number of methods for measuring such phenomena.

Mathematically, the standard efficient markets view of asset pricing (in the absence of bubbles) may be denoted as

(1) $$E(R_t | \Phi_t) = r_t + \alpha_t$$

where

$$R_t = \frac{P_{t+1} - P_t}{P_t} + \frac{D_t}{P_t}$$

and R_t is the return on the asset due to the capital gain and dividend yield, P_t is the price of the asset, D_t is the dividend issuing from the asset, r_t is the risk-free asset rate of return, and α_t is a risk premium which compensates the owners of the asset for the relatively high level of risk in the asset return. Φ_t is the information set available at time t and the expectation of R_t given Φ_t is rational, in the sense of Muth (1961).

The ex ante relationship in (1) can be expressed ex post in the following way

(2) $$R_t = r_t + \alpha_t + \epsilon_t$$

or

(3) $$g_t = r_t + \alpha_t - d_t + \epsilon_t$$
(4) $$= X_t + \epsilon_t$$

where ϵ_t is a random element distributed normally with mean zero and constant variance, g_t is the capital gain (price appreciation) component of R_t and d_t is the dividend yield.

In the situation where $X_t = 0$, g_t will appear in the data as a random variable without any trend component; the dynamic behaviour of P_t will therefore follow that of a random walk. Given, however, that $X_t > 0$ was the general state of affairs internationally in 1987 (and indeed, ex ante, is almost always true), as interest rates rose and dividend yields continued to fall, there is an implicit positive trend in stock price changes that will bias upward any tests for bubbles. Therefore, any finding that positively trending bubbles are empirically *unimportant* is even more strongly supported for the 1987 test period due to the upward bias in the test itself.[5]

The no-arbitrage condition in (1) can also be solved in terms of P_t using recursive substitution of P_{t+1} to yield

(5) $$P^*_t = \sum_{i=1}^{\infty}(1 + r_t + \alpha_t)^{-i}E(D_{t+i-1}| \Phi_t)$$

This equation prices the asset using the expected discounted value of all future dividends. Note that the price is strictly a function of the discount rate r_t, the risk premium α_t and the expected market fundamentals D_t.

The notion of a rational bubble enters when one considers other solutions to pricing the asset. One such solution takes the form

(6) $$P_t = \sum_{i=1}^{\infty}(1 + r_t + \alpha_t)^{-i}E(D_{t+i-1}| \Phi_t) + c_t$$
$$= P^*_t + c_t$$

and

(7) $$E(c_{t+1}| \Phi_t) = (1+r_t)c_t$$

In this case, the no-arbitrage condition between safe and risky assets holds but the price does not necessarily adhere to its fundamental value. Since r_t is non-negative, c_t is expected to grow over time and P_t is strictly greater than P^*_t.

There are various ways to specify c_t itself. A deterministic solution where $c_t = c_0(1+r_t)^t$ is somewhat unreasonable because it implies that the bubble will grow endlessly as t approaches infinity.

Another solution has

$$(8) \qquad c_t = \left\{ \frac{(1 + r_t)}{\Pi} \right\} c_{t-1} + \mu_t$$

or

$$c_t = \mu_t$$

The first equation occurs with probability π, while the second occurs with probability $(1-\pi)$. π is defined as the unconditional probability that the bubble continues while $(1-\pi)$ is the associated probability of a crash; μ_t is IID with mean equal to zero. The term $(1+r_t)\pi^{-1}$ is greater than $(1+r_t)$ during the duration of the bubble in order to compensate for the risk of the bubble bursting.

Finally, the bubble term c_t can be formulated in terms of a continuously regenerating process:

$$(9) \qquad c_t = c_{t-1} + \frac{\mu_t}{(1 + r_t)^t}$$

In this case, bubbles begin every period in a completely random fashion. Hamilton (1986) likens this process to looking at " which football team wins the Super Bowl before purchasing stock, because that is what everybody else is doing, and only by behaving in the same way can one make the expected rate of return $(1+r)$".

Relative to the no-bubble price solution P^*_t, the P_t resulting from any of these definitions of c_t has a higher variance, is less correlated to the market fundamentals and has the property of positive autocorrelation.[6] When testing for the existence of the third characteristic, one does not require any specification of D_t since the no-bubble alternative is a random walk with or without positive drift. This is an advantage of runs tests relative to tests for relative volatility and correlation since explicit assumptions must be made in the latter cases regarding the form of the fundamental factors. We will therefore focus on tests for autocorrelation in asset prices and, in particular, on the Evans (1986) modified runs test.

IIb. Empirical Bubble Tests

As mentioned above, the empirical tests have relied on testing for evidence of bubble behaviour against either random walk predictions or else against some specified model of asset pricing based on economic considerations. The variance ratio and runs tests fall into the former category while the variance bounds and fundamentals tests fall into the latter. While the former tests do not rely on assumptions of any specified model for asset pricing, they are essentially atheoretical and are therefore open to many interpretations.

The methodology used in this chapter is a variant of the runs test based on median returns. Evans (1986) presents a description of the test which may be summarised in the following fashion:

1) Generate 10,000 random samples of N pluses and minuses. For compatibility with the Evans paper, N is set equal to 155. The units for N are months in the case of the full equity bull market analysis and days in the case of the daily analysis for 1987.

2) For varying subsamples of size K in each of the 10,000 random samples, calculate statistics Z_K where

(10) $$Z_K = P_K - \frac{1}{2} * K$$

P_K is the actual number of pluses generated in sample size K and the second term on the right hand side of the equation is the random walk prediction of the number of pluses, ie 50% of the sample size.

For example, given that the subsample K is 12 months, the theoretically expected number of positive movements in a random variable is equal to 6. If the data sample actually indicates that 7 positive movements occurred, then Z_{12} is equal to 1. The value Z_K is therefore defined as the most extreme deviation from the null hypothesis of a random walk for a given subsample size.

3) Calculate A_K as the number of random samples of size K (maximum 10,000) that take on values greater than or equal to Z_K; A_K is therefore a *cumulative* distribution over Z_K.

For example, if K = 12 as above and the 10,000 random samples are distributed with 6,000 samples having Z=0; 3,000 with Z=1; 900 with Z=2; 90 with Z=3 and 10 with Z=4, then the distribution of A_{12} has a value of 10,000 at $Z \geq 0$; 4,000 at $Z \geq 1$; 1,000 at $Z \geq 2$; 100 at $Z \geq 3$ and 10 at $Z \geq 4$.

The value of $A_K/10{,}000$ is the nominal significance level used to test deviations from a random walk for any given Z and K. Given a critical value of .05, only the Z_{12} values equal to 3 and 4 in this example would indicate statistically significant positive deviations from a random walk. The reason for this is that $A_K/10{,}000$ at Z=3 and Z=4 is equal to .01 and .001 respectively.

A further step is undertaken to control the degree of data mining which may occur in any exercise such as this, where substantial degrees of freedom exist for choosing sample sizes and sample periods. Therefore,

4) Generate a further 10,000 random samples and set Y equal to the minimum of A over K.

$$Y = \min A_K \tag{11}$$

Y is the most extreme value of A for all subperiods K within N; low values of Y indicate higher probabilities of deviation from a random walk. In our example, Y is set to 10 since this is the most extreme deviation from a random walk given a subsample K of size 12. Adjusting the nominal significance level of $A_K/10{,}000$ by using the distribution of Y controls for potential data mining by the econometrician and therefore allows for a free choice of any sample size for consideration. In essence, this step is an optimal data mining exercise over 10,000 sample periods.

Given these Monte Carlo results for comparison, the researcher selects a sample size for his data, calculates the Z values and then obtains the bubble probabilities A and/or Y.

III. Empirical Results

The Evans bubble methodology is applied to the case of 23 countries over two time frames: October 1982 to October 1987 for the monthly data analysis and 2 January 1987 to 16 October 1987 for the daily data analysis. The first time frame is chosen to approximately correspond to the present upswing in the American business cycle and to provide a 5 year sample that is common across countries and appropriately sized to use Evans' derived probability tables. The second time frame is chosen to capture the rapid equity price appreciation in most exchanges prior to the crash and ends on the last trading day prior to the crash.

All of the data are expressed in percentage rate of change and are measured from closing day prices in consecutive periods. The probability values are calculated using a null hypothesis of a random walk in prices against the alternative hypothesis of positive movements in excess of a random walk. As noted in Table 1, one index is used per country with the listed exceptions taking on values equal to unweighted averages of several indices. The separate probability values for these latter countries do not differ markedly from each other and therefore the use of an unweighted average value is a very close approximation to the relevant bubble probability.

As one can see from Table 1, the range of probability values extends from 0.0027 to over 0.5. The countries are divided into categories according to whether their values fall within the .05 or .20 probability bounds and it is apparent from this distinction that less than one third of the countries demonstrate strong evidence of bubble behaviour. It should be noted that for the United States, the country which precipitated the sharpest international price movements on 19 October 1987, there is no evidence of any bubble activity whatsoever. In addition, as will be seen in the next section, it appears to be difficult to explain the cross country variation since countries with markedly different characteristics share similar probability values. For example, stock market capitalization or size of the domestic economy cannot explain the similar bubble activity in Japan and New Zealand nor can the differences in international investment access that exist in South Korea and Hong Kong explain their relative rankings.

Table 2 extends the monthly analysis to subperiods of K years within the 5 year bull market examined. Evans' adjusted probability values to control for data mining are used in this table, in contrast to the other probability tables, since the sample size is variable and there is a deliberate attempt to find the periods where bubble activity is most prominent. As with Table 1, there is evidence in many countries that prices deviated from random walks for sustained periods, although it is difficult to explain in a general fashion why the deviations occurred. The bubbles in Italy, Sweden and Austria are present even in the absence of longer term indications over the entire sample period, an illustration of the value of choosing varying time periods for an analysis of this type.

The previous analysis is refined and extended in Table 3 where daily price changes are tested over the 1987 pre-crash period. In addition, equity premiums are calculated, where the premium is defined as the percentage stock price change less the yield on risk-free bonds, and these values are examined for the existence of bubbles.[7] A comparison is also made with probabilities that are calculated from the beginning of the year to the date when the particular market peaked, usually prior to the crash. As is intuitively obvious, these latter values should always indicate higher bubble probabilities than those ending at the market crash.

Once again, the evidence for a bubble triggering the American market crash is not supported empirically; the values for both the market price and equity premium fall considerably outside of standard significance levels. A number of countries exhibit strong deviations from random walks at their market peaks but less so at the time of the crash. In fact, if a significance level for the existence of bubbles is imposed at approximately 95%, only Australia, Japan and the United Kingdom provide evidence for bubbles in prices and only Japan shows bubbles in the equity premium. As well, in the latter case, it is likely that the equity premium evidence is weaker than suggested in the table since daily varying bond prices were not available for this study. These daily movements, in a period when interest rates were rising rapidly, would have served to reduce the positive movements in the index and, therefore, the probability of deviations from a random walk.[8]

This section demonstrates that the Evans methodology can be used to find and calibrate deviations from random walks for asset prices expressed in rate of return form. The evidence does not support the argument that the American market had bubble characteristics prior to the crash but does find that other markets deviated from random walks for prolonged periods. Japan and the United Kingdom are especially important countries in the latter category because of their market size and international influence and also because of their high bubble ranking in both the monthly and daily analyses. The evidence is consistent with other studies that use different testing methodologies and find significant price deviations from random walks.[9]

IV. Option Pricing Evidence

Option pricing theory provides another perspective from which to judge the validity of the bubble explanation of the crash. Since the prices of options and the underlying cash market are intimately related, any bubble which occurs in the latter should by definition occur in the former. Likewise, the increase in the volatility of stock prices which accompanies the introduction of bubbles should also be reflected in option prices. Lastly, given that stock market price volatility can be implied from standard option pricing formulas, this volatility should increase over the period during which the bubble is formed.

It can be shown that volatility (as measured by the current variance of asset prices) is increasing in terms of the introduction of a bubble element in prices and rises over time as the bubble progresses. Following Blanchard and Watson (1982), return to equation (6)

$$P_t = P^*_t + c_t \tag{6}$$

The definition of the conditional variance of X is

$$V(X| \Phi_t) = E(X - E(X| \Phi_t))^2 \tag{13}$$

and so

$$\begin{aligned} V(P_t| \Phi_t) &= E(P_t - E(P_t| \Phi_t))^2 \\ &= E(\zeta_t + \xi_t)^2 \end{aligned} \tag{14}$$

where the first element is the innovation (unexpected component) in the fundamentals term and the second element is the innovation in the bubble term.

Separating elements,

$$(15) \qquad V(P_t | \Phi_t) = V(\zeta_t) + V(\xi_t) + 2\ cov(\zeta_t, \xi_t)$$

Assuming that the covariance term is non-negative, $V(P_t | \Phi)$ is strictly greater than $V(P^*_t | \Phi)$, the no-bubble case; this assumption is not very strong since it is most unlikely that positive innovations in the fundamental term are positively correlated with adverse bubble innovations. Since the implied variance derived from option pricing purports to measure the true variance of stock prices, one expects to find higher implied volatility in periods where bubbles occur.

It is trivial to show that $V(c_t | \Phi)$ is equal to σ^2_μ, and there is, therefore, no relation between the variance of the bubble term conditional on the information set and c_t itself. However, to see that $V(c_t)$ is strictly increasing in terms of c_t, and that the growth in the bubble term over time will lead to a monotonic increase in the variance of P_t, substitute equation (8) into the following equation for the unconditional variance and set $r_t = r$

$$(16) \qquad V(X_t) = E[V_{t-1}(X_t)] + V[E_{t-1}(X_t)]$$

Rearranging and cancelling terms results in

$$(17) \qquad V(c_t) = \sigma^2_\mu + (1+r)^2\ V(c_{t-1})$$

since μ_t is IID with constant variance and variables at t-1 are in the information set at time t.[10] Using the bubble formulation in (9) leads to similar results where $V(c_t)$, and therefore $V(P_t)$, is increasing in c_t.[11]

The bubble effect on option prices themselves can be seen by using the benchmark call option pricing formula of Black and Scholes (1976)

$$C_t = P_t N(X) - K_t r^{-t} N(X - \sigma_t \sqrt{t}) \tag{19}$$

where[12]

$$X = \frac{\log \left(\frac{P_t}{K_t} r^t \right)}{\sigma_t \sqrt{t}} + \frac{1}{2} \sigma_t \sqrt{t} \tag{20}$$

As Cox and Rubinstein (1985) show,

$$\frac{\delta C_t}{\delta P_t} = N(X) > 0 \tag{21}$$

and

$$\frac{\delta C_t}{\delta \sigma_t} = P \sqrt{t}\ N'(X) > 0$$

and so we should expect option prices, as well as the implied stock price variance, to increase in a bubble environment relative to a non-bubble environment and also during the progression of the bubble itself.

Table 4 and Diagram 1 demonstrate that the theoretical expectation of volatility under conditions of a bubble in prices is at variance with the empirical evidence, at least for the UK in the 1980's. The table specifies the averages and coefficients of variation of σ_t over several test periods between 1984 and 1987. The data frequency is weekly and the calculation is based on the weighted implied standard deviation type of formula found in Chiras and Manaster (1978).[13]

While the mean value of σ_t shows a trend increase from 1984 to 1986, Diagram 1 indicates that this pattern is uneven. As well, there is no significant upward trend in the 13 weeks prior to the crash. If anything, the options pricing data would indicate that the bubble burst in the week starting 1 June 1987, when σ_t was at a local apex. Looking back to Tables 1 and 3, in contrast, one sees that strong evidence exists there for bubbles in prices since the probability of a deviation from a random walk over the full bull market is .9841 and the associated probability during 1987 is .9464.

It therefore appears that there is some justification for rejecting the rational bubble explanation in the UK owing to the conflicting evidence shown in the options market. Other explanations for non-random pricing behaviour, such as those discussed in Footnote 5, are therefore much more plausible.

One leading candidate may be an asymmetric distribution in the innovations of fundamental factors. The UK corporate sector has posted a number of years of what many see, based on historical observation, as surprisingly strong growth figures. It may be that the stock market discounted these surprises as they occurred and, as a result, created a positive trend movement in prices; the asymmetry here is a positively skewed distribution of news coming to the market. The 1987 daily data results do not, however, support this sort of medium-term explanation since this asymmetry would have to operate on a daily basis.

V. Cross Country Differences

The hypothesis that bursting bubbles lie behind the occurrence of the 1987 crash leads on to specific implications for post crash price movements. Assuming that bubbles exist, and that they are burst at a constant rate over time according to their initial strength, it is possible to test the bubble theory by examining the correlation between price declines and bubble probabilities for different countries. It is expected that a positive correlation will exist since higher bubble probabilities should correspond to greater price declines.

The regression results reported in Table 5 and Diagrams 2 and 3 demonstrate that there is no correlation between bubble probabilities and post crash price performance. Table 5 presents ordinary least squares estimation equations where the cross-sectional price declines at a given point in time are regressed against the respective bubble probabilities. Diagrams 2 and 3 plot bubble probabilities against price declines where the X axis is labelled by country and is ordered in terms of declining bubble probabilities.

The F and t statistics from the table indicate that the explanatory power of these estimations is absolutely insignificant. In addition, if the focus is directed solely to those probabilities lying within the .05 probability bound, (Finland, Japan, the United Kingdom, New Zealand, France, Australia and Ireland for monthly data and Australia, the United Kingdom and Japan for daily data), it is readily seen from the diagrams that there is an incorrectly signed negative correlation in the former case and a correctly signed positive correlation in the latter. The small sample size for the daily data case (three observations) does not, however, allow firm conclusions to be drawn from the data.

This simple test of the bubble story seems to suggest that more sophisticated explanations are required in order to account for the marked differences observed across countries prior to the crash. Possible explanations for the differences might rest on continued batches of unexpectedly good news in the countries with indications of bubbles or evidence for continued learning processes due to structural changes in the flow of news to the market.[14] However, the failure of the regressions reported here seems to imply that the bubble story cannot be true for all of the countries in the sample. Certainly, it is not true for the United States, the central country during the crash, since it exhibits insignificant probabilities of non-random behaviour;[15] at the same time, this country's post crash price adjustments are in the middle of the range of international responses.

While a simple risk adjustment is used in the daily data analysis by calculating the equity premium, it can be argued that the prices should be appropriately adjusted for systematic risk on the basis of a CAPM-type model. Aside from the greater data requirements that this sort of exercise would entail, it is unlikely to shed further light on the issue of cross country differences. It is difficult to support the argument that the countries with high bubble probabilities were riskier over the specified sample periods than those with low probabilities. For example, the risk rankings of Finland, Australia or France seem to be little different from those of Sweden, Hong Kong or West Germany on an a priori basis, and yet each pair have divergent bubble probabilities.

VI. Conclusions

This chapter presents international estimates of deviations from random walk behaviour in stock market indices over the period 1982 to 1987. Two hypotheses are tested and rejected: first, that there is evidence for a bubble in the United States indices prior to the October 1987 market crash and, second, that the post crash price declines can be explained by the pre crash bubble probabilities.

While these hypotheses are rejected, the very existence of non-random behaviour may provide a challenge to the efficient markets hypothesis if it is assumed that information arrives into the market in a random fashion. A complete theoretical model of some alternative price generation mechanism in the stock market is needed in order to test whether this particular empirical bubble methodology has explanatory power for such issues. In terms of this thesis, however, the rejection of a bubble explanation for the 1987 crash, and the finding that bubbles existed for other countries and subperiods, are both consistent with a theory of stock market pricing that stresses economic *and* non-economic factors.

1. A bubble is defined in this chapter as a statistical construct that measures the probability of a deviation from a random walk in price movements. Evans (1986) presents the methodology and distribution properties behind this construct. It should be stressed that this definition of a bubble is not necessarily equivalent to theoretically defined bubbles or to the notion that prices may be over-valued relative to fundamental or other factors. A fuller discussion of these points is contained in Section II below.

2. There appears to be a widely held belief that the October 1987 crash was the inevitable result of previous market overvaluation. Market participants such as John Hennessy (1988) of CSFB talk of 'excessive speculation', government reports and politicians cite 'speculative bubbles' (Glauber (1988) and Healey (1988)) or state that the bull market was 'clearly too good to last' (Lawson (1987)). The American General Accounting Office (1988) report on the crash stressed that prior overvaluation may have existed in the market while the Chairman of the Federal Reserve Board of Governors stated that prices were unsustainably high (Greenspan (1988)).

The post-crash surveys conducted by Shiller (1987,1988) found that investors responded to price signals in a self-fulfilling fashion while generally ignoring news which was concurrently entering the market information set. While many argued the case for overvaluation from hindsight, most prescient market commentators felt that Japan, and not the United States, was the prime candidate for a sharp market correction; see Soros (1987) on this point. Santoni (1987) provides further references from the popular press and also lists a number of similar commentaries on the possibility of bubbles causing the 1929 crash. One recent comparison of the 1929 and 1987 experiences is found in Kindleberger (1988).

3. This classification is more fully specified in Evans (1986), Blanchard and Watson (1982) and Hamilton (1986) and the references therein.

4. The variance bounds tests are found in the papers by Shiller (1981) and Kleidon (1986) while the runs tests have been undertaken in Blanchard and Watson (1982). One recent reference to the variance ratio test is Poterba and Summers (1988). The fundamentals based models take a number of forms and can be found in the works of West (1985), Shiller (1984) and Summers (1986).

5. There are, of course, many other reasons for the detected drift or trend movements in equity prices. As Evans (1986) discusses, the distribution of price changes may be skewed to the right due to asymmetric distributions of fundamental factors which affect asset prices. Incremental learning by agents over regime shifts may also induce positive autocorrelation in prices, as may any other factors which lead to an overshooting type of pricing equilibrium in the manner of Dornbusch (1976).

Other explanations rest on assumptions of irrationality, unobserved fundamentals or pure random chance during a given subperiod. These latter explanations are, however, difficult to analyze using present theoretical and empirical techniques which rely on optimising behaviour and appropriate specification of the data and model.

6. See Blanchard and Watson (1982) for a discussion of these points.

7. Using the earlier notation, the relationship that is tested is

$$g_t - r_t = \alpha_t - d_t + \epsilon_t \quad (12)$$

The use of the equity premium should dampen the trend element of g and therefore reduce the positive bias in the bubble test. This will accordingly reduce the probability of rejecting a random walk in prices.

An examination of Table 3 shows this to be the result for all countries and all time periods except for Japan and the United States on October 16th. In the former case, weekly bond yields are used to proxy r_t and the low level and variability of these rates over 1987 made no difference to the bubble probabilities. In the latter case, both probabilities are well outside conventional significance levels.

The apparently sizeable change in the American probabilities in Table 3 is a function of the distribution of Z. For example, given that K = 120 (equivalent to a sample size of 4 months in the daily test), the Monte Carlo results indicate that A changes from .0001 to .0012 to .0144 to .0973 to .3802 to .8729 as Z declines from 24 to 4 in increments of 4; the increments between values of A therefore increase as Z decreases. In this regard, it is not surprising that the significance levels for the United States reported as .3729 and .2555 on October 16th differ from each other by a Z value of only one.

8. Roll (1989) presents evidence for 23 countries using daily data during 1987. Employing a variance ratio test, he finds that 18 of the 23 exhibit significant positive autocorrelation in stock prices. Since bull markets tend to have relatively larger positive price movements, while bear markets exhibit relatively larger negative price movements, see Schachter et al (1985), the Roll methodology is biased towards finding positive correlations over the bull market of 1987. In contrast, the sign test that underlies the Evans methodology is invariant to periods of bullish and bearish price movements since it is adjusted for potential data mining biases. Although this chapter finds that 5 out of 9 price indices deviate from random walks prior to the market peaks, see Table 3, it is difficult to make an exact comparison with the Roll paper since it is not clear which countries deviate from random walks there.

9. Examples of these studies are found in the references of Poterba and Summers (1988). The Poterba and Summers paper itself is in full agreement with this chapter's conclusions since they find evidence of positive correlation in stock returns at frequencies of less that one year for a wide variety of countries. It should be stated, however, that very few of their results are statistically significant at standard levels.

10. Although the variances in Equation 17 are likely undefined from period to period because of non-stationarity while the bubble is forming, the probability limit of $V(c_{t-k})$ as k increases from 1 should become stationary due to the rise and fall of the bubble over time. Therefore, Equation 17 is defined for some k > 1 and the variance of the bubble term grows over the progression of the bubble. I am indebted to Enrique Sentana for pointing out this line of thought to me.

11.

The resulting equation is

$$(18) \qquad V(c_t) = \sigma^2_\mu (1+r)^{-2t} + V(c_{t-1})$$

12. C_t is the spot option price, P_t is the stock price, K_t is the exercise price, σ_t is the standard deviation of P_t and N is a cumulative standard normal distribution for the given parameters.

13. I am grateful to Prof. Julian Franks for allowing me to use his data on implied volatility.

14. A discussion of the latter explanation in found in Tabellini (1988). The author notes, in a discussion centred on the volatility of exchange rates, that the existence of bubbles may indicate only that a continual learning process takes place in the market. This activity is due to expectational uncertainty concerning parameter stability in economic models.

15. This conclusion is consistent with the results in Santoni (1987). He presents autocorrelation coefficients and a runs test on daily price changes in the Dow Jones Industrial Index from January 2 1986 to August 25 1987 (the US market peak). The results of his exercise indicate that the hypothesis of random walk behaviour cannot be rejected.

Table 1

International Comparison of Bubbles in Price Indices
October 1, 1982 to October 1, 1987

Category	Country	Probability of Random Walk (in ascending order)
"Bubble"	Finland	.0027
	Japan	.0142
	United Kingdom	.0159
	New Zealand	.0182
	France	.0182
	Australia	.0303
	Ireland	.0396
Near "Bubble"	Spain	.0814
	Canada	.1773
	Norway	.1773
	Portugal	.1773
No "Bubble"	Sweden	.3121
	Germany	.4089
	Netherlands	.4955
	Belgium	.4955
	Austria	.4955
	Switzerland	>.5
	United States	>.5
	Hong Kong	>.5
	Greece	>.5
	South Korea	>.5
	Italy	>.5
	Denmark	>.5
	Singapore	>.5

Note: The data consist of commonly used composite or industrial indices which are sampled at the last trading day of each month. One index per country is examined, with the exception of the following countries which are ranked according to the unweighted average of several broad domestic indices: United States (7),United Kingdom (6), Japan (3), Australia (3), Netherlands (3),France (2), Germany (2), Italy (2), Denmark (2) and Hong Kong (2). The probability values are calculated in Evans (1986) using 10,000 random number computer simulations of 155 months each. A bubble is defined as upward movements in indices over time that are in excess of the number predicted by the random walk theory. A certain probability of a random walk would be expressed as a value equal to 1.
Data Source: Datastream

Table 2

International Comparison of Bubbles in Price Indices
Subsamples from October 1, 1982 to October 1, 1987

Country	Subsample	Probability of Random Walk (in ascending order)
Bubble		
Finland	8/85 - 8/87	.0009
U.K.: FT All Share	7/84 - 7/87	.0247
Italy	10/84 - 10/86	.0335
Near Bubble		
U.K.: Total Market	7/84 - 7/87	.0707
France	7/84 - 7/87	.0707
Canada	10/82 - 10/83	.1070
Finland	10/82 - 10/83	.1070
Greece	8/86 - 8/87	.1070
Ireland	9/86 - 9/87	.1070
Italy	4/85 - 4/86	.1070
New Zealand	1/83 - 1/84	.1070
	11/85 - 11/86	.1070
Austria	8/83 - 8/85	.1486
Portugal	8/83 - 8/85	.1486
Sweden	7/85 - 7/87	.1486
No Bubble		
Japan	subsamples of 12 months	>.2
West Germany	duration	"
Spain	"	"
Norway	"	"
Belgium	"	"
Australia	"	"
Switzerland	"	"
United States	"	"
Hong Kong	"	"
South Korea	"	"
Denmark	"	"
Singapore	"	"

Note: The data consist of commonly used composite or industrial indices which are sampled at the last trading day of each month. The probability values are calculated in Evans (1986) using 10,000 random number computer simulations of 155 months each. A bubble is defined as upward movements in indices over time that are in excess of the number predicted by the random walk theory. A certain probability of a random walk would be expressed as a value equal to 1. Data Source: Datastream

Table 3

International Comparison of Bubbles in Price Indices
January 2, 1987 to October 16, 1987 and Market Peak

Country	Peak	Market Peak Price	Market Peak Equity Premium	October 16 Price	October 16 Equity Premium
Pacific Economies					
Australia Joint All Ordinaries	Sept 21	.0030	.0782	.0324	.3242
Japan Nikkei-Dow	Oct 14	.0410	.0410	.0544	.0544
Hong Kong Hang Seng	Oct 1	.1290	.3822	.1602	.4228
Atlantic Economies					
United Kingdom FT-SE 100	July 16	.0182	.0587	.0536	.1794
United States Dow Jones Industrials	Aug 25	.0410	.0480	.3729	.2555
Canada Toronto Composite	Aug 13	.0109	.0449	>.5	>.5
European Economies					
Switzerland Swiss Bank Corp. General	Oct 5	>.5	>.5	>.5	>.5
France Paris CAC General	March 26	.4716	>.5	>.5	>.5
West Germany FAZ General	Aug 17	>.5	>.5	>.5	>.5

Note: The figures show the probability that the prices and equity premiums follow random walks; a bubble is defined as positive index movements in excess of that predicted by a random walk expectation. Probabilities are calculated as in Evans (1986) and are interpolated to account for the larger sample sizes used here. The equity premium is calculated as the return above that earned by risk-free assets (defined as 30 to 90 day bonds where the prices are market determined). The Hong Kong equity premium uses a U.S. bond as the risk-free asset, while the Japanese bond varies only on a weekly basis.
Data Source: Datastream

Table 4

Implied Volatility of United Kingdom Stock Prices
Derived from Option Prices, 1984 to 1987

Sample Period	Mean	Coefficient of Variation
15 October 1984 - 14 October 1985	.114	.14
14 October 1985 - 13 October 1986	.180	.29
13 October 1986 - 12 October 1987	.195	.22
5 January 1987 - 1 June 1987	.207	.16
1 June 1987 - 12 October 1987	.217	.14
19 October 1987	.739	.04

Note: The coefficient of variation is the ratio of the standard deviation to the mean. The mean for 19 October 1987 is the value during that week while the standard deviation is that for 1 June 1987 to 12 October 1987. The index used is the FTSE 100. The data are provided courtesy of Prof. J. Franks.

Table 5

Regression Results: Cross Section of Monthly Bubble Probabilities on Various Periods of Stock Price Declines

Independent Variable	Coefficient Value (t statistic)	F statistic
One day after crash	-1.56 (0.28)	.076
Two days after crash	6.88 (0.98)	.954
One week after crash	1.68 (0.24)	.059
One month after crash	5.74 (0.77)	.596
Six months after crash	5.63 (0.50)	.249

Note: Sample size is generally equal to 22. The one day regression excludes Hong Kong while the two day regression excludes both Hong Kong and Singapore due to missing data. All equations include a constant term which was always negative and significantly different from zero at .95 probability. The F statistics test the null hypothesis that the estimated coefficient is equal to zero.

Diagram 1

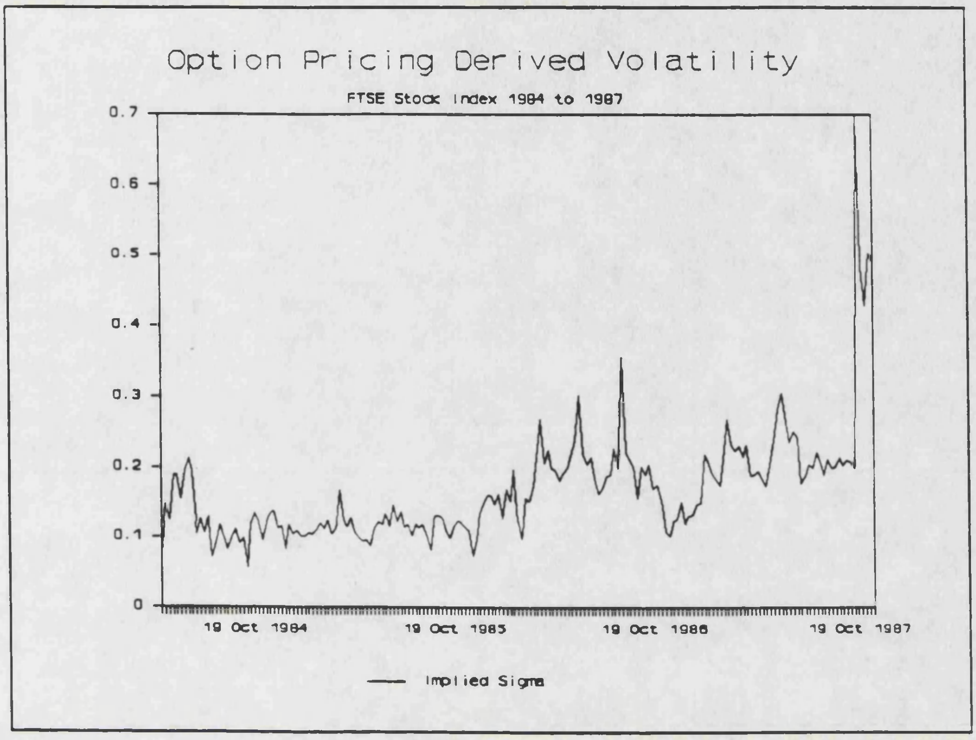


Diagram 2

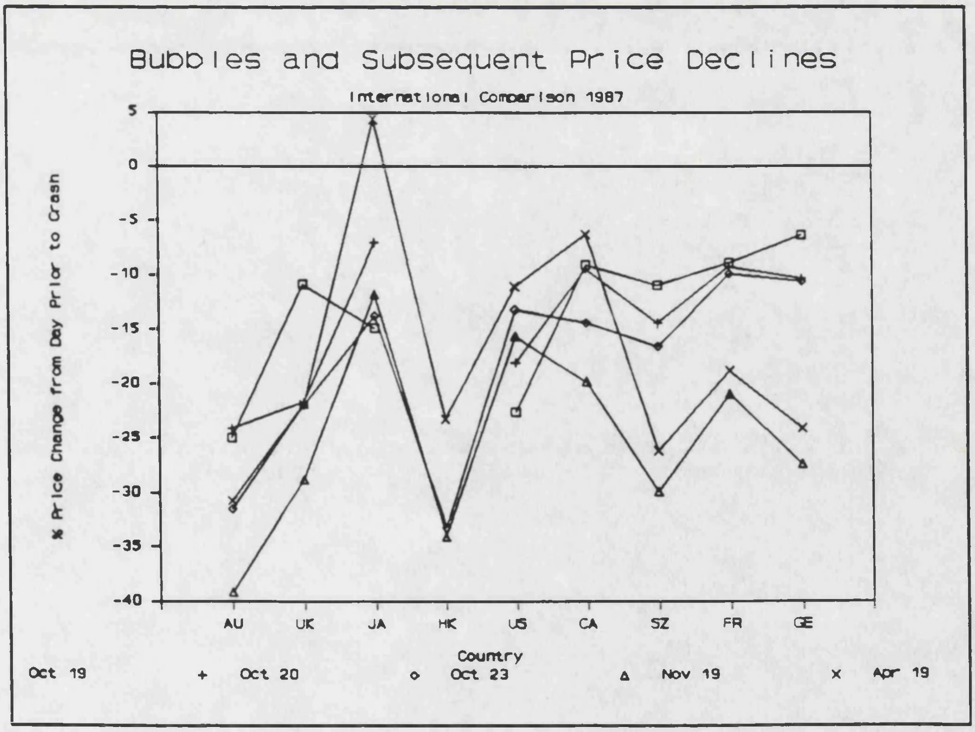
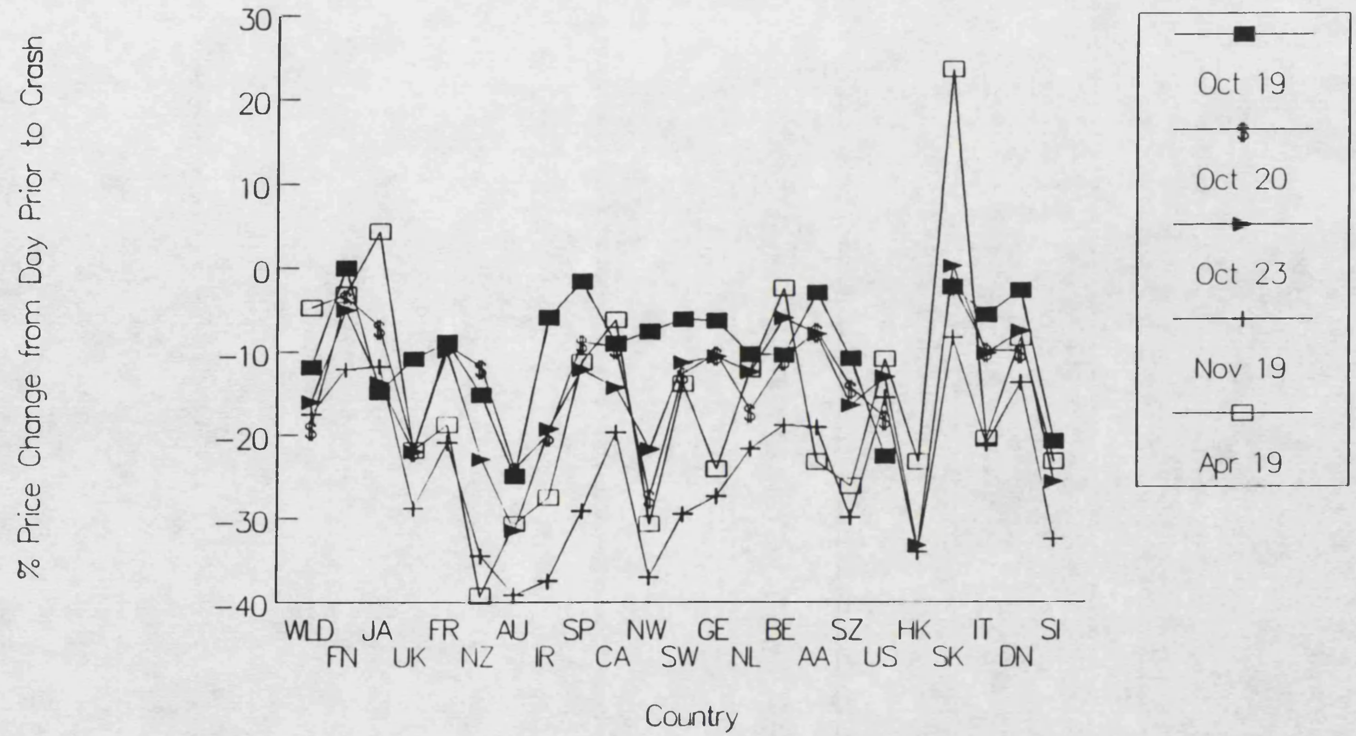


Diagram 3

Bubbles and Subsequent Price Declines
International Comparison 1982–87



Chapter II: Stock Prices and Inflation

I. Introduction

The previous chapter investigated the stock market crash of 1987 and found that a rational bubble explanation is not wholly convincing, although there exists sufficient evidence of non-random price behaviour to bring into question the assumption of efficient markets. This chapter broadens the analysis of equity prices by extending the investigation back in time, while exploring whether nominal prices are important determinants of the real equity premium. In particular, it appears that inflation and nominal interest rates do not have similar effects on equity prices (at least in the U.K.) over a sample period extending from 1700 to the present.

The examination of the link between inflation, both expected and unexpected, and share prices follows an extensive literature which documents a negative relationship between the two.[1] Virtually all previous studies confine their analysis to the post-1950 period, however, and none (to our knowledge) examine the 18th and early 19th centuries. Using a newly developed data set, this chapter finds that the negative relationship between inflation and excess returns is confined to the post-1950 period. In the preceding two and a half centuries, there is no consistent correlation between the two; if anything, there are long periods of time when there is a positive association.

Even though inflation is not found to be generally detrimental for equity returns, there is evidence that *nominal* interest rates have a consistently negative relationship since 1700. As well, the 'Fisher Effect' (the notion that nominal interest rates rise point-to-point with expected inflation) is essentially absent in the pre-World War II period, a result possibly related to the gold standard of that period.[2] So, while the use of recent data makes it difficult to discriminate between nominal interest rates and inflation as predictors of stock returns,[3] the use of data from 1700 is more appropriate in this respect. The data, methodology and results are discussed in Sections II and III below.

There are a number of interesting attempts to explain the link between inflation and stock returns, for example, Fama (1981), Geske and Roll (1983), Modigliani and Cohn (1979), Pindyck (1988) and Stulz (1986), to name the main contributions. Section IV briefly reviews the implications of our findings for such work and then concludes the chapter. Finally, a detailed appendix follows which presents the data used here (and later in Chapter III of this thesis).

II. Data and Methodology

In the work below, we present estimated equations of the form

(1) $$R_{Et} - R_{Ft} = \alpha_0 - \alpha_1 E_{t-1}\pi_t - \alpha_2 E_{t-1}R_{Ft} + u_t$$

where R_{Et} is the ex post return on equities, R_{Ft} is the interest rate, $E_{t-1}\pi_t$ is the rate of inflation expected at time t-1 and u_t is distributed $N(0,\sigma^2)$. The dependent variable is the excess return on equities (or the equity premium).

Equation (1) is representative of much of the research in this field. Given the theoretical result of the Capital Asset Pricing Model (CAPM) that the equity premium is a function of risk alone, the 'puzzle' that arises here, as elsewhere, is that α_1 and/or α_2 are estimated to be statistically significant. Note that although the equation takes required excess equity returns to be constant, this assumption will be relaxed below by introducing the expected volatility of returns as an additional regressor.

IIa. The Data

As discussed in Appendix I, there is no single index of share prices that goes back to 1700. Researchers are, therefore, forced to splice together various different indices to obtain a complete series. While coverage may vary across sectors and companies over time, the indices used here have the common property that they measure the changes in share prices of the leading quoted companies of the day.

Unfortunately, for a part of this period (1700 to 1810), the data are only available in the form of annual averages[4]; for consistency, the entire data set was, therefore, put together in this way. The data were then transformed prior to estimation to deal with the moving average error process which is introduced by averaging truly random processes.[5] As a robustness check, estimates are also presented below for selected subsamples where end-of-period data exist.

A second problem with the data is the absence of a long series on dividend yields.

Therefore, R_{Ft} generally refers to only the capital gain portion of equity returns, except for those subperiods indicated below where dividend yield information is available.[6]

As mentioned in Appendix I, consumer prices are used to measure inflation and the short and long interest rates are the three month commercial paper rates and 3% government consols, respectively. Due to the absence of data prior to 1827 and the use of lagged instruments, equations employing the short interest rate begin in 1830.

Before turning to the formal results, it is worth reminding the reader that the behaviour of inflation over the past half century has been quite different from that in the previous two centuries. Diagram 1 demonstrates that the mean inflation rate from 1700 to the 1930s was very close to zero. In contrast, the period since that time is marked by the absence of deflation, with the exception of the year 1943 (which is marked in any case by wartime price controls and is not a free market outcome). The radical change in the underlying inflation generation process is suggestive of the possibility that the relationship between inflation and equity returns might also have changed.[7]

IIb. Methodological Issues

As previously mentioned, the use of time-averaged data implies that the error term (u_t) in Equation (1) will follow a first-order moving average process with a serial correlation coefficient of approximately 0.25, (see Working (1960)). We replace $E_{t-1}\pi_t$ and $E_{t-1}R_{Ft}$ in Equation (1) by the actual outcomes, which, under a Rational Expectations assumption, only differ by a serially uncorrelated error term. In addition, the 'errors-in-variables' problem is treated by using instrumental variables estimation.

However, as Hayashi and Sims (1983) note, some care is needed in a situation where there is a moving average error. Therefore, in order to preserve the timing conditions that make the instruments and the transformed disturbances orthogonal, the data are pre-transformed by subtracting future rather than past values.[8] Sargan's (1958) test for the validity of instrumental variables is also reported.

III. Empirical Results

IIIa. Basic Results: Excess Returns and Inflation

The link between excess returns and inflation is examined first by setting $\alpha_2 = 0$. The results are shown in Table 1 where two alternative dependent variables are employed: ERS, which is the excess return on equities defined relative to the short interest rate, and ERL, the excess return relative to long interest rates. The instruments that are used are lagged, untransformed values of inflation, stock returns, industrial production growth, real money supply growth, interest rates and armed forces employment (to capture the effect of wars and government expenditure).

It is clear from Table 1 that a significant negative relationship between expected inflation and excess returns is confined to the post-1950 period. The estimated coefficients on expected inflation in earlier subperiods range from -0.01 to +0.44. Notice that there is some evidence of a modest *positive* association between inflation and excess returns over 1830 to 1913. The basic thrust of the result is independent of the form of the left hand side variable, the precise sample period, or the actual estimation technique (the OLS and IV results are not very dissimilar).

We next investigate the relationship between interest rates, inflation and excess returns.

IIIb. Basic Results: Excess Returns and Interest Rates

In this section, α_1 is set equal to zero to concentrate on the effect of nominal interest rates on excess returns. The results of Table 2 indicate the existence of a consistent, negative relationship between expected interest rates and excess returns; this holds irrespective of subsample or choice of dependent variable. The coefficient on the nominal interest rate is also generally statistically significant and large, ranging from -1.30 to -6.09.

The basic result that there is a consistent, negative relationship between nominal interest rates and the equity premium also holds if end-of-period data are used, or if equity returns are measured by including the dividend yield. This may be seen in Table 3, where, in the upper section, evidence is presented for end-of-period data; since the Hayashi-Sims transformation was unnecessary, conventional instrumental variable estimates are given. Notice that the results are very similar to those obtained using the H-S transformed data (e.g., over 1914-1949, the coefficient on interest rates is -3.06, as compared to -2.92 previously).

The lower section of Table 3 contains estimates of the interest rate-excess return relationship when excess returns are correctly defined to include the dividend yield. Once again, the results are largely unchanged: the coefficient for 1919-1983 is -2.96, as compared to -2.92 previously, although, over 1950-1983, the coefficient falls from -1.97 to -1.41. So, the basic result does seem robust to the definition of the dependent variable and whether or not the Hayashi-Sims transformation is needed.

So, on these results, inflation appears to affect excess returns, but only via the nominal interest rate. Additional direct effects from inflation are tested, however, in Table 4. The typical result there is that the nominal interest rate depresses excess returns. Further, inflation only contributes any significant additional explanatory power in one out of the ten cases presented.[9] This suggests that attention should probably be concentrated on the interest rate estimates shown in Table 2.

IIIc. How Robust is the Link Between Nominal Interest Rates and Excess Returns?

The results in Table 2 suggest that there is a fairly stable and consistent negative correlation between expected nominal interest rates and excess returns. In this section, various experiments are performed to assess the robustness of this empirical result.

Under the standard CAPM,

$$(4) \qquad E_{t-1}(R_{Et} - R_{Ft}) = \alpha_0 + \beta E_{t-1}\sigma^2_t$$

where σ^2_t is a measure of equity risk, (see Merton (1980)). Equation (1) excludes any term which allows changes in volatility to affect stock returns, and so the first robustness check introduces lagged squared excess returns as a proxy for expected volatility.[10] Although expected volatility often attracted a positive coefficient (which was sometimes statistically significant), the basic negative correlation between nominal interest rates and excess returns was unaffected. Columns 1 and 2 of Table 5 show representative results of this experiment.

A second factor which may affect the basic result stems from Fama's (1981) assertion that the correlation between inflation and the stock market may be spurious. He argues that high inflation is merely a proxy variable for lower future output growth (which it might be according to money demand theory). Similarly, nominal interest rates may also presage lower activity and, hence, be associated with lower equity returns.

In deference to this view, the future growth rate of industrial production was added to Equation (1).[11] The results in Table 5, Columns 3 and 4, show that our basic argument about nominal interest rates stays intact with a coefficient which is largely unchanged. Additional experiments using future growth in real GNP for shorter subperiods produced similar results.

IIId. The Changing Relationship Between Interest Rates and Inflation

The previous results show that higher expected nominal interest rates depress stock returns, while changes in expected inflation rates bear no consistent relationship with these returns. This section examines how the relationship between the two nominal variables has changed over time.

In our experiments, when the following equation was estimated

(5) $$R_{Et} - R_{Ft} = \alpha_0 + \beta_1 E_{t-1}\pi_t + \beta_2 E_{t-1}r_t + u_t$$

(where $E_{t-1}r_t$ is the expected real interest rate), we obtained a negative statistically significant estimate of β_1 and, typically, $\beta_1 = \beta_2$. However, if $E_{t-1}r_t$ is omitted from the equation, then β_1 is estimated to be positive prior to 1950 and negative after that date. Of course, if Equation (5) describes the true underlying data generation process, then the estimate of β_1 is biased for standard omitted variables reasons, i.e.

$$\text{(6)} \qquad \text{Bias } (b_1) = (\beta_2)\delta_{\pi,r}$$

where b_1 is the estimate of β_1 and $\delta_{\pi,r}$ is the coefficient of π in a regression of $E_{t-1}r_t$ on $E_{t-1}\pi_t$.

It is well known from the sources in Endnote 2 that the correlation between interest rates and inflation has changed over the period since 1700. Some confirming evidence is presented in this regard by estimating

$$\text{(7)} \qquad R_{Ft} = \alpha_0 + \alpha_1 E_t\pi_{t+1} + v_t$$

and similar variations. The results are presented in Table 6 and show that the estimate of α_1 rises markedly during the most recent sample period. Of course, $\alpha_1 < 1$ corresponds to $\delta_{\pi,r} < 0$, a negative correlation between real interest rates and inflation. So, given a negative value for β_2, b_1 will be biased towards becoming positive. Since the absolute value of $\delta_{\pi,r}$ declines through the sample period, it is clear that the size of the bias of b_1 also falls. So, in the period prior to 1950, the size of the bias of b_1 is sufficient to make β_1 positive, but since interest rates are more responsive to inflation after 1950, the size of the bias also falls.

Another way of summarizing these results is that there was no consistent relationship between inflation and stock returns in the pre-World War II period, because the direct depressing effect of inflation on stock returns was offset by the boost to equities provided by an inflation-induced decline in real interest rates. However, in the post-World War II period, higher inflation had only a modest depressing effect on real interest rates; so, overall, equity returns tended to fall with inflation.

An important component of an 'omitted-variable'-based explanation of these findings is that the Fisher hypothesis did not hold prior to 1950. Some have argued that regressions of interest rates on expected inflation are not very informative about the Fisher effect since inflation was not very forecastable over the gold standard period (see especially Barsky (1987)). While it is true that autoregressive processes for inflation do not provide good forecasts of future inflation, this is not true of more general inflation prediction processes.

So, while Barsky (1987) finds that past values of inflation have virtually no explanatory power before 1913 (R^2 = 0.006 from Table 7), thus rendering tests of the Fisher hypothesis suspect, this is *not* true of our more general information set (R^2 = 0.30). We believe that this latter information set, even limited as it is with respect to the information in financial journals of the day and, therefore, a substantial underestimate of the market's ability to predict inflation, provides sufficient forecastability of future inflation to credibly test the Fisher hypothesis on 18th and 19th century data.

IIIe. The Role of Changing Monetary Institutions: The Gold Standard

The previous discussion on the differential effect of real interest rates and inflation on excess returns is formalised in Tables 8a and 8b. In the tables, a dummy variable for the period of time when Britain was on and off of the gold standard is interacted with the expected nominal interest rate and its subcomponents, expected real interest rates and expected inflation. As before, I.V. and OLS estimates are shown for both short and long interest rates and returns.

The first and third columns of each table demonstrate that the effect of nominal interest rates on the equity premium was stronger while Britain was on the gold standard; this result is essentially a restatement of the subsample estimated coefficients in Table 2 above. The interesting point to note is that when the expected nominal interest rate is decomposed into its constituent components (Column 2 in Table 8a), one finds that the stronger depressing effect of nominal interest rates on excess returns during the gold standard years is primarily due to the role of real interest rates.[12] In contrast, there is no significant difference between the effect of inflation on excess returns on and off of the gold standard.

These findings are consistent with the discussion in Section IIId above which stressed that the effect of inflation on excess returns before World War II (or in this case before 1932 when Britain last left the gold standard) depended on the role of real interest rates. The predominant effect of real interest rates relative to inflation during the gold standard, and the reverse situation after 1950, emphasises that both must be explained to provide a complete interpretation of the effect of nominal interest rates over the entire sample period.

IV. Implications and Conclusions

There is an extensive literature that attempts to explain the link between inflation and stock returns. We briefly review this literature to assess whether these theories can explain the basic empirical result that inflation and real interest rates *together* depress returns, but inflation on its own bears no consistent relationship with returns.

Modigliani and Cohn (1979) argue that because investors suffer from 'inflation illusion', they incorrectly use nominal interest rates to capitalise real cash flows. However, this story predicts that the required return on equity *rises* with higher inflation (although it does explain a negative relationship between returns and unexpected inflation).[13] Further, it is not clear that Modigliani and Cohn could explain a link between real interest rates and returns which coexists with one between inflation and returns.

As discussed above, Fama (1981) argues that higher inflation simply proxies for lower expected growth. In the empirical experiments reported above, the inclusion of the expected future growth rate did not appear to affect the basic relationship between nominal interest rates and the equity premium. Also, it is not clear that a money-demand based explanation could account for the absence of a link between inflation and stock returns in the pre-World War II period.

Another class of explanations relies on the existence of tax effects (see, e.g., Feldstein (1982)). However, it does not seem plausible that tax-based effects can even account for the post-war effect (as Modigliani and Cohn (1984) and Pindyck (1984) note). On our findings, it is difficult to see why the nominal interest rate would depress returns by nearly twice as much in the low taxation period of 1830-1913, as in the high tax regime of 1950-1983. Furthermore, it seems that this explanation would have the same difficulty as the other stories in simultaneously accounting for inflation and real interest rate effects.

A further class of explanations are based on the need to measure risk appropriately. So, for example, Pindyck (1984) argues that higher inflation is associated with higher variability of returns. Of course, in standard models, greater uncertainty regarding equity returns would be rewarded with a higher risk premium, so while this explanation can account for a negative relationship between unexpected inflation and returns, it perversely predicts a positive association between expected inflation and returns. Once again, it is not obvious that this theory can account for the real interest rate effect, as well as the accompanying inflation effect.

A further possible explanation that is also based on risk considerations is offered by Stulz (1986), who, by including real balances in his definition of wealth, is able to construct an equilibrium model where higher expected inflation lowers equity returns. However, the model does not appear to account for a negative relationship between real interest rates and excess returns in addition to the inflation-excess returns link.

So, to conclude, it seems that existing theories need to be amended to explain:

(I) A consistent, negative relationship between higher expected nominal interest rates and excess returns and,

(II) The absence of a link between expected inflation and returns in the pre-World War II period, followed by the well-documented negative relationship in the post-World War II period.

If finding (I) could be adequately explained, then (II) might be explained by appealing to the change in the relationship between nominal interest rates and inflation that occurred prior to 1950 (although the latter needs explaining as well).

In any case, for the purposes of this thesis, it seems that stock prices and the process of general inflation are not consistently linked over time. This fact, combined with the puzzling linkage between nominal variables and the real excess return, is possibly evidence of the influence of non-economic factors, such as institutional structure, on stock prices.

Appendix I: U.K. Historical Data, 1700 to 1987

This data appendix provides the details for the construction of indices measuring equity prices, short and long term interest rates, consumer prices, two definitions of money supply, industrial production and a proxy for government deficit financing, total employment in the armed forces. The description of sources in this section is followed by diagrams and a list of the data.

The data extend from 1700 to 1987 and are all measured as annual averages. Although coverage varies from one subperiod to another, the general thrust is directed towards obtaining the broadest possible measure of each variable. Therefore, the data usually refer to the entire United Kingdom and to the most comprehensive subsector of the particular market being measured.

Table 1 summarizes some of the discussion in the rest of this appendix. The table includes the source of the index, the period covered and the conversion factor used to transform the raw data to the final stated form. Standard splicing techniques were used to link the various data sets.

Equity Prices

The final index has a base year of 1750 equal to 100.

The data from Mirowski (1981) consist of an equally weighted index of the Bank of England, East India Co., South Sea Co., London Assurance, the Royal Exchange Assurance and the Million Bank. All of the companies, with the exception of the East India Co., were financial corporations of one sort or another.

The Bank of England is well known, as is the South Sea Co., an early example of debt for equity conversion which helped to spark off the South Sea Bubble of 1720. The London and Royal Exchange Assurance were insurance companies with large holdings of mortgages and stock and annuities from the other major publicly listed companies. In similar fashion, the Million Bank, contrary to its name, was primarily an investment trust specialising in government annuities.[14]

Although Scott (1912) estimates that some 150 joint stock companies existed in 1695, very few of these companies were listed in the financial press of the day. For example, the Course of the Exchange, the most comprehensive contemporary source and the precursor of the Official List of the Stock Exchange, reported on the shares of only 13 different companies during the eighteenth century.[15] It therefore seems reasonable to assume that the market index used here is broadly indicative of market movements, especially since it includes the three largest quasi-public corporations, the Bank of England, the East India Co. and the South Sea Co.

The year 1811 marked the first occasion when prices for non-government or quasi-public corporations appeared on the official quotation list. Included in these new listings were canal, dock, insurance and waterworks shares, and those of American firms. Gayer et al (1953) includes representative companies from each of the foregoing domestic categories (plus insurance) from 1812, as well as railway companies, banks and mining firms in later years;[16] there are 52 different companies included in all.

The Gayer et al (1953) sub-indices are constructed as average share prices weighted by the number of outstanding shares. The final index is then constructed by weighting the sub-indices by the ratio of paid-up capital in the sub-index to the total market. The total index, exclusive of mining shares, is used here since the mining companies were almost all producing in the Americas; as well, the speculative mining boom of 1825 and the sharp slump of 1841 in this sub-sector are only weakly echoed in the other sub-indices.[17]

A monthly index produced by Hayek is found in Gayer et al (1953), p.457. His index includes most of the sub-sectors listed above, with the exception of banks and insurance companies (but including British mining and coke production shares). The index is an unweighted average and consists of high capitalization companies with continuous quotations.

The Smith and Horne (1934) Index of Industrials, by contrast, includes a sub-sample of companies in the following sectors: coal and iron, electrical goods, textiles, food, drink, building materials, lighting, chemicals, stores and transport (excluding railways). The number of companies listed rises from 26 in 1870 to 92 in 1925. As with the Hayek index, the share prices enter the index in an unweighted form. The London and Cambridge Economic Service (LCES (1971)) Industrial Ordinary index is simply a continuation of the Smith and Horne index of 92 industrials. The final component of the share price index is the FT Industrial Ordinaries index presently used in the London market.

It should be noted that the average price of equities in 1914 is only based on the first six months data due to the closure of the exchange in mid-year.

Dividend Yield

Very few of the foregoing sources for share prices present equivalent information for dividend payments. Therefore, the series used here combines the BZW (1987) index income yield from 1919 to 1954 with the CSO FT Industrials dividend yield from 1955 to 1987. The resulting series is presented as an annual percentage rate of change.

Consumer Prices

The final index has a base year of 1750 equal to 100 and is the broadest possible measure of consumer goods prices.

The Schumpeter (1938) price index is composed of the unweighted averages of 31 consumer goods, while the Rousseaux (1938) Indice Total measures industrial and agricultural prices. The Retail Price Index (RPI) is published in Feinstein (1971) and is extended in Cappie and Webber (1986) and CSO (1986,1988). Inflation rates based on this series are constructed as differences of log levels.

Industrial Production

The index has a base year of 1750 equal to 100. The construction industry has been excluded from the analysis, although most other large industries are included.

The industrial production data in Hoffman (1934,1955) are indices of consumer and producer goods industries. The series excludes the construction industry because the data for this sector are calculated using a double 10 year moving average and are, therefore, less accurate measures of yearly production. Hoffman's series includes 50% of total industrial production prior to 1800 and up to 74% at various points in the nineteenth century. While acknowledging the criticisms by Deane and Cole (1962) concerning the validity of this series, there appears to be no consistent alternative source of data prior to 1800.

The Lomax (1959) index also excludes building and is calculated by interpolating between the census years of 1930, 1933, 1934, 1935 and 1937. The post-war series from UN (1953) was used to bridge the gap from 1946 to the start of the CSO (1986,1988) data in 1948 and also to align the 1938 and 1946 values to a common base year. This index measures total manufacturing industry output, adjusted for the number of working days per month.

The data from 1939 to 1945 do not exist and they were therefore interpolated from the figures for real GNP found in Feinstein (1971). The GNP data from 1938 to 1946 were regressed against a constant and a time variable to remove the trend element.[18] The residuals from this regression were then aligned to the industrial production data endpoints at 1938 and 1946 and these formed the new intra-war data.[19]

The last component of this index is the index of output in the production industry in CSO (1986,1988). Like the other components, the output of the construction industry is excluded.

Long Interest Rate

The interest rate used is the British government 3% consol. The data are expressed at market rates with no base year.

The data to 1958 are found primarily in Homer (1963), with the exception of the new issue rates for 1698 and 1704-1708 found in Dickson (1967). Following Homer

(1963) and Shiller and Siegel (1977), market yields on two and one half percent consols were used between 1881 and 1888; the reason for this is that the low level of interest rates at that time constrained the 3% consol yield from falling further because of the possibility of redemption.

Since continuous data on market rates exist from only 1729 onwards, market data prior to that date were estimated by using new issue rates. Market rates were regressed on a constant and the new issue rate for all years in the eighteenth century for which matching data were available.[20] New issue rates for missing data points were then interpolated from existing new issue rates in adjacent years[21] and these data were used with the estimated regression coefficients to backcast the market rates prior to 1729.

The remainder of the bond yield data are taken from Capie and Webber (1986) and CSO (1986,1988).

Short Interest Rate

The three month commercial paper rate is taken from Deane and Cole (1962), which is in turn derived from the Overend Gurney and Williams primary sources. The data from 1845 to 1856 are averages of the two sources and those for 1911 to 1937 are averages of the high/low Williams data. From 1938 to 1987, the interest rates are averages of the monthly data presented in CSO publications. All data are expressed at market rates with no base year.

M0 - Narrow Money

The index has a base year of 1750 equal to 100. Narrow money is defined as notes in circulation and deposits at the Bank of England.

The initial data come from Bank of England (1967) and are derived from balance sheets of the Bank. The missing data in 1765 and 1774 are linearly interpolated from adjacent values. Starting in 1870, the Capie and Webber (1986) high powered money base series is used. The series ends with M0 values for 1983 to 1987 from CSO

(1986,1988).

M3 - Broad Money

The index has a base year of 1750 equal to 100. Broad money is defined as notes in circulation, deposits at the Bank of England and deposits at commercial banks.

From 1844 to 1869, total net public liabilities of joint stock banks from Collins (1983) are added to the Bank of England (1967) data. The Capie and Webber (1986) series for M3 is used from 1870 and CSO (1986,1988) fills the gap from 1970.

The net public liability data cover England and Wales while the Capie and Webber and CSO data are measured for the entire United Kingdom. The increasing financial linkages between London and the provinces over time implies that these differences in the scale of coverage should not greatly affect the intertemporal fluctuations in money due to economic factors.

Armed Forces Employment

This series is a proxy for the extent of deficit financing undertaken by the British government over the period in question. Under conditions where the Ricardian Equivalence Theorem does not hold, increased demand for funds by the government places upward pressure on interest rates and hence influences other financial variables via portfolio rebalancing and arbitrage.

From 1700, the series is calculated as the sum of the number bourne in the navy and the number voted in the army from BPP (1868-69). Values for 1716, 1717 and 1800 are linearly interpolated from adjacent data. From 1868, the Feinstein (1971) data for armed forces employment are used. CSO data are used from 1966 to 1987 to complete the index.

The series is scaled by the total population of the United Kingdom in order to remove an upward trend element. Annual values are linearly interpolated for 1700 to 1869 from decennial information in Deane and Cole (1962) and Maddison (1982);

data for England/Wales in several years are grossed up by the ratio of these countries to total U.K. population in 1750. Maddison (1982) annual population data are used from 1870 to 1978 and UN sources finish the series to 1987.

Gold Standard Dummy Variable

This variable takes the value 1 for 1700-1797, 1821-1914 and 1925-1932. In all other years, the U.K. was off of the gold standard. Dates come from Bordo and Schwartz (1984).

War Periods Dummy Variable

The periods of warfare with other nations are divided into two categories following Rasler and Thompson (1983). The global warfare index takes the value one for 1701-1713, 1793-1815, 1914-1918 and 1939-1945, while the interstate warfare variable takes the value one for 1718-1720, 1727-1728, 1739-1748, 1778-1783 and 1854-1856. A general index is formed as the sum of these two subindices.

End-of-Period Data

The December equity price series uses data compiled by Prof. G. W. Schwert of the University of Rochester and provided by him on a floppy diskette. In addition, equity capitalization values for 387 representative stocks from the Bankers' Magazine are used from December 1913 to December 1919, while December 1920 to December 1925 price index values come from Bowley et al (1931).

The December short interest rate values from 1880 to 1938 come from the Bankers' Magazine and those from 1939 are from the CSO. Midpoints of bid and ask prices are used where both prices are quoted in the Bankers' Magazine.

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The December short interest rate values from 1880 to 1938 come from the Bankers' Magazine and those from 1939 are from the CSO. Midpoints of bid and ask prices are used where both prices are quoted in the Bankers' Magazine.

1. Some early examples for the U.S. are Fama and Schwert (1977), Lintner (1975) and Nelson (1976). There is also evidence that the negative correlation holds for many other countries; on this, see Cohn and Lessard (1981) and Gultekin (1983).

2. Friedman and Schwartz (1982) and Shiller and Siegel (1977) have previously noted the absence of the Fisher effect prior to 1950.

3. For example, Modigliani and Cohn (1979) use the nominal interest rate, not inflation, in their investigation and Fama's (1981) measure of expected inflation rises one-to-one with the nominal Treasury bill yield.

4. One could, of course, turn to primary sources such as the Course of the Exchange or the Bankers' Magazine to obtain finer frequencies of share prices. The amount of work in such an undertaking seemed to be inordinate, however, in comparison to the added value of such regression estimates in this chapter. In addition, as Mirowski (1981) stresses, there are considerable gaps in even popular biweekly publications such as the Course of the Exchange. Finally, unless the researcher is interested in only univariate estimation, it is virtually impossible to find corresponding data for interest rates, inflation, industrial production, etc. at frequencies of less than one year.

5. See Working (1960).

6. As shown below, the equations which include the dividend yield term support the results using only the capital gain component. The main reason for this is that the dividend yield series is rather smooth relative to the capital gain and, therefore, does not affect the variability of the total return greatly.

In addition to recent research which describes this smoothness statistically, (cf. Marsh and Merton (1987)), Gayer et al (1953) also present dividend yield data for selected companies and years in the U.K. between 1811 and 1850. Most of these companies kept their payout ratio constant for 5 or 10 years at a time and then changed the rates in full or half percentages; if this behaviour is descriptive of the fuller sample here, the constant term in the equity premium regressions should be biased most from the absence of the dividend yield portion of returns, while the α_1 and α_2 coefficients of interest should be relatively unaffected.

7. The changing autocorrelation properties of inflation over the full sample period can be seen in the following regression:

$$\text{(2)} \qquad \underset{}{\pi_t} = \underset{(0.4)}{-\,.006\ \text{Constant}} + \underset{(0.4)}{.009\ \text{Gold}} + \underset{(3.9)}{1.10\ \pi_{t-1}} - \underset{(3.1)}{1.45\ \text{Gold}^{*}\pi_{t-1}}$$

Sargan Test: 0.9 $(F(12,\infty)_{0.05}=1.75)$ — Sample: 1705-1983 — Estimation Method: I.V.

where π is the inflation rate, Constant is a constant term and Gold is a gold standard dummy variable equal to 1 on the gold standard and 0 otherwise.

It appears that prices followed a random walk during the gold standard, at least in terms of their own autocorrelation properties, while there was substantial positive autocorrelation in inflation when the U.K. was off of the gold standard.

8. In our case, under the null hypothesis where $\alpha_1 = \alpha_1 = 0$, u_t should follow an MA(1) process with a parameter of 0.27. Noting that this process can be reformulated as an infinite order autoregressive structure, all variables are transformed using the approximation

$$x'_t = x_t - .268x_{t+1} + .0718x_{t+2} - .0192x_{t+3} + .0052x_{t+4} \quad (3)$$

Lagged, untransformed variables may then be used as appropriate instrumental variables.

9. The one case is for ERS over 1830 to 1913.

10. Sentana and Wadhwani (1989) use a number of different proxies for σ^2_t in their study of Japanese share prices in recent years. Even though lagged squared excess returns are a rough proxy of the true measure of volatility, the variable seems to fare equally as well as more sophisticated parametric and non-parametric alternatives in their paper.

11. The actual growth rate is used and, assuming Rational Expectations, is instrumented for standard errors-in-variables considerations.

12. The estimated coefficients of Column 2 in Table 8b do not confirm the results in Column 2 of Table 8a. This is not surprising since the interest rate used in the former table is a perpetuity which includes an expected inflation term which spans multiple periods into the future. Therefore, it is not appropriate to use the same inflation rate to deflate both long and short interest rates. The table is shown here, however, for completeness and in order to demonstrate that the depressing effect of interest rates on excess returns during the gold standard holds from 1705, as well as from 1830.

13. Of course, if one relaxes the assumption of Rational Expectations and relies instead on Adaptive Expectations, then the Modigliani-Cohn story might account for a negative relationship between expected inflation and stock returns as well (see, e.g., Attanasio and Wadhwani (1989)).

14. See Mirowski (1981) for further details.

15. See Mirowski (1981), p.566.

16. See Gayer et al (1953), Table 7.

17. See Gayer et al (1953), Diagram 93.

18. The time variable coefficient value was 3.03 with a standard error of .93. The R-squared statistic equalled .60 and the constant was statistically significant.

19. This method is used in preference to an estimation based on the correlation between industrial production and real GNP before 1938 and after 1946, since there are substantial differences between the two periods. The earlier period is adversely influenced by the post-World War I inflation and the subsequent depression of 1921 and the 1930's. In contrast, the post-World War II years were marked by an acceleration in the growth rate of real economic activity.

20. The details of the regression are as follows: Sample size equal to 42, R-squared equal to .87, a constant coefficient equal to 1.113 and a new issues (X) coefficient equal to .687 with a standard error of .042. The estimates imply that new issues were usually priced at a premium to secondary market paper when market rates were above 3.6% and at a discount when below 3.6%.

Differences between primary and secondary market rates should not arise in perfect markets with homogenously traded goods. However, debt at this time had certain lottery and redemption privileges attached to it which varied substantially from issue to issue. As well, it was a new financial instrument with considerable counterpart risk, since sovereigns had traditionally defaulted on obligations when repayment became difficult. Therefore, changing political circumstances may also have introduced a wedge between primary and secondary market rates.

21. This applies to the years 1700-1701, 1703, 1709, 1716, 1720, 1723-1725 and 1728.

Table 1: The Effect of Inflation on Excess Returns

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	ERS	ERS	ERS	ERS	ERS
Sample Period	1830/1983	1830/1913	1914/1949	1950/1983	1830/1913
Coefficient of Inflation	-0.22 (0.9)	0.44 (1.6)	0.13 (0.3)	-1.68 (2.0)	0.34 (2.2)
Estimation Method	I.V.	I.V.	I.V.	I.V.	OLS
Sargan Test	1.42	1.67	1.41	1.09	N/A

	(6)	(7)	(8)	(9)	(10)
Dependent Variable	ERL	ERL	ERL	ERL	ERL
Sample Period	1705/1983	1705/1913	1914/1949	1950/1983	1705/1913
Coefficient of Inflation	-0.29 (1.4)	-0.01 (0.0)	0.16 (0.4)	-1.54 (2.0)	0.19 (2.1)
Estimation Method	I.V.	I.V.	I.V.	I.V.	OLS
Sargan Test	1.38	1.36	1.77	0.83	N/A

Note: t-ratios are in parentheses. All regressions are of the form $R_{Et} - R_{Ft} = \alpha_0 + \alpha_1 E_{t-1}\pi_t + u_t$. All Sargan test values are insignificant at the 5% level, for example, $F(12,22)_{0.05}=2.23$, $F(12,120)_{0.05}=1.83$ and $F(12,\infty)_{0.05}=1.75$.

Table 2: The Effect of Nominal Interest Rates on Excess Returns

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	ERS	ERS	ERS	ERS	ERS
Sample Period	1830/1983	1830/1913	1914/1949	1950/1983	1830/1983
Coefficient of Nominal Interest Rate	-1.33 (2.9)	-3.50 (3.3)	-2.92 (1.7)	-1.97 (2.0)	-1.67 (4.0)
Estimation Method	I.V.	I.V.	I.V.	I.V.	OLS
Sargan Test	1.62	1.10	1.29	1.12	N/A

	(6)	(7)	(8)	(9)	(10)
Dependent Variable	ERL	ERL	ERL	ERL	ERL
Sample Period	1705/1983	1705/1913	1914/1949	1950/1983	1705/1913
Coefficient of Nominal Interest Rate	-0.70 (1.7)	-1.66 (1.8)	-6.09 (1.6)	-1.65 (1.6)	-2.94 (3.6)
Estimation Method	I.V.	I.V.	I.V.	I.V.	OLS
Sargan Test	1.40	1.07	1.47	1.18	N/A

Note: t-ratios are in parentheses. All regressions are of the form $R_{Et} - R_{Ft} = \alpha_0 + \alpha_1 E_{t-1}R_{Ft} + u_t$. All Sargan test values are insignificant at the 5% level, for example, $F(12,22)_{0.05}=2.23$, $F(12,120)_{0.05}=1.83$ and $F(12,\infty)_{0.05}=1.75$.

Table 3: The Effect of Nominal Interest Rates on Excess Returns Using End-of-Period and Total Excess Returns

End-of-Period Excess Returns

	(1)	(2)	(3)	(4)
Dependent Variable	ERS	ERS	ERS	ERS
Sample Period	1880/1913	1914/1949	1950/1987	1880/1987
Coefficient of Nominal Interest Rate	-3.59 (3.1)	-3.06 (2.1)	-1.83 (1.7)	-1.52 (3.2)
Estimation Method	I.V.	I.V.	I.V.	OLS
Sargan Test	0.99	1.68	1.75	N/A

Total Excess Returns

	(5)	(6)	(7)	(8)
Dependent Variable	ERS	ERS	ERS	ERS
Sample Period	1919/1983	1919/1949	1950/1983	1919/1983
Coefficient of Nominal Interest Rate	-1.09 (1.6)	-2.96 (1.6)	-1.41 (1.4)	-1.58 (2.6)
Estimation Method	I.V.	I.V.	I.V.	OLS
Sargan Test	1.55	1.56	1.21	N/A

Note: t-ratios are in parentheses. All regressions are of the form $R_{Et} - R_{Ft} = \alpha_0 + \alpha_1 E_{t-1}R_{Ft} + u_t$. All Sargan test values are insignificant at the 5% level, for example, $F(12,22)_{0.05}=2.23$, $F(12,120)_{0.05}=1.83$ and $F(12,\infty)_{0.05}=1.75$.

Table 4: The Effect of Inflation and Nominal Interest Rates on Excess Returns

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	ERS	ERS	ERS	ERS	ERS
Sample Period	1830/1983	1830/1913	1914/1949	1950/1983	1950/1983
Coefficient of Nominal Interest Rate	-1.63 (2.9)	-3.82 (3.8)	-2.95 (1.7)	-0.94 (0.6)	-2.97 (2.4)
Coefficient of Inflation	0.27 (0.9)	0.53 (2.1)	0.15 (0.3)	-1.10 (0.9)	0.52 (0.6)
Estimation Method	I.V.	I.V.	I.V.	I.V.	OLS
Sargan Test	1.58	0.82	1.28	1.21	N/A

	(6)	(7)	(8)	(9)	(10)
Dependent Variable	ERL	ERL	ERL	ERL	ERL
Sample Period	1705/1983	1705/1913	1914/1949	1950/1983	1950/1983
Coefficient of Nominal Interest Rate	-0.64 (1.3)	-1.66 (1.8)	-6.00 (1.5)	1.08 (0.4)	-2.46 (1.5)
Coefficient of Inflation	-0.06 (0.2)	-0.00 (0.0)	0.07 (0.2)	-2.22 (1.5)	0.32 (0.3)
Estimation Method	I.V.	I.V.	I.V.	I.V.	OLS
Sargan Test	1.38	1.07	1.47	0.72	N/A

Note: t-ratios are in parentheses. All regressions are of the form $R_{Et} - R_{Ft} = \alpha_0 + \alpha_1 E_{t-1}\pi_t + \alpha_2 E_{t-1}R_{Ft} + u_t$. All Sargan test values are insignificant at the 5% level, for example, $F(12,22)_{0.05}=2.23$, $F(12,120)_{0.05}=1.83$ and $F(12,\infty)_{0.05}=1.75$.

Table 5: Some Further Experiments Using Nominal Interest Rates

	(1)	(2)	(3)	(4)
Dependent Variable	ERS	ERL	ERS	ERL
Sample Period	1830/1983	1705/1913	1830/1983	1705/1913
Coefficient of Nominal Interest Rate	-1.25 (1.7)	-1.87 (1.8)	-1.42 (2.8)	-1.68 (1.8)
Coefficient of Industrial Production Growth at t+1	N/A	N/A	0.17 (0.3)	0.06 (0.2)
Coefficient of σ^2_{t-1}	0.43 (0.5)	0.69 (0.7)	N/A	N/A
Estimation Method	I.V.	I.V.	I.V.	I.V.
Sargan Test	1.64	0.86	1.57	1.06

Note: t-ratios are in parentheses. All regressions are of the form $R_{Et} - R_{Ft} = \alpha_0 + \alpha_1 E_{t-1}R_{Ft} + \alpha_2 E_{t-1}X + u_t$. All Sargan test values are insignificant at the 5% level, for example, $F(12,22)_{0.05}=2.23$, $F(12,120)_{0.05}=1.83$ and $F(12,\infty)_{0.05}=1.75$.

Table 6: Fisher Equations

	(1)	(2)	(3)
Dependent Variable	R_F	R_F	R_F
Sample Period	1830/1913	1914/1949	1950/1983
Coefficient of Inflation	0.13 (2.8)	0.03 (0.7)	0.68 (5.4)
Estimation Method	I.V.	I.V.	I.V.
Sargan Test	1.70	0.39	1.50
	(4)	(5)	(6)
Dependent Variable	R_F	R_F	R_F
Sample Period	1830/1913	1914/1949	1950/1983
Coefficient of Inflation at t+1	0.07 (0.7)	-0.12 (2.2)	0.75 (5.0)
Estimation Method	I.V.	I.V.	I.V.
Sargan Test	1.15	1.70	1.15

Note: t-ratios are in parentheses. All regressions are of the form $R_{Ft} = \alpha_0 + \alpha_1 E_{t-1}\pi_t + u_t$. Short interest rates are used throughout. All Sargan test values are insignificant at the 5% level, for example, $F(12,22)_{0.05}=2.23$, $F(12,120)_{0.05}=1.83$ and $F(12,\infty)_{0.05}=1.75$.

Table 7: Forecastability of Inflation

Information Set	Sample Period	R^2
Lagged Inflation	1830/1913	0.006
Lagged Inflation	1914/1949	0.184
Lagged Inflation	1950/1983	0.454
General Information Set	1830/1913	0.307
General Information Set	1914/1949	0.604
General Information Set	1950/1983	0.813

Note: The 'General Information Set' includes lags of the money supply, industrial production, interest rates, stock returns and armed forces employment.

Table 8A: The Effect of Inflation and Short Interest Rates On and Off of the Gold Standard

	(1)	(2)	(3)	(4)
Dependent Variable	ERS	ERS	ERS	ERS
Sample Period	1830/1983	1830/1983	1830/1983	1830/1983
Coefficient of Nominal Interest Rate	-1.03 (2.0)	N/A	-1.67 (4.0)	N/A
Coefficient of Nominal Interest Rate on Gold Standard	-1.28 (1.8)	N/A	-1.22 (2.1)	N/A
Coefficient of Real Interest Rate	N/A	-0.44 (0.7)	N/A	-1.85 (3.8)
Coefficient of Real Interest Rate on Gold Standard	N/A	-2.00 (2.4)	N/A	-1.29 (1.9)
Coefficient of Inflation	N/A	-1.03 (2.0)	N/A	-1.77 (4.3)
Coefficient of Inflation on Gold Standard	N/A	-0.93 (1.1)	N/A	-0.80 (1.3)
Estimation Method	I.V.	I.V.	OLS	OLS
Sargan Test	1.63	1.40	N/A	N/A

Note: t-ratios are in parentheses. All regressions are of the form $R_{Et} - R_{Ft} = \alpha_0 + \alpha_1 E_{t-1}\pi_t + \alpha_2 E_{t-1}R_{Ft} + u_t$. All Sargan test values are insignificant at the 5% level, for example, $F(12,22)_{0.05}=2.23$, $F(12,120)_{0.05}=1.83$ and $F(12,\infty)_{0.05}=1.75$.

Table 8B: The Effect of Inflation and Long Interest Rates On and Off of the Gold Standard

	(1)	(2)	(3)	(4)
Dependent Variable	ERL	ERL	ERL	ERL
Sample Period	1705/1983	1705/1983	1705/1983	1705/1983
Coefficient of Nominal Interest Rate	-1.02 (2.4)	N/A	-1.66 (4.0)	N/A
Coefficient of Nominal Interest Rate on Gold Standard	-1.15 (2.2)	N/A	-1.41 (3.0)	N/A
Coefficient of Real Interest Rate	N/A	-1.01 (2.0)	N/A	-1.80 (4.1)
Coefficient of Real Interest Rate on Gold Standard	N/A	-1.15 (2.1)	N/A	-1.34 (2.8)
Coefficient of Inflation	N/A	-1.02 (2.3)	N/A	-1.67 (4.1)
Coefficient of Inflation on Gold Standard	N/A	-1.34 (2.0)	N/A	-1.23 (2.5)
Estimation Method	I.V.	I.V.	OLS	OLS
Sargan Test	1.39	1.32	N/A	N/A

Note: t-ratios are in parentheses. All regressions are of the form $R_{Et} - R_{Ft} = \alpha_0 + \alpha_1 E_{t-1}\pi_t + \alpha_2 E_{t-1}R_{Ft} + u_t$. All Sargan test values are insignificant at the 5% level, for example, $F(12,22)_{0.05}=2.23$, $F(12,120)_{0.05}=1.83$ and $F(12,\infty)_{0.05}=1.75$.

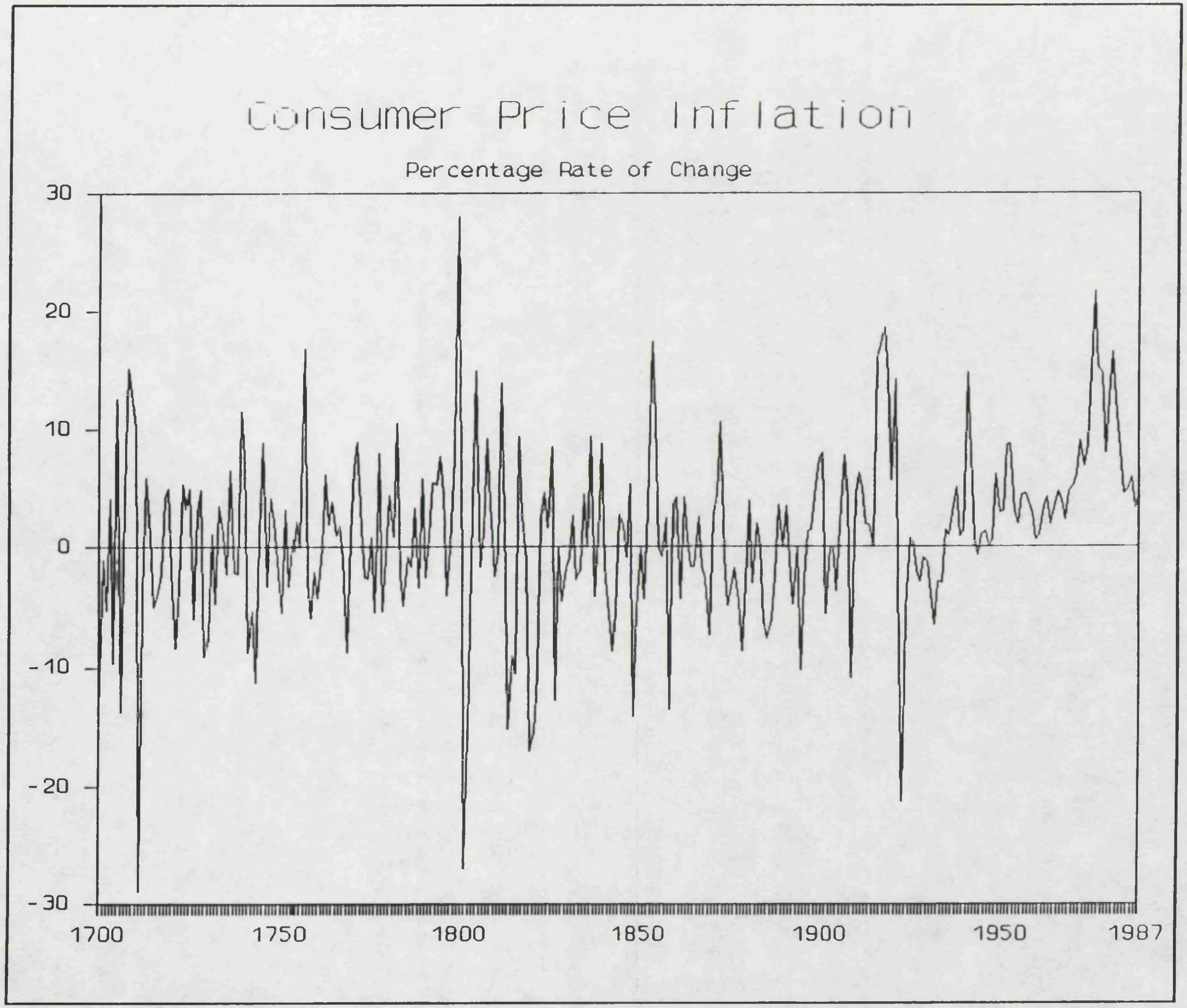

Consumer Price Inflation
Percentage Rate of Change
30
20
10
0
-10
-20
-30
1700
1750
1800
1850
1900
1950
1987

Diagram 1

Appendix I

Table 1: Data Sources and Conversion Factors		
Source	Date	Conversion Factor to 1750=100
Stock Price		
Mirowski	1700-1810	1.00
Gayer et al	1811-1850	1.45
Hayek	1851-1867	1.08
Smith and Horne	1868-1933	1.82
LCES	1934-1954	22.98
CSO	1955-1987	5.77
Consumer Price		
Schumpeter	1700-1799	1.11
Rousseau	1800-1912	1.12
Capie and Webber	1913-1979	8.77
CSO (1985=100)	1980-1987	32.74
Industrial Production		
Hoffman	1700-1931	41.67
Lomax	1932-1938	36.06
Mullins	1939-1945	
UN	1946-1947	61.31
CSO (1980=100)	1948-1987	137.78
Long Interest Rate		
Mullins	1700-1728	
Homer	1729-1958	1.00
Capie and Webber	1959-1982	1.00
CSO	1983-1987	0.88
Narrow Money		
Bank of England	1700-1869	14.29
Capie and Webber	1870-1982	5.20
CSO	1983-1987	5.25
Broad Money		
Collins	1844-1869	2.32
Capie and Webber	1870-1969	2.54
CSO	1970-1987	2.49

Table 2: List of Historical U.K. Data, 1700 to 1987

Year	Stock Returns	Long Interest Rate	Consumer Price Inflation	M0	Industrial Production	Armed Forces Employment
1700		5.922	-14.004	3.210	4.110	0.206
1701	-9.760	5.578	-0.995	3.439	4.314	0.457
1702	6.193	5.235	-5.225	3.423	3.936	0.858
1703	15.015	5.441	4.220	3.517	4.135	1.039
1704	0.000	5.647	-9.632	3.228	4.159	1.103
1705	-14.876	5.647	12.617	3.425	4.214	1.136
1706	-9.503	5.510	-13.736	3.238	4.004	1.221
1707	8.803	5.407	4.401	3.543	4.031	1.372
1708	9.633	5.407	15.135	3.649	4.496	1.335
1709	-0.768	6.111	13.143	2.925	4.167	1.474
1710	-8.305	6.815	10.093	2.453	4.110	1.564
1711	-9.979	7.090	-29.035	2.758	4.110	1.810
1712	3.934	7.090	-4.001	3.478	4.110	1.784
1713	11.745	5.166	5.942	2.907	4.206	0.449
1714	3.245	5.578	1.043	3.735	4.251	0.287
1715	6.550	4.548	-4.966	2.952	4.314	0.316
1716	5.583	4.376	-4.082	3.738	4.406	0.310
1717	11.829	4.205	-2.202	3.628	4.455	0.295
1718	6.517	4.205	4.264	3.522	4.443	0.308
1719	-0.851	3.861	4.976	3.576	4.374	0.365
1720	35.115	4.205	-1.961	4.078	4.412	0.396
1721	-50.483	4.548	-8.350	3.888	4.393	0.355
1722	-20.858	3.174	-3.282	4.257	4.524	0.291
1723	3.749	3.174	5.412	4.642	4.507	0.311
1724	8.317	3.174	3.205	4.928	4.294	0.301
1725	16.566	3.174	4.976	4.350	4.461	0.294
1726	-7.332	3.174	-6.002	4.379	4.431	0.398
1727	4.104	3.861	3.046	4.693	4.412	0.517
1728	4.349	3.732	4.966	4.673	4.335	0.425
1729	-1.944	3.240	-9.048	4.601	4.348	0.429
1730	4.247	3.300	-7.673	4.620	4.418	0.329
1731	2.927	3.120	1.118	4.649	4.374	0.343
1732	0.575	3.030	-4.657	4.713	4.393	0.316
1733	-2.910	3.090	3.538	4.651	4.507	0.329
1734	-9.060	3.190	1.118	4.773	4.381	0.480
1735	4.013	3.190	-2.250	4.780	4.490	0.621
1736	10.970	2.860	6.602	4.793	4.478	0.426
1737	1.929	2.830	-2.153	4.709	4.406	0.355
1738	-1.190	2.860	-2.200	4.736	4.557	0.439
1739	-8.350	3.060	11.632	4.696	4.501	0.497
1740	-3.049	3.000	7.706	4.770	4.412	0.769
1741	0.720	3.030	-8.701	4.771	4.328	0.990

1742	0.918	3.000	-5.225	4.838	4.425	0.936
1743	3.295	2.970	-11.241	4.741	4.381	0.994
1744	-2.587	3.240	1.172	4.730	4.518	1.045
1745	-0.911	3.530	9.010	4.521	4.472	1.036
1746	-7.607	3.410	-3.247	4.755	4.518	1.314
1747	-1.437	3.660	4.306	4.598	4.518	1.158
1748	0.000	3.410	2.179	4.504	4.518	1.111
1749	6.676	2.970	-1.036	4.584	4.563	0.450
1750	4.082	3.000	-5.449	4.605	4.605	0.393
1751	2.176	3.030	3.247	4.740	4.605	0.372
1752	4.027	2.860	-3.247	4.702	4.563	0.367
1753	1.122	2.860	0.000	4.598	4.563	0.351
1754	-2.923	2.910	2.176	4.540	4.605	0.365
1755	-7.242	3.140	0.000	4.634	4.563	0.602
1756	-8.253	3.370	16.968	4.761	4.563	0.922
1757	1.552	3.390	-2.763	4.866	4.518	1.206
1758	1.094	3.210	-5.856	4.747	4.518	1.443
1759	-9.108	3.590	-2.000	4.666	4.605	1.585
1760	-1.079	3.770	-4.220	4.728	4.563	1.661
1761	-3.806	3.900	0.000	4.775	4.605	1.655
1762	-5.268	4.290	6.220	4.867	4.563	1.813
1763	21.520	3.370	1.961	4.729	4.563	1.392
1764	-7.624	3.610	3.895	4.811	4.685	0.456
1765	10.559	3.410	0.929	4.742	4.646	0.440
1766	4.741	3.390	1.833	4.668	4.685	0.417
1767	7.951	3.370	-0.912	4.675	4.759	0.405
1768	4.883	3.310	-8.701	4.765	4.759	0.399
1769	-3.528	3.470	0.995	4.742	4.794	0.406
1770	-7.646	3.640	6.785	4.726	4.794	0.423
1771	1.824	3.550	8.925	4.871	4.828	0.619
1772	2.072	3.300	1.678	4.712	4.861	0.468
1773	-7.748	3.470	-2.528	4.757	4.794	0.427
1774	2.093	3.430	-2.593	4.925	4.723	0.410
1775	3.011	3.390	0.872	5.070	4.794	0.407
1776	-0.192	3.510	-5.433	4.999	4.828	0.651
1777	-3.513	3.850	8.004	5.010	4.861	1.063
1778	-14.280	4.510	-5.291	4.943	4.861	1.228
1779	-3.260	4.880	-0.896	5.098	4.828	1.600
1780	-8.647	4.880	4.481	5.074	4.828	1.722
1781	-3.146	5.220	0.857	4.995	4.828	1.767
1782	-2.290	5.260	10.590	5.139	4.924	1.819
1783	8.485	4.760	-2.330	4.957	4.924	1.439
1784	-13.085	5.410	-4.904	4.807	4.982	0.446
1785	11.062	4.760	-0.829	4.839	5.038	0.383
1786	14.701	4.060	-1.678	5.012	5.038	0.371
1787	3.361	4.080	3.329	5.051	5.065	0.397
1788	4.584	4.060	-3.329	5.157	5.091	0.370
1789	2.315	3.920	5.827	5.203	5.141	0.417
1790	0.397	3.900	-2.498	5.230	5.165	0.546
1791	6.615	3.580	0.889	5.375	5.211	0.653

1792	10.053	3.330	5.523	5.289	5.277	0.507
1793	-13.834	3.960	5.300	5.337	5.211	1.464
1794	-8.544	4.400	7.765	5.261	5.211	1.982
1795	-1.907	4.520	4.666	5.528	5.298	2.898
1796	1.486	4.800	-3.995	5.257	5.298	2.390
1797	-21.815	5.900	0.000	5.180	5.256	2.472
1798	-2.522	5.940	7.836	5.433	5.298	2.509
1799	15.645	5.070	28.148	5.507	5.397	2.512
1800	11.702	4.710	7.244	5.674	5.416	2.335
1801	0.102	4.920	-27.033	5.794	5.378	2.194
1802	9.354	4.230	-10.922	5.586	5.416	1.770
1803	-16.334	4.990	3.180	5.618	5.452	1.696
1804	-2.551	5.300	14.975	5.700	5.470	2.449
1805	8.813	5.040	-1.650	5.912	5.452	2.483
1806	7.528	4.870	1.119	5.791	5.505	2.630
1807	3.838	4.920	9.236	5.785	5.554	2.689
1808	2.539	4.550	3.851	5.841	5.505	2.840
1809	6.750	4.490	-2.406	5.804	5.538	2.868
1810	0.667	4.470	-0.479	5.920	5.617	2.850
1811	-6.172	4.670	14.001	6.027	5.676	2.809
1812	-8.870	5.080	2.513	6.045	5.602	2.784
1813	-5.563	4.920	-15.082	6.033	5.602	2.832
1814	4.884	4.920	-9.007	6.109	5.632	2.731
1815	-7.471	4.480	-10.473	6.167	5.718	1.833
1816	-10.373	5.020	9.431	6.180	5.690	0.923
1817	6.961	4.100	2.632	6.144	5.784	0.630
1818	19.543	3.870	-1.073	6.107	5.797	0.613
1819	-0.537	4.170	-16.974	5.980	5.758	0.548
1820	-4.682	4.420	-15.341	5.895	5.784	0.602
1821	4.323	4.070	-10.579	5.988	5.834	0.600
1822	7.789	3.790	2.348	5.739	5.881	0.484
1823	5.507	3.800	4.671	5.831	5.938	0.490
1824	18.180	3.300	1.664	5.980	6.002	0.523
1825	-6.165	3.540	8.597	6.013	6.072	0.568
1826	-14.973	3.790	-12.775	6.058	5.981	0.568
1827	2.064	3.610	0.000	6.014	6.118	0.562
1828	3.679	3.540	-4.433	6.021	6.181	0.571
1829	-0.989	3.340	-1.742	5.953	6.146	0.562
1830	-1.865	3.490	-0.956	6.010	6.223	0.539
1831	-10.711	3.760	2.698	6.029	6.231	0.524
1832	0.477	3.580	-2.698	5.892	6.231	0.515
1833	1.471	3.420	-1.865	6.065	6.295	0.510
1834	1.768	3.320	4.563	6.095	6.354	0.505
1835	2.709	3.290	0.000	5.979	6.397	0.460
1836	22.454	3.350	9.400	6.099	6.496	0.472
1837	-16.595	3.300	-4.145	5.982	6.438	0.471
1838	7.866	3.230	0.816	6.017	6.527	0.501
1839	-4.363	3.280	8.870	5.886	6.615	0.528
1840	1.228	3.350	-1.561	5.817	6.592	0.529
1841	-4.280	3.380	-5.631	5.771	6.586	0.536

1842	2.506	3.270	-8.616	5.867	6.539	0.575
1843	7.764	3.170	-5.520	6.079	6.598	0.559
1844	14.393	3.030	2.798	6.145	6.715	0.548
1845	10.454	3.120	1.847	6.214	6.769	0.553
1846	-5.633	3.130	-0.956	6.465	6.774	0.602
1847	-12.452	3.440	5.395	6.203	6.735	0.609
1848	-15.214	3.510	-14.036	6.190	6.839	0.630
1849	-8.148	3.240	-5.125	6.188	6.865	0.572
1850	-1.336	3.110	0.000	6.250	6.870	0.555
1851	2.568	3.090	-4.245	6.238	6.908	0.551
1852	4.995	3.020	3.222	6.320	6.976	0.576
1853	2.925	3.070	17.487	6.384	7.058	0.594
1854	-10.480	3.270	11.024	6.250	7.058	0.802
1855	0.777	3.310	0.000	6.196	7.040	1.008
1856	1.674	3.220	-0.841	6.282	7.134	1.087
1857	0.168	3.270	2.439	6.270	7.177	0.638
1858	-0.292	3.100	-13.489	6.350	7.114	0.663
1859	-0.404	3.150	3.564	6.415	7.205	0.683
1860	1.959	3.190	4.250	6.398	7.279	0.773
1861	7.666	3.280	-4.250	6.282	7.259	0.772
1862	13.189	3.230	4.250	6.367	7.199	0.751
1863	16.906	3.240	0.802	6.358	7.247	0.743
1864	0.930	3.330	-1.678	6.355	7.279	0.729
1865	5.636	3.350	-1.638	6.360	7.349	0.702
1866	-15.759	3.410	2.515	6.322	7.388	0.679
1867	-5.651	3.230	-1.692	6.509	7.373	0.678
1868	-3.477	3.200	-2.558	6.518	7.426	0.673
1869	4.351	3.230	-7.260	6.473	7.441	0.640
1870	10.686	3.240	2.821	6.548	7.509	0.635
1871	11.973	3.230	4.439	6.619	7.571	0.655
1872	12.246	3.240	10.683	6.661	7.599	0.649
1873	2.722	3.240	-0.758	6.645	7.630	0.617
1874	-2.966	3.240	-4.873	6.647	7.652	0.611
1875	-5.951	3.200	-3.317	6.680	7.638	0.605
1876	-6.788	3.160	-1.736	6.695	7.650	0.598
1877	-5.412	3.150	-4.439	6.658	7.675	0.616
1878	-8.232	3.150	-8.555	6.653	7.622	0.634
1879	-8.048	3.080	-2.995	6.699	7.576	0.603
1880	16.476	3.050	3.947	6.635	7.737	0.573
1881	-1.077	2.780	-2.966	6.624	7.744	0.568
1882	-3.710	2.910	2.014	6.629	7.809	0.564
1883	-5.350	2.840	0.000	6.615	7.832	0.560
1884	-4.858	2.690	-6.167	6.615	7.809	0.556
1885	-1.596	2.720	-7.574	6.632	7.773	0.574
1886	1.256	2.790	-5.937	6.590	7.751	0.592
1887	-3.347	2.680	-2.358	6.585	7.797	0.610
1888	3.120	2.560	3.612	6.580	7.871	0.606
1889	12.496	2.810	0.000	6.585	7.933	0.601
1890	0.100	2.670	3.486	6.643	7.927	0.596
1891	-1.822	2.700	-1.117	6.684	7.930	0.613

1892	-1.233	2.650	-4.795	6.721	7.879	0.607
1893	1.029	2.610	0.000	6.721	7.852	0.623
1894	3.322	2.520	-10.231	6.756	7.918	0.617
1895	9.890	2.390	-2.758	6.809	7.949	0.633
1896	19.051	2.280	1.333	6.854	8.005	0.648
1897	9.874	2.250	1.425	6.827	8.006	0.641
1898	-0.539	2.280	5.195	6.829	8.041	0.656
1899	2.599	2.360	7.462	6.886	8.084	0.690
1900	-1.258	2.540	8.012	6.922	8.080	0.985
1901	-5.336	2.670	-5.643	6.942	8.063	1.055
1902	-1.844	2.660	0.000	6.953	8.081	0.987
1903	-2.391	2.750	0.000	6.952	8.080	0.822
1904	-5.889	2.830	-3.623	6.932	8.074	0.796
1905	5.889	2.780	3.623	6.922	8.139	0.770
1906	1.456	2.830	7.831	6.950	8.178	0.744
1907	-1.823	2.970	4.155	6.990	8.197	0.719
1908	-6.224	2.900	-10.869	6.985	8.138	0.712
1909	-0.392	2.980	4.526	7.010	8.153	0.725
1910	8.222	3.080	6.343	7.028	8.190	0.718
1911	4.599	3.150	5.021	7.053	8.223	0.731
1912	-0.138	3.280	1.955	7.073	8.238	0.728
1913	-1.325	3.390	1.918	7.116	8.335	0.725
1914	-1.485	3.460	0.000	7.312	8.264	1.455
1915	-12.173	3.820	15.978	7.464	8.273	4.445
1916	-4.407	4.310	17.212	7.600	8.196	6.224
1917	-6.039	4.580	18.695	7.691	8.157	7.542
1918	-0.308	4.400	14.382	7.923	8.099	7.868
1919	1.309	4.620	5.672	8.095	8.221	3.786
1920	0.414	5.320	14.192	8.139	8.235	1.343
1921	-38.299	5.210	-9.422	8.078	7.849	0.860
1922	13.050	4.430	-21.314	8.019	8.068	0.682
1923	20.598	4.310	-5.106	7.970	8.147	0.603
1924	-1.307	4.390	0.778	7.973	8.212	0.595
1925	10.008	4.430	0.410	7.983	8.198	0.600
1926	5.407	4.550	-2.018	7.971	8.070	0.596
1927	7.946	4.560	-2.867	7.973	8.323	0.590
1928	13.310	4.470	-0.862	7.989	8.279	0.569
1929	-1.841	4.600	-1.258	7.972	8.369	0.563
1930	-21.313	4.460	-3.924	7.984	8.318	0.551
1931	-25.131	4.530	-6.434	7.966	8.209	0.545
1932	-3.000	3.760	-2.850	7.975	8.210	0.538
1933	19.744	3.380	-2.990	8.066	8.265	0.536
1934	23.361	3.080	1.478	8.088	8.356	0.538
1935	8.004	2.890	1.011	8.088	8.437	0.549
1936	14.310	2.940	2.864	8.137	8.521	0.573
1937	-6.899	3.280	5.132	8.198	8.580	0.616
1938	-19.671	3.380	0.873	8.223	8.556	0.703
1939	-4.445	3.720	1.371	8.247	8.514	0.773
1940	-20.067	3.400	14.786	8.339	8.540	3.636
1941	5.407	3.130	8.061	8.466	8.638	5.414

1942	10.008	3.030	0.680	8.655	8.664	6.527
1943	17.435	3.100	-0.680	8.822	8.685	7.567
1944	11.333	3.140	1.038	8.958	8.640	7.863
1945	3.509	2.920	1.380	9.074	8.614	8.056
1946	9.844	2.600	0.000	9.154	8.582	4.284
1947	3.077	2.760	0.703	9.195	8.638	2.277
1948	-3.077	3.210	6.257	9.129	8.721	1.452
1949	-6.454	3.300	2.846	9.136	8.786	1.213
1950	3.279	3.550	3.077	9.140	8.852	1.106
1951	14.953	3.790	8.670	9.169	8.883	1.280
1952	-18.232	4.230	8.762	9.208	8.844	1.337
1953	6.454	4.080	2.992	9.252	8.905	1.318
1954	27.193	3.760	1.946	9.303	8.956	1.277
1955	15.415	4.170	4.495	9.355	9.008	1.214
1956	-7.671	4.740	4.504	9.396	9.010	1.164
1957	4.175	4.980	3.681	9.430	9.033	1.036
1958	-3.458	4.980	2.727	9.464	9.023	0.913
1959	31.880	4.825	0.635	9.496	9.072	0.832
1960	24.168	5.458	1.027	9.543	9.141	0.757
1961	0.376	6.270	3.400	9.583	9.144	0.684
1962	-11.345	5.979	4.239	9.597	9.152	0.635
1963	10.434	5.588	1.875	9.621	9.187	0.613
1964	9.045	6.060	3.260	9.675	9.266	0.606
1965	-2.806	6.433	4.728	9.739	9.293	0.599
1966	-1.614	6.818	3.861	9.784	9.309	0.591
1967	6.728	6.730	2.280	9.813	9.315	0.586
1968	26.626	7.459	4.707	9.865	9.389	0.567
1969	-9.860	8.941	5.228	9.901	9.422	0.534
1970	-15.090	9.233	6.208	9.936	9.428	0.519
1971	6.748	9.041	9.029	10.014	9.422	0.510
1972	26.582	9.198	6.881	10.066	9.440	0.513
1973	-14.546	10.909	8.707	10.178	9.526	0.506
1974	-55.047	15.173	14.879	10.285	9.505	0.481
1975	21.354	14.601	21.701	10.418	9.451	0.466
1976	16.829	14.227	15.314	10.532	9.483	0.465
1977	20.626	12.192	14.709	10.635	9.533	0.457
1978	5.819	12.022	7.972	10.774	9.562	0.444
1979	-0.817	11.346	12.569	10.900	9.599	0.435
1980	-2.362	11.929	16.541	10.976	9.531	0.445
1981	11.025	13.012	11.209	11.025	9.496	0.460
1982	10.289	11.741	8.241	11.054	9.515	0.447
1983	18.660	9.539	4.529	11.114	9.550	0.444
1984	21.047	9.441	4.827	11.168	9.562	0.448
1985	16.144	9.380	5.917	11.213	9.610	0.447
1986	24.777	8.717	3.343	11.252	9.632	0.440
1987	21.761	8.364	4.075	11.297	9.670	0.435

Note: Stock returns and the inflation rate are calculated as differences of logarithms. M0 and industrial production are both set to a base year 1750 = ln(100). Armed forces employment is expressed as a ratio to total population.

Diagram 1

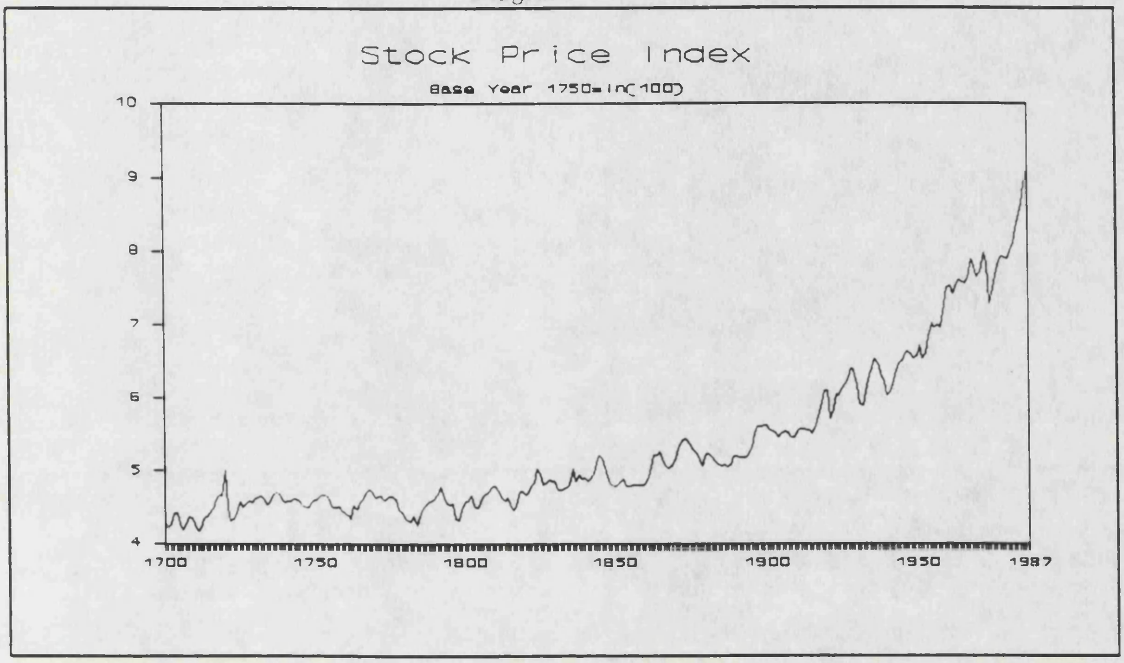


Diagram 2

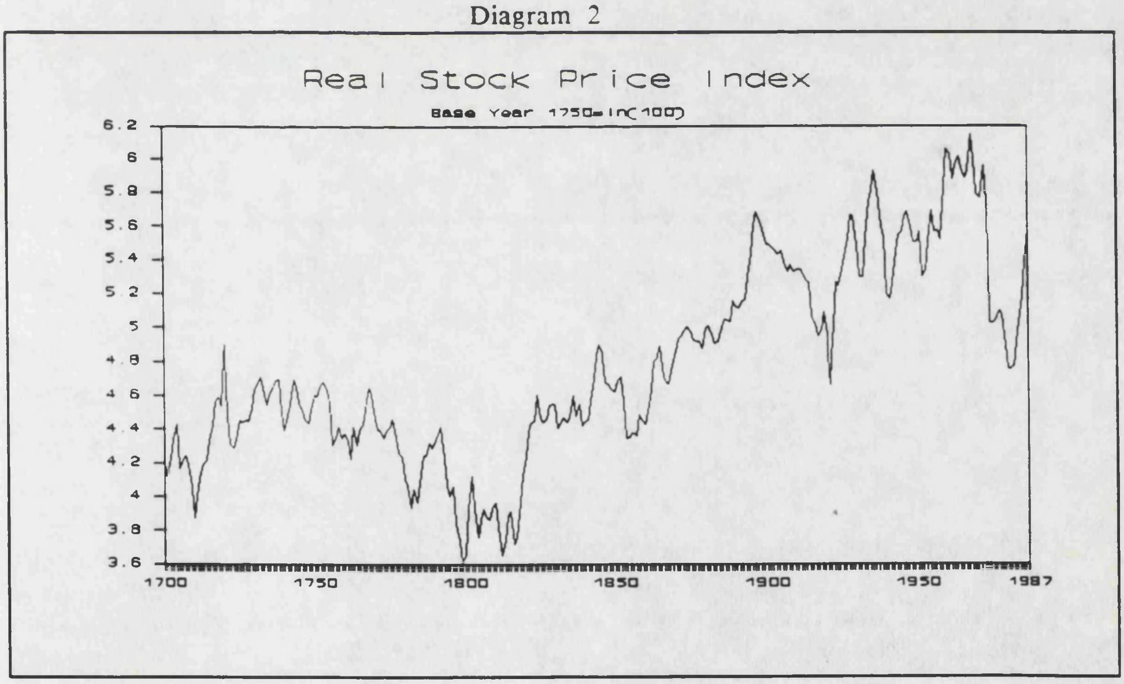


Diagram 3

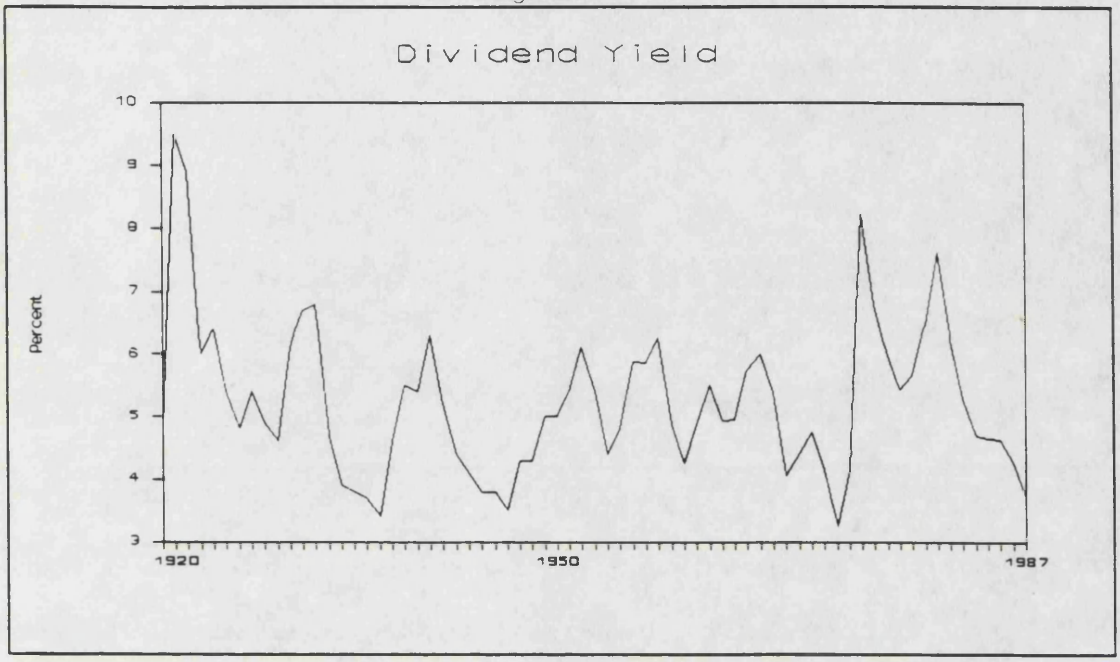


Diagram 4

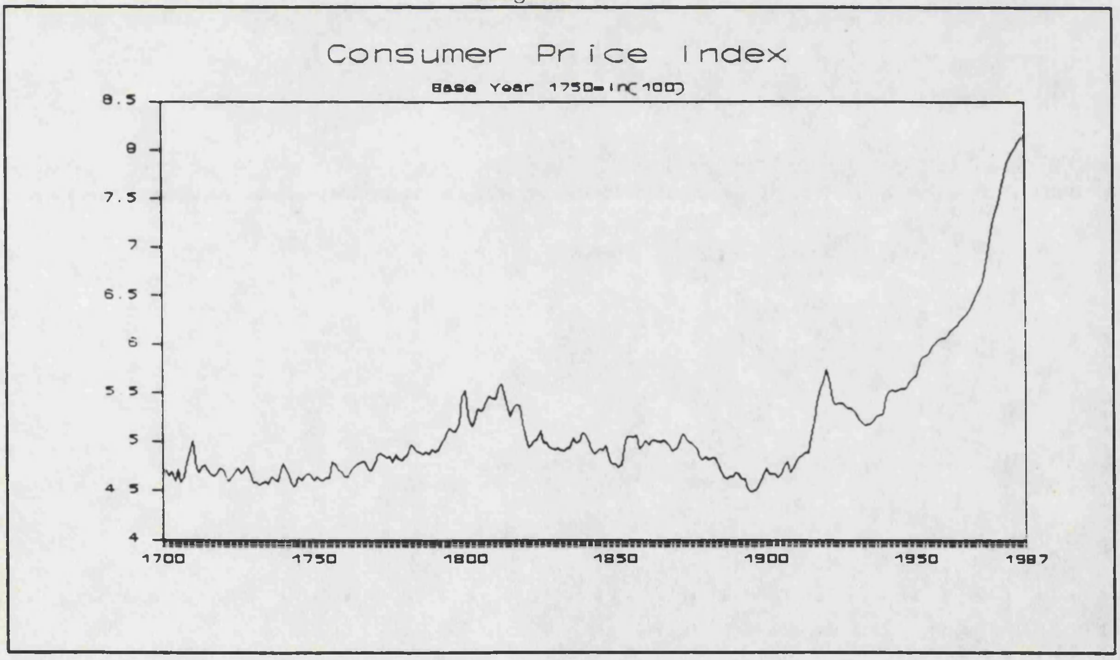


Diagram 5

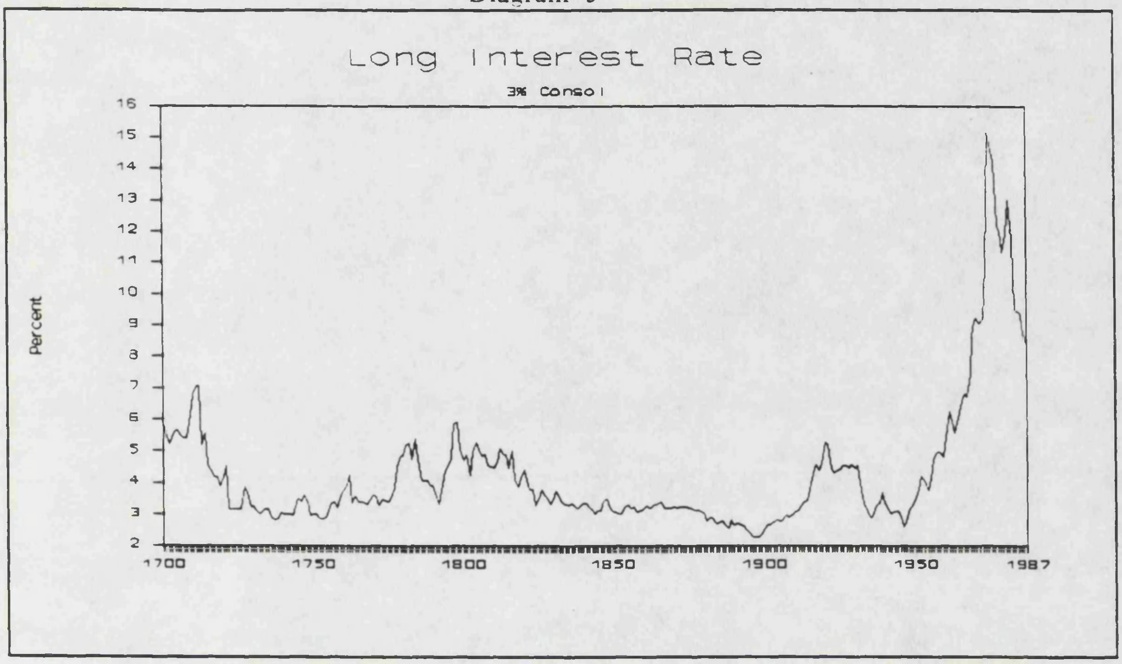


Diagram 6

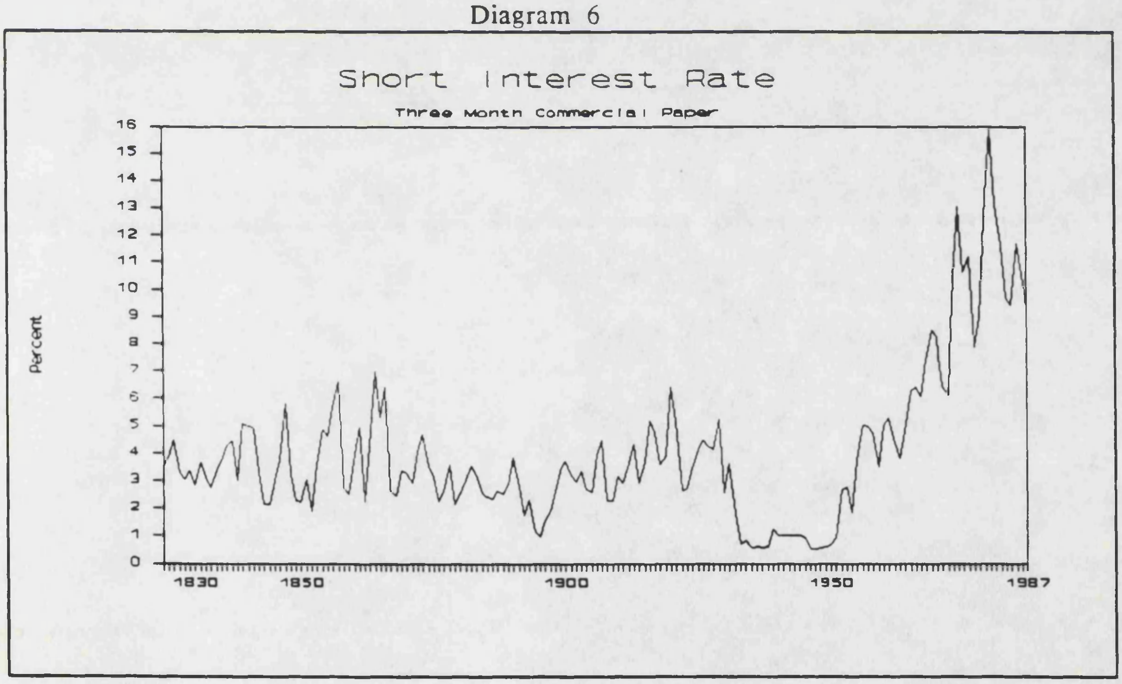


Diagram 7

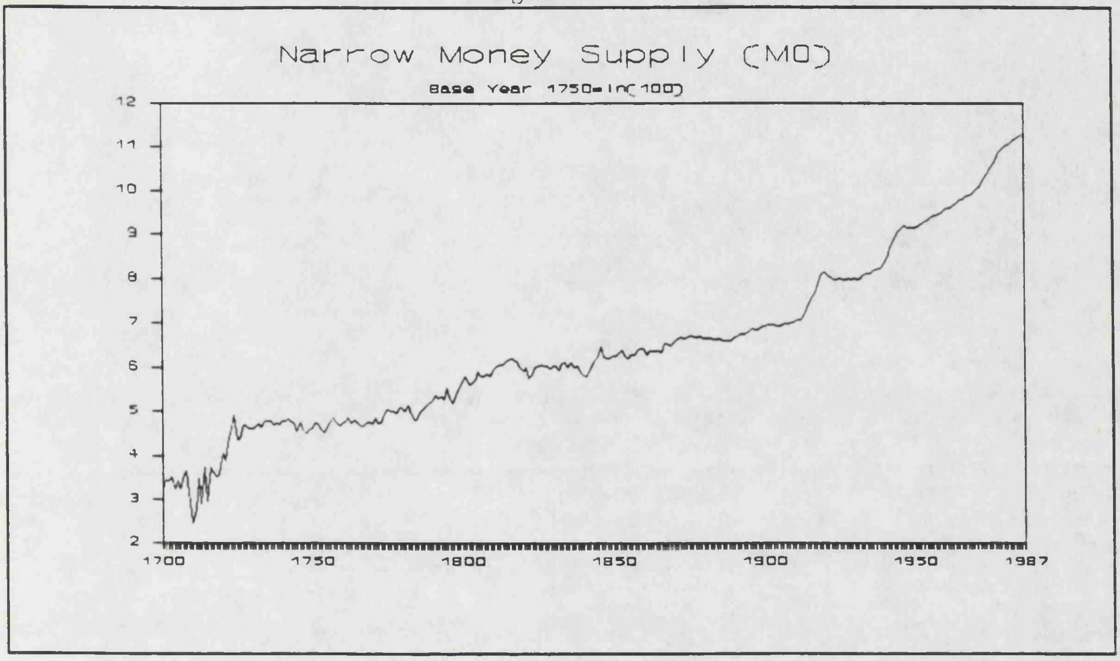


Diagram 8

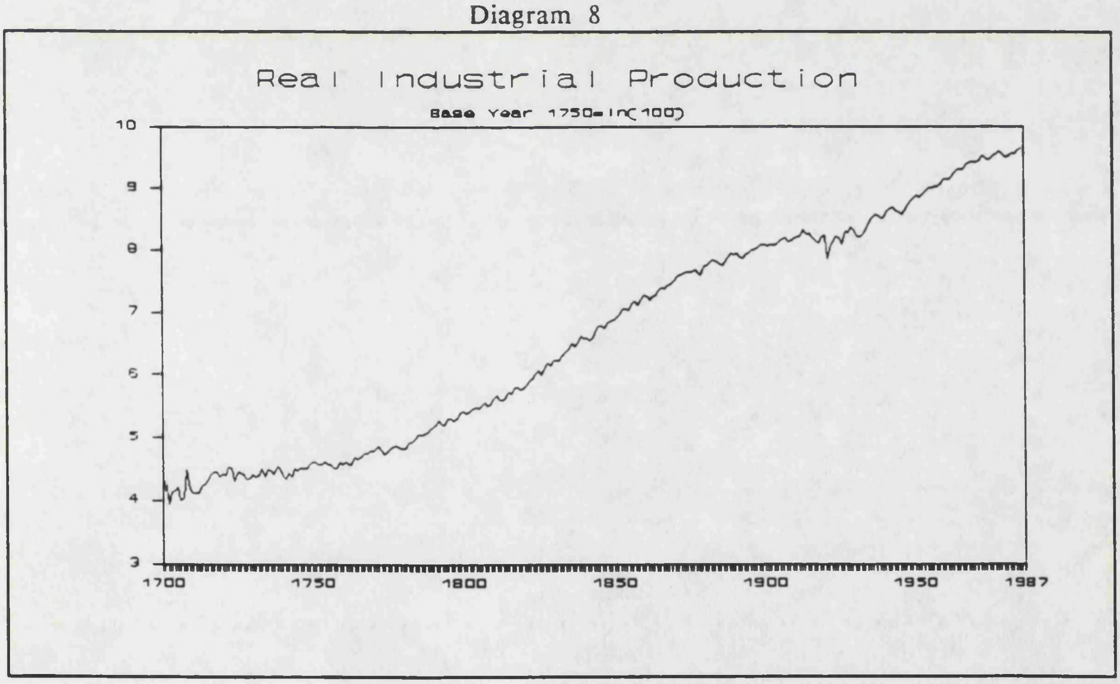
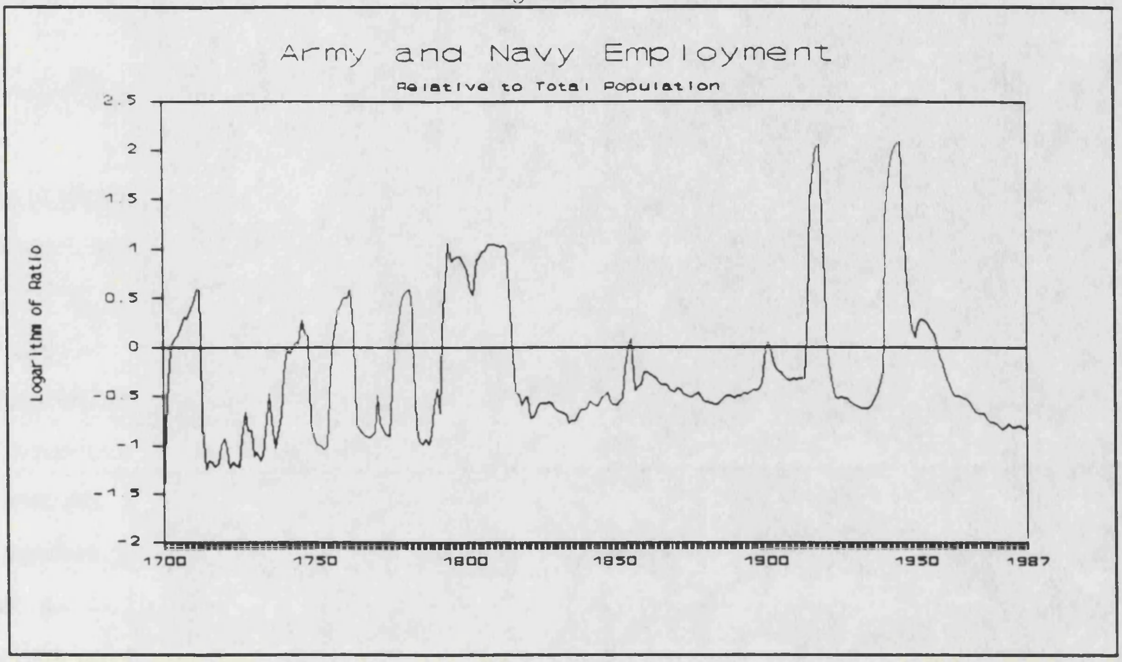


Diagram 9


Army and Navy Employment
Relative to Total Population
Logarithm of Ratio
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
1700
1750
1800
1850
1900
1950
1987

Chapter III: Stock Prices and Financial Crises

I. Introduction

The present chapter examines financial market crashes and crises from a historical perspective, rather than focusing strictly on the 1987 event as did Chapter I. A statistical methodology is used, as in the rest of the thesis, in contrast to the descriptive and anecdotal approach common to the study of these historical incidents.[1] The chapter examines market crises using British time series data from 1700 to the present, and then employs various models using macroeconomic variables to extract a measure of relative speculative behaviour. While the analysis is somewhat rough and ready, due to the use of annual data and disagreements amongst economists on what constitutes a market crash or crisis, it does provide a starting point for more detailed studies in the future.

In brief, the chapter concludes that macroeconomic variables are important for driving stock price fluctuations, but can by no means account for the bulk of such movements. The efficient and non-efficient market models developed here appear to operate equally well during crisis and non-crisis years, with only a handful of exceptions related to periods of market crashes. These exceptions account for less than one fifth of all observed financial crises since 1700 and have mostly been described in the historical literature as arising from excessive speculative activity.

There may, therefore, be some support for the existence of speculative bubbles or other non-efficient market behaviour unrelated to macroeconomic variables. The last statement remains tentative, however, because the evidence is indirect and may equally be a function of model misspecification or omitted fundamentals. In any case, the ability of lagged variables to explain stock returns is direct evidence of non-efficient market behaviour *related* to macroeconomic variables.

The outline of the chapter is as follows. The next section distinguishes two views of market crashes based on fundamental and non-fundamental factors, while Section III explores some definitional considerations. In Section IV, the impact of macroeconomic variables is assessed for normal stock market behaviour. Three such models are presented: one based on news to the market, one unrestricted multivariate autoregression and one restricted model with an error correction mechanism; the first model adheres to the efficient markets hypothesis but the latter two deviate from this theory by using lagged variables to predict stock returns. Sections V and VI set out a chronology of financial crises and then apply the estimated models to periods of crisis which have experienced marked prior equity price appreciation. Finally, Section VII concludes the chapter.

II. Market Crises: Theoretical Approaches

The very source and definition of market crises is a subject of much debate. On the one hand, there are supporters of extreme versions of the efficient markets theory who claim that equity price movements can be wholly explained on the basis of a continuous stream of news to the market. Crashes therefore occur due to the arrival of relatively more important bits of news and are intrinsically no different than any other news-generated fluctuations.[2]

To demonstrate this point of view mathematically, note that one period expected equity returns are defined as

$$(1) \qquad E(R_{t+1}) = E\left\{\frac{P_{t+1} - P_t + D_{t+1}}{P_t}\right\}$$

where R_t is the total return, P_t is the market price, D_t is the dividend paid on the stock and E is the expectations operator utilising the information set at time t.

Substituting recursively for P_t, one obtains

$$(2) \; P_t = E\{D_{t+1}(1 + E(R_{t+1}))^{-1} + D_{t+2}\prod_{j=1}^{2}(1 + E(R_{t+j}))^{-2} + D_{t+3}\prod_{j=1}^{3}(1 + E(R_{t+j}))^{-3} + \ldots$$

and gathering terms yields

$$(3) \qquad P_t = E\left\{\sum_{i=1}^{\infty} D_{t+i}\prod_{j=1}^{i}(1 + E(R_{t+j}))^{-1}\right\}$$

Given the existence of effective arbitrage, in equilibrium

$$E(R_{t+1}) = E(r_{t+1} + \alpha_{t+1}) \tag{4}$$

where r_t is the risk free rate of interest and α_t is the risk premium which compensates investors for relatively high stock market risk. Substituting (4) into (3), and taking first differences, gives

$$P_{t+1} - P_t = \underset{t+1}{E}\{\sum_{i=1}^{\infty} D_{t+i+1} \prod_{j=1}^{i}(1 + \underset{t+1}{E}(r_{t+j+1} + \alpha_{t+j+1}))^{-i}\} - E\{\sum_{i=1}^{\infty} D_{t+i} \prod_{j=1}^{i}(1 + E(r_{t+j} + \alpha_{t+j}))^{-i}\} \tag{5}$$

Equity prices therefore fluctuate due to shocks which change expectations of either future dividends, discount rates or the risk premium. Traditionally, these elements have been referred to as economic fundamentals, in contrast to other factors related to market psychology or irrational behaviour.

On the other hand, supporters of the market irrationality explanation of equity price fluctuations tend to identify crashes with reckless investment practices and the dashing of previous over-optimism.[3] To accommodate non-fundamental elements, the previous analysis can be amended as follows:

Rewrite equation (1) as

(6) $$E(R^{B}_{t+1}) = E\left\{\frac{P_{t+1} - P_t + D_{t+1} + B_{t+1}}{P_t}\right\}$$

where B_t is a rational bubble term which is usually motivated as an expectation of capital gain in excess of that justified by the present value of future dividends.

Substitute as before to obtain

(7) $$P_t^B = P_t + E(\beta)$$

where

(8) $$\beta = \sum_{i=1}^{\infty} B_{t+i} \prod_{j=1}^{i} (1 + E(r_{t+j} + \alpha_{t+j}))^{-i}$$

Providing that the present value of β is zero, P_t and P_t^B are indistinguishable in an empirical sense.[4] However, the time path of β may be such that sustained upward movements are eventually compensated by short and sharp downward price revisions: in essence, a bubble and a crash. The β term in equation (7) is, therefore, a function of non-fundamental expectations and is broad enough to accommodate speculative tendencies arising from irrationality or emotional contagion across investors.

As discussed in Chapter I above, a realistic formulation of β with a ready application to financial crises is

(10) $$\beta_{t+1} = \left\{\frac{(1 + r_{t+1} + \alpha_{t+1})}{\Pi}\right\} \beta_t + \mu_{t+1}$$

or $$\beta_{t+1} = \mu_{t+1}$$

The first equation occurs with probability π, while the second occurs with probability (1-π). π is defined as the unconditional probability that the bubble continues while (1-π) is the associated probability of a crash; μ_t is IID with mean equal to zero. The term $(1+r_t+\alpha_t)\pi^{-1}$ is greater than $(1+r_t+\alpha_t)$ during the duration of the bubble in order to compensate for the risk of the bubble bursting.

Alternatively, a broader interpretation of the β term in equation (7) ties market behaviour more strongly to a social and psychological structure responding to changing economic conditions. The essence of this school of thought can be succinctly described by a process of "(p)rosperity, boom, crisis, slump, and recovery succeed(ing) each other with a regularity that suggest(s) inevitability".[5] The stock market is characterised here as an intrinsic element of cyclical fluctuations in the general economy and, due to uncertainty and the liquid nature of the market, is a medium for amplifying pervading waves of mass euphoria and depression.

Kindleberger (1978) catalogues dozens of these speculative episodes since the early 18th century in Europe and the United States. In general, following Minsky (1977), he argues that market crises are the ultimate consequence of the credit structure in advanced capitalistic economies. Firms go through several stages of liquidity and financial structure over the business cycle, with financial fragility increasing at each stage as debt loads are increased. The boom conditions set off by a positive economic shock are reinforced by investment and speculative behaviour until it becomes apparent that expectations are excessive with respect to sustainable real growth. The process then unwinds with bankruptcy, credit contraction and downward revaluations of asset prices. Once the nadir is reached, the cycle turns up once more based on healthier firm balance sheets and the progressive lack of investor inhibition regarding reinvestment in securities.[6]

In conclusion, several approaches can therefore be differentiated in any discussion of financial market crashes or crises. The efficient markets school argues for rational investor behaviour and the importance of economic fundamentals, while the non-fundamentals approach stresses the roles of self-fulfilling expectations and social interaction; the latter approach can also be distinguished between independently generated rational bubbles and broader speculative tendencies which arise out of the economic cycle. In this chapter, such non-efficient market behaviour is classified into two categories, according to whether or not it is linked to macroeconomic information. Lastly, there may be a role for irrationality in the market; however, it is difficult to test for such aberrant behaviour using traditional economic techniques.

In what follows below, it will be seen that these broad crash determinant stories are all partially supported. In some circumstances, it seems that pre-crash returns can be explained by an efficient market model, while in others, it appears that non-efficient market behaviour linked to macroeconomic variables is more appropriate. Finally, when neither of these two classes of models are helpful, it may be that rational bubbles, speculation or irrationality unrelated to the real economy are motivating the pre-crash share price increases. The historical narrative record and the nature of the data used here both conspire against reaching sharp conclusions.

III. Market Crises: Definitional Considerations

Thus far, we have discussed stock market price determinants and crashes in a loose generic sense. There are considerable differences, however, on the definition of the point where relatively ordinary price movements degenerate into market crashes.[7] Common terms used when describing events akin to the 1987 price revaluation include bubble, crash, crisis, distress, deflation, mania and panic.

Bubble and mania are synonymous and have been discussed above as either mathematical constructs or terms used to describe excessive valuation of assets relative to long term sustainable levels. The terms crash, panic and (sharp) deflation typically refer to situations where relatively large price revisions occur over a relatively short time span.

Crisis and distress refer primarily to the follow on effects of the crash. First, there is typically a flight to liquidity by investors and a commensurate raising of risk premiums on all lesser liquid assets. Secondly, this increased demand for liquidity may prompt illiquidity within the banking and financial system as calls on loans, credit rationing and bank runs become widespread. Lastly, general economic activity may be affected by instability in the credit system, increases in the cost of capital and wealth effects issuing from the price revaluation.[8]

The view taken here is that all of these events either describe or impact upon the stock market through the functioning of arbitrage relationships between credit and other financial assets and through the linkages between investor sentiment in industry and the stock market. Therefore, an encompassing approach will be taken here by examining all such incidents described in the historical literature. A consequence of this approach is that the terms defined above will be used interchangeably throughout the chapter.

Before setting down a crisis chronology and examining any common tendencies, it is appropriate to examine the extent to which macroeconomic variables drive the equity market in every day circumstances and then move from there to an examination of such influences at times of crisis. The base models developed will be used to test the extent to which the efficient markets view is appropriate, recognising of course that unexplained residuals can stem from inadequate model specification, unobserved fundamentals or non-fundamental speculative tendencies in the market.

IV. Stock Returns and Macroeconomic Information

This section examines the explanatory power of various macroeconomic magnitudes for stock returns in the United Kingdom since 1700. The variables examined are the growth rates of real industrial production and the real monetary base, consumer price inflation, long and short term interest rates and the ratio of armed forces employment to the general population.[9] These measures will be correlated to various definitions of equity returns using three different modelling strategies: a vector autoregression (VAR) news generating process, an unrestricted multivariate autoregression employing lagged, current and leading values and a restricted error correction model. As will become apparent, all three approaches yield similar results in terms of the influence of macroeconomic information on the stock market.

Table 1 describes the data and suggests a useful partition that will be employed elsewhere in the chapter. The most important split in the series comes after 1913, with the end of the classical gold standard and the start of World War I. A second split occurs after 1949 with the end of post-war price controls and the beginning of the reintroduction of market forces to financial markets. Following 1913, it can be seen that the levels of inflation and interest rates increased markedly, as well as the volatility of equity returns and interest rates. The use of the 1913-1987 sample disguises the weak and volatile nature of industrial production in the wartime and interwar period but is necessary in what follows in order to preserve the degrees of freedom required for a robust VAR investigation. The last point to note is the negative average equity premium; this occurs due to the absence of a full sample dividend yield series which would restore the equity return series to its correct positive value.[10]

Tables 2 to 4 present the results from the first model, a VAR news generation mechanism which is consistent with efficient market prescriptions. Relative to the other models to come, this approach uses a limited set of information; it therefore unsurprisingly produces the weakest results in favour of the fundamentals view of equity pricing. Briefly, the approach is as follows. First, a VAR system is constructed using the five macroeconomic variables and squared stock returns to proxy for risk.

Secondly, the residuals from each VAR become the news variables which are entered into the equity return equations shown in Tables 2 to 4.[11]

Throughout the three tables, one sees that interest rate shocks are the predominant elements correlated with equity returns, followed by industrial production and inflation shocks. All coefficients are of the appropriate signs except for the poorly determined armed forces variable, which is positive in the earliest period.[12,13] The size of the coefficients generally rise from the early to the later period, with the exception of the inflation term in the real return equation and interest rates. In spite of this, the adjusted R squared value declines over time. Altogether, macroeconomic news accounts for up to one third of equity price variability and depends on a news generation process using information no more than two years old, as evidenced by the rapidly declining adjusted R squared values as further lags are added to the VARs. We see, therefore, that in a limited information model, the efficient markets theory produces sensible coefficients but leaves the bulk of market fluctuations unaccounted for across both crisis and non-crisis years.

The other end of the modelling spectrum is investigated in Table 5, which excludes full sample results because of their similarity to those shown in the table. Following Cutler et al (1988), adjusted R squared values are given for multivariate autoregressions of equity returns on macroeconomic variables.[14] The first column shows the results using lagged values only and the other two columns progressively add current and next period variables. The aim here is to set a notional upper limit to the explanatory power of macroeconomic factors by including current and future values, in contrast to the sparseness of the news regressions above. Since lagged variables are used to predict stock returns, this model and the restricted error correction model to come are evidence of non-efficient markets behaviour linked to macroeconomic variables.

Once again, the short equity premium produces the weakest results, especially for regressions including only lagged variables. The inclusion of leading variables makes very little difference to the explanatory power, except in the case of the short equity premium prior to 1913. In contrast to the news regressions, macroeconomic information now accounts for up to one half of equity price variation. This explanatory power is likely overstated due to the use of averaged variables but is understated to the extent that other important variables, in particular dividends, are excluded from the regressions.

Tables 6 and 7 show the results of a restricted equation augmented with an error correction mechanism. The integration results shown in Table 6 indicate that all of the variables aside from armed forces employment are integrated of order one. It is therefore appropriate to use first differences of the variables in the restricted equation, as has previously been done with the other two models. The cointegrating equations also suggest that long term bilateral equilibrium relationships exist between stock prices and these variables, with the exceptions of long interest rates and the armed forces ratio to total population. As seen in the sixth row of the table, all of the variables are jointly cointegrated with stock prices.[15]

Table 7 indicates that the estimated coefficients of the final restricted regression are well specified and that the equation passes standard diagnostic tests.[16] The steps taken to impose linear and exclusion restrictions on the general specification may be retraced by examining the table from left to right and by studying the F test statistics at the bottom. Note that the data favour a specification in second differences, indicating that the equity return series is correlated to acceleration terms as well as to the long term level effects embodied in the error correction term.

The exclusion of the armed forces employment and industrial production variables in acceleration form may be an indication that the stock market responds more closely to financial factors expressed in this way, like money supply, interest rates and inflation, rather than to variables more closely linked to the real economy; if this is generally true, the Fisher/Minsky/Kindleberger means of shock transmission at times of accelerated activity may operate primarily through the financial system rather than the real economy. Another point to note is the gold standard dummy variable which accommodates the switch in monetary institutions that took place this century. It mainly acts to segregate the effects of inflation on equity returns into a completely neutral gold standard period and a strongly negative period off of the gold standard.[17]

The restricted equation coefficients indicate that accelerations in interest rates and inflation are detrimental for equity returns, while acceleration in the real money base is positively correlated. The existence of effective arbitrage and the theoretical literature on the costs of inflation support the first finding, while the second can possibly be explained as a short term response to easing of monetary conditions. The error correction term is well specified in all of the equations shown in Table 7 as the value -.07 and implies that equity returns converge to long term equilibrium with the macroeconomic variables after periods measured in decades. Finally, the R bar squared value, though small in magnitude, is comparable to the VAR results discussed above.

All in all, we have developed three different models of equity returns in this section. Each specification has its own merits in terms of theoretical plausibility and empirical fit and the hope is that the three approximate the spectrum of modelling possibilities in a parsimonious manner. The models will now be used to investigate whether macroeconomic information is the predominant factor in explaining equity returns prior to crises or whether there is a large residual which may be attributable to rational bubbles or other non-efficient markets behaviour divorced from the macroeconomy. In addition, since the restricted model incorporates only financial factors, it may be possible to indicate where prior returns are generated by real or financial variables by comparing the restricted model results with the more fully encompassing VARs.

V. Financial Crisis Chronology

The preceding section concluded that efficient and non-efficient market models of equity pricing can account for up to one half of market fluctuations. While this establishes the importance of macroeconomic factors, it still leaves a rather large unexplained residual. In addition, it does not directly examine periods when market crashes have occurred, dissimilar as they seem to be to more stable periods. This section will therefore outline a chronology of financial crises and discuss the preceding economic and market activity that may have prompted the crashes.

Table 8 lists the years, sources and purported causes underlying British crises since 1700. As the definitional section above made clear, there is little agreement on the essence of a crash and so any reference to a crash or panic that was found in the relevant sources is included in the table. Even if some of these years did not produce market movements on the scale of October 1987, the fact that crises, crashes or signs of distress were noted is sufficient to consider whether there were measurable predeterminants underlying the events. For, if a rational bubble story of crashes is correct, it is reasonable to think that there is a sustained period of excessive speculative activity prior to a crash or crisis.[18]

As can be seen from the sources column, there is not a great deal of overlap between different accounts. Morgenstern (1959), in particular, lists a number of stock market crashes which are not mentioned elsewhere but he unfortunately does not provide original sources. It is also difficult to give an exact date for each crisis because of conflicting narrative accounts, sometimes even from the same source.[19] One should therefore not be overly confident that any individual account is authoritative.

The origins of the crises seem to fall into at least four categories: threat of war, international transmission, excessive speculation and feedback from the real economy.[20] While the first two are presumably verifiable on the basis of historical record, the latter two are somewhat subjective; the third explanation, especially, could be attributed without evidence to almost any market crisis. It is therefore necessary to examine the prior movements of the market to determine whether a potential rational bubble or other non-efficient market behaviour divorced from the real economy existed in prices prior to a crash.[21]

A number of points can be made about the a priori evidence from Table 9.[22] First, relatively few of the crises were preceded by substantial price appreciation. Of the 41 listed crisis years, only 12 show 1, 2 or 5 year prior returns which are statistically different from the sample averages at conventional significance levels.[23] A number of crises, for example those of 1816, 1878 and 1904, are actually preceded by substantial and sustained price declines; in this vein, the importance of inflation adjustment is seen in the cases of 1921 and 1974. Second, the equity return from the crisis to the following year, shown in the first column and demonstrating the relative magnitude of the crash, is usually substantial and negative. The most eventful years in terms of market decline appear to be 1720, 1797, 1866, 1921, 1929, 1940, 1973 and 1974; looking back to Table 8, it appears that the there is, however, no common causal element linking these years. A last point to note is the weak effect seen in the returns series for some years; either the crash was of small magnitude or else the market rebounded substantially within the crisis year.

In general, it appears from this simple examination that the rational bubble theory, like that based on the use of macroeconomic variables in efficient and non-efficient market models, can have at most only partial application to financial crashes. We turn now to a more sophisticated examination of the cases where prior speculation may have been in existence in order to measure the relative importance of macroeconomic factors during the years prior to market crashes.

VI. Estimated Models and Market Crises

The segregation of returns prior to crises into elements related to, and separate from, macroeconomic variables employs the three models developed in Section IV above. Three points should be stressed in what follows. First, the failure of macroeconomic factors to account for excessive equity returns prior to crisis years can be attributed to either non-efficient market explanations unrelated to the real economy, or else to misspecified or missing variables in the estimation equation.

Second, the models being used should not be interpreted as belonging to the investors' information set at the onset of each crash; rather, the fitted equations represent long term relationships which the crisis and non-crisis years alike should match if they are generated by the same underlying data generation process. A more detailed study utilising higher frequency data will be required to investigate models which satisfy information orthogonality with respect to returns.

Third, the residual returns which are generated by the estimated models test a null hypothesis that there is no significant difference between the model residuals generated over the full sample compared to those prior to times of financial crisis, against an alternative that such prior returns are significantly greater than the sample average. The test is therefore robust to examining rational bubbles, which are generally thought to be positively trending, but is not appropriate for testing non-efficient market behaviour divorced from the real economy, such as noise trading, which does necessarily produce positive autocorrelation of returns.

Tables 10 and 11 present the results for the macroeconomic news model.[24] The returns shown are estimation residuals aggregated over 1, 2 and 5 years before a given crisis year; they are therefore directly comparable to the actual returns in Table 9. Of the 15 cases selected from that table,[25] roughly one half show evidence of residual returns that are significantly greater than the average produced by the news model; the macroeconomic news model therefore fails to account for the substantial rise in the market prior to the crises in these years. Only the crises of 1720, 1763, 1836 and 1973 follow the expected rational bubble pattern, however, with the strength and significance of the residual return increasing from 5 or 2 years before the crash to the event itself. All of the others either peak more than two years before the crash or are too small in magnitude; in either case, the rational bubble theory is not easily supported without substantial modification to account for time lags in speculative response to the bull market peak.

Table 12 extends the same analysis to the unrestricted multivariate autoregression model, which falls under a non-efficient market paradigm.[26] Less than half of the potential rational bubble generated crashes now display residual returns which are excessive from the point of view of the estimated model. In addition, those residuals which are greater than the average do so at a lower level of significance. The years which follow an expected rational bubble pattern, with significance levels increasing as the crash draws nearer, are restricted, as before, to 1720, 1763, 1836 and 1973. The 1987 crash is notable not only for the fact that it culminated the greatest bull market since 1700, as seen in Table 9, but also that this run is largely explained by the estimated model. In support of the results from Chapter I, it is therefore difficult to resort to a bubble explanation for most of the price appreciation prior to 1987.[27]

Turning now to Table 13, one sees that the restricted model produces the same general conclusions as the other two models. Approximately two thirds of the years exhibit evidence of significant residual activity, although typical rational bubble behaviour is limited to 1720, 1763, 1825 and 1973. In common with the nominal news model, 1987 appears to be a crisis year where excessive returns developed two years prior to the crash. Given that the other models indicate that 1987 was not unusual in *real* terms, it may be that the possible rational bubble suggested by this table and by the nominal returns analysis of Table 11 was generated by real macroeconomic factors which are excluded from the models underlying these tables.

Tables 10 to 13 have uncovered a number of crisis years when the macroeconomic models are not able to account for prior returns. In years such as 1715, 1847 and 1895, when prior residual returns are statistically excessive only under the restricted (financial) model and the nominal news model, but not when generated by the other models, it may be that *real* macroeconomic factors are determining the equity return process.

In the case of 1836, the residual returns are higher than normal only under the news and unrestricted multivariate autoregression models. This result may indicate that the returns are generated by *financial* factors which the restricted model is able to explain.

The last permutation, where excessively positive returns are found under all three models, applies most strongly to 1720, 1825 and 1973 and, with provision for lags in response to speculative activity, 1866 and 1873. In these cases, the way is open for explanations ranging from rational bubbles to irrational mania and delusion. It is noteworthy that the efficient market model, using only macroeconomic news, and the non-efficient market models which incorporate lagged variables, are in broad agreements on the years which are unexplained by macroeconomic information.

VII. Conclusions

The conclusions of the chapter can be summarised as follows.

First, there seems to be a structural break in the British economy's underlying data generation process after 1913. This may be related to the expiration of the classical gold standard at that time and the subsequent introduction of substantive government fiscal and monetary policies. In any case, it is important to account for structural change in institutions over the period 1700 to present in any examination of the stock market.

Second, macroeconomic factors account for up to one half of fluctuations in equity market returns; the unexplained residual element from all of the models is, therefore, rather large. The unrestricted multivariate autoregression model provides the best data fit, albeit at the cost of theoretical rigour, while the poorest fit comes from the news model using long variable lags. In general, most macroeconomic information is embodied in variables with lags no longer than two periods. The success of models which use lagged variables to explain equity returns suggests that the efficient markets hypothesis cannot fully explain such returns.

Third, a comprehensive list of financial crises of all types reveals that these are triggered by a number of factors. Those preceded by substantially positive equity returns are relatively few, amounting to approximately one third of the total since 1700. When the estimated models are applied to explaining this subset of crises, there is strong evidence for possible rational bubble-like activity unrelated to macroeconomic variables in only three years: 1720, 1825 and 1973. The other crisis years for which prior returns are high are explained by real or financial factors or else reach a peak in returns more than two years before the crisis.

The dichotomy between the fundamental and speculative explanations of market crises is not, therefore, completely resolved. On the one hand, the macroeconomic variables models account for less than half of the fluctuations in the equity market. On the other hand, there seem to be only a handful of potential rational bubbles over the three centuries under examination which cannot be explained by the macroeconomic models. A more detailed study utilising disaggregated and higher frequency data will, therefore, probably be needed to eventually resolve the issues examined here.

1. Three important exceptions are Zarnowitz (1989), Garber (1989) and the contributors to the Capie and Wood (1986) compilation of papers on financial crises.

2. See Fama (1970) on the traditional definitions of market efficiency with respect to news and Hardouvelis (1987) and Jain (1988) for empirical estimates of the reaction of stock prices to macroeconomic news.

3. See Fisher (1933), Minsky (1977) and Kindleberger (1978) for a detailed exposition of this theory of asset pricing.

4. Indeed, Summers (1986) shows that the power to distinguish between random walk pricing processes generated by a fundamentals model and a pricing profile generated by an autoregressive bubble process is very weak.

5. Ashton (1959), p.136.

6. One empirical application of Minsky's theory for the recent evolution of the Canadian economy is found in Seccareccia (1988).

7. It may seem somewhat odd that rapid upward revisions to price levels are not treated with the same seriousness by economists that similar downward movements provoke. Within the stock market, there are always two sides to any bargain and, following a price change, the ex post gain of one investor (the seller or purchaser of the stock) is had at the expense of the other (the buyer or seller of the stock); this state of affairs obviously holds for both upward and downward price movements.

The asymmetry of interest on this question is probably related to the knock-on economic effects of crashes on confidence, monetary stability and investor wealth. As well, Kahneman and Tversky (1979) note that subjective valuations of capital gains and losses differ, with the perceived marginal cost of the latter higher than the perceived marginal benefit of the former; investors therefore tend to focus more attention on market downturns. Lastly, downward revisions to aggregate investor wealth may run up against collateral or other liquidity constraints which prompt investors to sell further assets and therefore reinforce the original price decline. On upward ticks, the regret felt on the part of the investor on the "wrong" side of the bargain is in terms of unrealised accretions to wealth; the only liquidity constraint here is the opportunity cost of foregone investments which could have been funded from the higher ex post equity valuation.

8. An early distinction between panics and crises is found in Powell (1913), where the latter is characterised by financial illiquidity in the financial system and the former describes the emotional panic experienced during the crisis. Schwartz (1986, p.11) suggests a division between financial and pseudo-financial crises (or distress) by arguing that the former is short-lived and is "fueled by fears that means of payment will be unobtainable at any price", while the latter may be drawn out over time and is "a consequence of restricted growth of bank reserves but is not precipitated by the public's behaviour". Hoppit (1986) likewise makes a distinction for 18th century British crises between those related to public finance, typically of a local nature with a London locus, and those impinging more directly on private (business) finance. As the 18th century progressed, crises apparently became more far reaching in effect due to the growth of the provincial banking system and of the financial and economic connections between London and other regions.

9. The data are described fully in Appendix I above and are all expressed in natural logarithms, with the exception of interest rates. It has been necessary to use annual averages in order to obtain a full sample from 1700 to the present; as a result, the estimated regressions specify correlations between averaged variables and do not examine the random behaviour of the underlying data generation process.

10. Most recent research indicates that dividends are a relatively smooth series over time, in contrast to the volatility of equity prices, cf. Marsh and Merton (1987). If this observation is assumed to hold for the full sample, it is likely that the absence of the dividend-price ratio does not alter our results substantially. As noted in Appendix I above, consistent dividend yield data are available only from 1919.

11. Formal LM(2) tests for autocorrelation of these residuals show that a null hypothesis of a random process against an AR(2)/MA(2) alternative cannot be rejected. As shown in the Memorandum items in Tables 2 to 4, the highest F-test value of 1.34 was that for short interest rate news, a value which is insignificant at conventional levels.

12. This variable is both a proxy for government expenditure, and therefore pressure on financial markets for funds, and for wartime effects on the stock market. Prior to the most recent period, British governments financed wartime expenditure by issuing debt since conventional means of raising revenue, in the absence of widespread taxation, were inadequate during times of stress, cf. Dickson (1967). The manpower variable is used here in preference to a series based on actual expenditure because of data limitations.

13. The changing coefficients on the inflation variable before and after 1913 may be related to the shift in monetary institutions which occurred at that time. See Chapter II above for a fuller discussion of this and related issues.

14. In contrast to Cutler et al (1988), all of the included variables are stationary, a prerequisite for applying standard asymptotic theory to VARs. Column 1 regresses stock returns on lagged macroeconomic values and squared returns, column 2 adds current macroeconomic values and column 3 adds one period ahead macroeconomic values.

It should be noted that the absence of a dividend yield series substantial biases downward the explanatory power of the equations, given the result in the Cutler et al paper that the dividend yield is usually the most important explanatory factor for historical U.S. real returns. It is therefore likely that the explanatory power of the macroeconomic variables would be considerably higher if additional data were available.

15. Further investigation of the relationship between interest rates and stock prices revealed that cointegration is supported for 1705 to 1913 (t-statistic of -3.00 significant at 5% level) but is weaker for 1914 to 1987 (t-statistic of -2.63 significant at 10% level). The error correction mechanism from the cointegrating regression using all five variables is employed in the real stock return restricted equation below. Real returns are used in preference to nominal returns due to the stronger evidence for integration and cointegration.

16. The Chow test statistics support previous evidence indicating that there is a structural break after 1913. The full sample restricted equation is used, nevertheless, in order to examine crashes over time with a common model. The structural change has been

accommodated by using subsample means and standard deviations to calculate significance levels.

17. The gold standard dummy variable takes the value 1 from 1700 to 1797, 1821 to 1914 and 1925 to 1932. The negative effect of inflation acceleration largely stems from the sharply different data generation processes at work before and after 1913: inflation was strongly mean reverting in the earlier period and highly persistent in the latter. The gold standard effect is not a proxy for a wartime effect, since appropriate dummy variables used to account for both interstate and global wars are not significantly different from zero at the 10 percent level. See Appendix I above for further details of these dummy variables.

18. Weil (1989) notes, however, that theoretical bubbles can be generated which lead to price declines, rather than increases. The intuition behind the result is that the presence of the bubble depresses the value of the fundamentals term by raising the discount rate to such an extent that total fundamental plus bubble return is declining over time. The notion seems to be impractical on a real world basis since it calls for negative interest elasticities of demand by savers. In addition, as a practical matter, the fact that annual values are used in this chapter means that bubbles which last for less than one year are generally undetectable.

19. For example, see the separate Kindleberger (1978) dates for the 1857 crisis.

20. It should be noted that there are multiple causes of many, if not most, of these market crises. The selection shown in the third column of Table 8 are merely those stressed by the relevant source.

21. It is also of interest to note that crises triggered by political factors are often unexpected and, therefore, not necessarily accompanied by prior speculation in the equity market. The crashes of 1761, 1914 and 1940 bear out this point.

22. Both nominal and real returns are shown in Table 9 for a number of reasons. First, standard economic theory implies that real magnitudes motivate investor behaviour. Second, given that crashes sometimes occur on a shorter time scale than the data at hand, the inflation element at a time of crisis may be irrelevant relative to the size of the equity price change. Third, as Table 1 demonstrates, there was a marked change in the inflation process after 1913 which upwardly biases nominal returns. The first and third reasons argue for analyzing real returns while the second supports examining nominal returns. In any case, the results using both approaches are broadly in agreement. It should also be noted that the relatively high volatility of real returns may be related to the influence of grain prices in the consumer price deflator.

23. Means and standard deviations were calculated for three periods, pre 1913, post 1913 and full sample, to account for changing economic structure. As well, previous year 1, 2 and 5 year equity returns were employed where the crisis occurred in the first half of the year or where it appeared that the peak of a potential speculative bubble occurred prior to the crisis year. In no case did these permutations alter the choice of years exhibiting statistically significant prior returns.

24. The full sample models for real and nominal stock returns are used to generate the residual returns.

25. The cases all demonstrate prior returns which are significantly greater than the sample average at the 10% level. As well, the crises of 1810, 1895 and 1901 have prior returns which are marginally significant at that level.

26. The analysis is identical for both nominal and real returns since each equation is a linear transformation of the other. The full sample model includes only one and two period lagged variables to generate the residual returns.

27. The large size of the residual does not, however, rule out the total absence of excessive speculative activity.

Table 1: Means and Standard Deviations of Sample Data

Variable	1700 to 1913	1914 to 1987	1830 to 1913	1914 to 1949	1950 to 1987
Nominal Stock Return	0.6 (8.9)	4.8 (15.6)	0.8 (7.6)	2.7 (14.1)	6.8 (16.8)
Real Stock Return	0.6 (10.4)	0.4 (17.0)	0.9 (8.0)	0.6 (15.5)	0.2 (18.5)
Long Equity Premium	-3.1 (9.1)	-1.2 (16.0)	-2.2 (7.7)	-1.1 (14.3)	-1.3 (17.6)
Short Equity Premium	N/A N/A	-0.1 (16.1)	-2.5 (8.0)	0.3 (14.4)	-0.5 (17.8)
Inflation Rate	0.0 (7.1)	4.4 (6.9)	0.0 (5.5)	2.1 (8.0)	6.7 (4.9)
Long Interest Rate	3.7 (0.9)	6.0 (3.3)	3.1 (0.3)	3.8 (0.7)	8.1 (3.4)
Short Interest Rate	N/A N/A	4.9 (3.8)	3.3 (1.2)	2.5 (1.8)	7.3 (3.8)
Industrial Production Growth	2.0 (7.6)	1.8 (7.8)	2.6 (4.7)	1.3 (10.7)	2.3 (3.6)

Note: Numbers on the first line of each set are sample means and those on the second are standard deviations. All variables are in nominal terms, with the exception of industrial production, the equity premiums and real stock prices. The long and short equity premiums are calculated as stock returns less long and short interest rates.

Table 2: Pre-1913 Stock Market Returns and Macroeconomic News

VAR Lags	Industrial Production	Real Money	Interest Rate	Army & Navy Employment	Inflation Rate	R-bar Squared
			Real Stock Returns: 1705-1913			
1,2	0.15	0.07	-12.86	0.01	-0.74	.352
	(1.5)	(1.7)	(5.8)	(0.2)	(7.2)	
1,2,3	0.16	0.05	-13.58	0.01	-0.76	.334
	(1.5)	(1.1)	(5.7)	(0.2)	(7.0)	
			Long Equity Premium: 1705-1913			
1,2	0.15	0.07	-13.86	0.01	0.26	.199
	(1.5)	(1.7)	(6.5)	(0.2)	(2.7)	
1,2,3	0.16	0.05	-14.58	0.01	0.24	.163
	(1.6)	(1.1)	(6.4)	(0.2)	(2.3)	
			Short Equity Premium: 1830-1913			
1,2	0.57	0.19	-1.73	-0.07	0.46	.093
	(2.5)	(1.4)	(1.5)	(0.6)	(2.0)	
1,2,3	0.54	0.19	-1.54	-0.05	0.51	-.010
	(2.1)	(1.3)	(1.3)	(0.4)	(2.1)	
			Memorandum: LM(2) Test for Whiteness of News			
			Real Returns and Long Equity Premium			
1,2	0.63	0.93	0.44	0.46	0.15	
1,2,3	0.27	0.17	0.06	0.09	0.22	
			Short Equity Premium			
1,2	0.06	0.06	0.17	0.02	0.05	
1,2,3	0.03	0.08	0.03	0.11	0.12	

Note: All variables are expressed as natural logarithms; industrial production and real money (M0) are first differences of the original data in levels. The interest rate used in the short premium regressions is the 3 month commercial paper rate while the 3% consol rate is used elsewhere. R-bar squared is calculated as $1 - \{(T-1)/(T-K)\}\{1-R^2\}$, where T is the sample size, K is the degrees of freedom and R squared is from the original regression.

Table 3: Post-1913 Stock Market Returns and Macroeconomic News

VAR Lags	Industrial Production	Real Money	Interest Rate	Army & Navy Employment	Inflation Rate	R-bar Squared
			Real Stock Returns: 1914-1987			
1,2	0.55	0.34	-8.93	-0.10	-0.38	.078
	(1.7)	(0.6)	(3.2)	(0.9)	(0.4)	
1,2,3	0.58	0.29	-9.05	-0.07	-0.47	-.041
	(1.6)	(0.4)	(2.8)	(0.6)	(0.5)	
			Long Equity Premium: 1914-1987			
1,2	0.55	0.34	-9.93	-0.10	0.62	.097
	(1.8)	(0.6)	(3.8)	(1.0)	(0.7)	
1,2,3	0.58	0.29	-10.05	-0.07	0.53	-.033
	(1.7)	(0.5)	(3.4)	(0.7)	(0.6)	
			Short Equity Premium: 1914-1987			
1,2	0.75	0.18	-4.37	-0.06	0.27	.046
	(2.4)	(0.3)	(2.9)	(0.6)	(0.3)	
1,2,3	0.81	0.06	-3.74	-0.01	-0.04	-.096
	(2.3)	(0.1)	(2.0)	(0.1)	(0.5)	
			Memorandum: LM(2) Test for Whiteness of News			
			Real Returns and Long Equity Premium			
1,2	0.06	0.16	0.12	0.66	0.11	
1,2,3	0.08	0.20	0.16	0.38	0.29	
			Short Equity Premium			
1,2	0.11	0.31	0.60	0.82	0.16	
1,2,3	0.12	0.27	0.04	0.46	0.36	

Note: All variables are expressed as natural logarithms; industrial production and real money (M0) are first differences of the original data in levels. The interest rate used in the short premium regressions is the 3 month commercial paper rate while the 3% consol rate is used elsewhere. R-bar squared is calculated as $1 - \{(T-1)/(T-K)\}\{1-R^2\}$, where T is the sample size, K is the degrees of freedom and R squared is from the original regression.

Table 4: Stock Market Returns and Macroeconomic News - Full Sample

VAR Lags	Industrial Production	Real Money	Interest Rate	Army & Navy Employment	Inflation Rate	R-bar Squared
			Real Stock Returns: 1705-1987			
1,2	0.31	0.07	-8.84	-0.02	-0.70	.247
	(2.9)	(1.5)	(6.2)	(0.7)	(6.0)	
1,2,3	0.31	0.06	-8.90	-0.02	-0.70	.231
	(2.9)	(1.3)	(6.1)	(0.8)	(5.9)	
			Long Equity Premium: 1705-1987			
1,2	0.31	0.07	-9.84	-0.02	0.30	.185
	(3.1)	(1.6)	(7.3)	(0.8)	(2.8)	
1,2,3	0.31	0.06	-9.87	-0.02	0.30	.160
	(3.1)	(1.4)	(7.1)	(0.8)	(2.7)	
			Short Equity Premium: 1830-1987			
1,2	0.69	0.11	-3.42	-0.06	0.36	.130
	(4.0)	(0.7)	(3.9)	(1.1)	(1.5)	
1,2,3	0.66	0.10	-3.27	-0.05	0.37	.066
	(3.7)	(0.6)	(3.2)	(0.9)	(1.5)	
			Memorandum: LM(2) Test for Whiteness of News			
			Real Returns and Long Equity Premium			
1,2	0.39	0.64	0.28	0.10	0.13	
1,2,3	0.33	0.16	0.10	0.03	0.15	
			Short Equity Premium			
1,2	0.42	0.14	1.34	0.10	0.06	
1,2,3	0.30	0.11	0.14	0.03	0.09	

Note: All variables are expressed as natural logarithms; industrial production and real money (M0) are first differences of the original data in levels. The interest rate used in the short premium regressions is the 3 month commercial paper rate while the 3% consol rate is used elsewhere. R-bar squared is calculated as $1 - \{(T-1)/(T-K)\}\{1-R^2\}$, where T is the sample size, K is the degrees of freedom and R squared is from the original regression.

Table 5: Stock Returns and Unrestricted Autoregression

VAR Lags	Lagged Variables Only	Lagged and Current Variables	Lagged, Current and Leading
		Pre-1913 Equations	
		Real Stock Returns (1705-1913)	
2	.154	.548	.563
3	.145	.551	.565
4	.125	.558	.568
		Long Equity Premium (1705-1913)	
2	.162	.399	.420
3	.173	.403	.422
4	.177	.412	.426
		Short Equity Premium (1830-1913)	
2	.063	.242	.484
3	.058	.197	.441
4	.061	.336	.431
		Post-1913 Equations	
		Real Stock Returns (1914-1986)	
2	.236	.443	.438
3	.234	.419	.430
4	.184	.379	.385
		Long Equity Premium (1914-1986)	
2	.153	.374	.368
3	.163	.347	.359
4	.101	.303	.309
		Short Equity Premium (1914-1986)	
2	.163	.322	.420
3	.177	.285	.421
4	.113	.217	.366

Note: All variables are expressed as natural logarithms and are stationary; the variables are interest and inflation rates, growth in real M0 and industrial production, army and navy employment relative to total population and squared one year stock returns. Current and leading values of the squared stock return are not included in the regressions. The interest rate used in the short premium regressions is the 3 month commercial paper rate while the 3% consol rate is used elsewhere. R-bar squared is calculated as $1 - \{(T-1)/(T-K)\}\{1-R^2\}$, where T is the sample size, K is the degrees of freedom and R squared is from the original regression.

Table 6: Integration and Cointegration Results: 1705 to 1987				
Variable	One Unit Root	Two Unit Roots	Cointegration with Stock Prices	
			Nominal	Real
Long Interest Rate	-1.94	-12.01[1]	-1.86	-2.14
Armed Forces to Population Ratio	-5.16[1]	-9.53[1]	1.91	-1.93
Level of Industrial Production	0.54	-17.42[1]	0.25	-3.72[1]
Consumer Price Level	2.57	-10.76[1]	-2.60[5]	-2.60[5]
Level of Real M0	-1.38	-14.60[1]	-0.07	-3.81[1]
All Above	N/A	N/A	-4.12[1]	-4.12[1]
Stock Price Level	1.91	-12.97[1]	N/A	N/A
Real Stock Price Level	-2.00	-12.99 [1]	N/A	N/A

Note: [1], [5] and [10] are significant at 1%, 5% and 10% levels according to the cumulative distribution table given in Fuller (1976, p.373).

Table 7: Restricted Equation Regression Results

Variable	Lag	General	Restricted		Gold Standard		Final Equation	
			First Differences in Variables					
					Gold Standard Off	On	Off	On
		(1)	(2)	(3)	(4)		(5)	
Constant		0.03 (1.6)	0.01 (0.7)	0.01 (0.7)	0.01 (0.6)		0.01 (0.6)	
Interest Rate	-1	-8.34 (5.1)	-8.14 (5.3)	-8.33 (5.5)	-6.65 (4.0)	-1.09 (0.3)	-6.96 (4.9)	
	-2	7.76 (3.1)						
	-3	0.27 (0.2)						
Real Money Supply Growth	-1	0.03 (0.5)	0.06 (2.1)	0.06 (2.1)	0.01 (0.1)	0.05 (0.4)	0.05 (1.9)	
	-2	-0.11 (2.1)						
	-3	-0.05 (1.0)						
Inflation Rate	-1	-0.07 (0.5)	-0.17 (1.9)	-0.17 (1.9)	-0.66 (3.3)	0.69 (3.1)	-0.61 (4.3)	0.64 (3.8)
	-2	0.12 (0.9)						
	-3	-0.15 (1.3)						
Industrial Production Growth	-1	-0.31 (2.7)	0.02 (0.3)					
	-2	-0.36 (3.2)						
	-3	0.03 (0.3)						

Table 7: Restricted Equation Regression Results continued								
Variable	Lag	General	Restricted		Gold Standard		Final Equation	
			First Differences in Variables					
					Gold Standard Off	On	Off	On
Armed Forces to Population Ratio	-1	-0.04 (1.2)	-0.02 (0.9)					
	-2	0.02 (0.4)						
	-3	0.02 (0.6)						
Squared Returns	-1	0.33 (1.2)	0.36 (1.8)	0.35 (1.7)				
	-2	-0.35 (1.2)						
	-3	0.33 (1.3)						
Error Correction	-1	-0.07 (2.7)	-0.07 (3.0)	-0.07 (3.0)		-0.07 (2.8)		-0.07 (2.8)
R-bar Squared		0.167	0.142	0.146		0.173		0.178
LM(2) F-test		0.20	0.41	0.48		0.34		0.42
Chow test at 1913 (all significant at 1%)		2.67	2.31	2.29		2.30		2.29

Restriction F-tests (none of which can be rejected at 5% significance levels):

a) Set all lag 3 coefficients to zero $F(6,263) = 0.67$

b) Set armed forces ratio coefficients to zero plus a) $F(8,263) = 0.80$

c) Set squared return coefficients to zero plus a) $F(8,263) = 0.86$

d) Set lag 1 and lag 2 coefficients equal to each other plus a) $F(12,263) = 1.69$

e) Set armed forces, squared returns, and industrial production coefficients to zero plus d) $F(15,263) = 1.61$

Table 8: Crisis Chronology, Sources and Triggers

Year	Date	Source	Trigger or Origin
1710	October	A/H	Prior speculation; Jacobite fear
1715	September	A/H	Threat of Jacobite rebellion
1720	September	A/H,K	South Sea Co. speculation
1726	October	A/H	Threat of Spanish war
1745	September	A/H	Threat of Jacobite rebellion
1761	August	A/H	Threat of Spanish war
1763	July/September	A/H	Transmission from Continental exchanges
1773	January	A/H,K	Collapse of investment and exports
1778	January	A/H	French join American Revolution
1788	N/A	A/H	Cotton trade depression
1793	February	A/H,K	Threat of French war
1797	February	A/H,K	French land at Fishguard
1810	Summer	K,G	Napoleonic blockade
1816	September	K,G	Cyclical economic contraction
1825	December	K	South American shares speculation
1836	December	G,K	Speculation in foreign securities
1847	October	K	Railway shares speculation
1857	August/October	K	Transmission from New York exchange
1866	May	K,B	Bank collapse
1873	Sept/October	M,K	Weak transmission from overseas
1875	Summer	M,Au	Political
1878	October	M	Bank failures
1880	First Half	M,Au	Weak transmission from overseas
1882	First Half	M,Au	Weak transmission from overseas
1884	N/A	M	Weak transmission from overseas
1887	First Half	M	N/A
1890	November	K,M	Speculation in Argentine securities
1893	May	M	Strong transmission from overseas
1895	September	M	South African gold shares speculation
1901	Summer	M,Au	Weak transmission from overseas
1904	Summer	M,Au	Strong transmission from overseas
1907	October	M,Gl	Weak transmission from overseas
1912	October	M,W	Weak transmission from overseas
1914	July	M,S	War threat; overseas transmission
1921	Spring	K,M	End of postwar boom
1929	October	M	Strong transmission from overseas
1931	September	K,C	Sterling crisis
1940	May	R	Threat of German invasion
1973	October	E/S	Arab oil boycott
1974	All Year	R	Political and financial distress
1987	October	FT	Transmission from overseas

Note: A/H is Ashton (1959) and Hoppit (1986), Au is author's estimate from monthly equity price indices, B is Batchelor (1986), C is Capie et al (1986), E/S is Ellinger and Stewart (1980), FT is Financial Times (1987), G is Gayer et al (1953), Gl is Galbraith (1955), K is Kindleberger (1978), M is Morgenstern (1959), R is Riley (1983,1984), S is Seabourne (1986) and W is Weissman and Williams (1980. The weak and strong attributes of international transmission are given by Morgenstern (1959).

	Real Returns				Nominal Returns			
	During	Prior			During	Prior		
		1 Year	2 Years	5 Years		1 Year	2 Years	5 Year
1710	19.1	-18.4	-32.3	-29.2	-10.0	-8.3	-9.1	-0.1
1715	9.7	11.5	13.7	46.5[5]	5.6	6.5	9.8	15.5
1720	-42.1	37.1[1]	31.2[10]	57.2[5]	-50.5	35.1[1]	34.3[5]	58.2[5]
1726	1.1	-1.3	10.3	-3.9	4.1	-7.3	9.2	0.4
1745	-4.4	-9.9	-13.7	16.4	-7.6	-0.9	-3.5	1.4
1761	-11.5	-3.8	-0.7	3.5	-5.3	-3.8	-4.9	-11.3
1763	-11.5	19.6[10]	8.1	0.3	-7.6	21.5[5]	16.3	2.3
1773 *	-5.2	0.4	-6.7	-12.1	-7.7	2.1	3.9	-2.4
1778 *	-9.0	-11.5	-6.3	-4.7	-14.3	-3.5	-3.7	-6.3
1788	-3.5	7.9	7.9	28.0	2.3	4.6	7.9	20.6
1793 *	-19.1	4.5	10.3	17.6	-13.8	10.1	16.7	24.0
1797 *	-21.8	5.5	-1.1	-32.0	-21.8	1.5	-0.4	-12.7
1810	-20.2	1.1	10.3	10.0	-6.2	0.7	7.4	21.3
1816	4.3	-19.8	-16.8	-4.8	7.0	-10.4	-17.8	-27.4
1825 *	-14.8	16.5[10]	17.4	48.4[5]	-6.2	18.2[10]	23.7	31.1
1836	-12.5	13.1	15.8	19.5	-16.6	22.5[5]	25.2[10]	28.9
1847 *	-17.8	-4.7	3.9	39.9[10]	-12.5	-5.6	4.8	29.5
1857	13.2	-2.3	0.2	-35.0	-0.3	0.2	1.8	-4.9
1866 *	-18.3	7.3	9.9	46.8[10]	-15.8	5.6	6.6	44.3[10]
1873	1.9	3.5	5.0	32.1	-3.0	2.7	15.0	42.0[10]
1875	-5.1	-2.6	-0.7	11.9	-6.8	-6.0	-8.9	18.0
1878	-5.1	0.3	-0.7	-6.4	-8.0	-8.2	-13.6	-29.3
1880	1.9	12.5	7.5	1.8	-1.1	16.5	8.4	-12.0
1882	-5.3	-5.7	-3.8	4.0	-5.3	-3.7	-4.8	-4.6
1884	6.0	1.3	-4.0	4.7	-1.6	-4.9	-10.2	1.5
1887 *	-1.0	7.2	13.2	3.4	-3.3	1.3	-0.3	-14.3
1890	-0.7	-3.4	9.1	14.8	-1.8	0.1	12.6	13.6
1893 *	1.0	3.6	2.9	11.5	1.0	-1.2	-3.1	12.7
1895	17.7	12.6	26.2	30.1	19.1	9.9	13.2	11.2
1901 *	0.3	-9.3	-14.1	6.3	-5.3	-1.3	1.3	29.7
1904	2.3	-2.3	-4.7	-15.5	5.9	-5.9	-8.3	-16.7
1907	4.6	-6.0	-12.4	-14.7	-6.2	-1.8	-0.4	-2.8
1912	-3.2	-2.1	-2.5	-0.9	-1.3	-0.1	4.5	6.1
1914	-20.6	-1.5	-4.7	-5.4	-4.7	-1.5	-2.8	9.9
1921 *	-28.9	-13.8	-3.3	-11.0	-38.3	0.4	16.6	59.1[5]
1929	-17.4	-0.6	13.6	41.4[10]	-21.3	-1.8	11.5	34.8
1931	-0.2	-18.7	-36.1	-11.7	-3.0	-25.1	-46.4	-27.0
1940 *	-34.9	-5.8	-26.4	-20.0	-20.1	-4.4	-24.1	-8.7
1973 *	-23.3	19.7[10]	17.4	3.0	-14.5	26.6[5]	33.3[5]	35.0
1974 *	-69.9	-23.3	-3.6	-42.2	-55.0	-14.5	12.0	-6.2
1987	-14.8	17.7[10]	39.1[5]	79.7[1]	-9.9	21.8[5]	46.5[1]	102.4

Note: * indicates that the previous year is shown. [1], [5] and [10] are 1%, 5% and 10% one-tail test significance levels based on the real and nominal return means and standard deviations from 1705 to 1987.

Table 10: Unexplained Real Return from News Model

	Prior		
	1 Year	2 Years	5 Years
1715	1.3	8.4	9.2
1720	38.0[1]	35.1[1]	43.6[1]
1763	10.1	6.7	-3.3
1810	-2.0	5.1	4.6
1825 *	8.9	10.9	27.1[10]
1836	16.2[5]	14.1	10.0
1847 *	-9.9	-7.4	19.6
1866 *	2.4	4.9	43.9[1]
1873	-1.4	3.7	24.3[10]
1895	10.6[10]	16.5[10]	22.0
1901 *	-3.6	-4.4	17.8
1921 *	-1.7	9.4	29.3
1929	-5.9	4.2	26.8
1973 *	22.8[10]	21.2	18.6
1987	17.5	30.5	64.3[5]

Table 11: Unexplained Nominal Return from News Model

	Prior		
	1 Year	2 Years	5 Years
1715	1.2	3.7	1.6
1720	35.2[1]	31.1[1]	43.0[1]
1763	12.6[5]	10.0	-2.1
1810	-2.8	3.9	8.4
1825 *	8.0	9.5	18.4[10]
1836	13.6[5]	13.3[5]	4.8
1847 *	-9.9	-3.7	15.9[10]
1866 *	1.6	1.9	36.5[1]
1873	-0.3	5.8	24.0[5]
1895	6.5	9.6	7.8
1901 *	-4.3	-6.8	12.5
1921 *	-1.6	10.4	47.6
1929	-4.3	6.5	28.1
1973 *	27.7[5]	31.1	42.3
1987	20.3	39.1[10]	84.0[1]

Note: * indicates that the previous year is shown. [1], [5] and [10] are 1%, 5% and 10% one-tail test significance levels based on the model's residual mean and standard deviation from 1705 to 1913 and 1914 to 1987.

Table 12: Unexplained Returns from Unrestricted Model

	Prior		
	1 Year	2 Years	5 Years
1715	-3.4	-7.3	-25.0
1720	30.2[1]	27.3[5]	39.9[5]
1763	13.3[10]	10.7	4.4
1810	-4.2	-2.2	-3.9
1825 *	8.1	11.9	26.9[5]
1836	16.9[5]	18.2[10]	12.1
1847 *	-6.6	2.4	19.7
1866 *	4.6	5.0	43.3[1]
1873	0.6	8.4	31.8[5]
1895	7.9	10.3	9.3
1901 *	-2.6	-3.6	21.2[10]
1921 *	-1.8	2.0	31.1
1929	-1.6	10.7	34.2
1973 *	21.1[10]	22.1	41.2
1987	12.1	26.7	29.8

Table 13: Unexplained Real Return from Restricted Model

	Prior		
	1 Year	2 Years	5 Years
1715	7.5	5.4	46.1[5]
1720	37.0[1]	34.3[1]	62.0[1]
1763	21.7[5]	11.4	8.8
1810	-4.4	-3.8	-17.5
1825 *	12.9[10]	11.7	24.5[10]
1836	10.8	10.6	4.6
1847 *	-4.4	3.3	31.5[10]
1866 *	7.0	9.2	38.4[5]
1873	3.2	3.7	25.2[10]
1895	10.8	23.1[5]	21.7
1901 *	-7.6	-10.8	10.7
1921 *	-17.0	-10.3	3.3
1929	0.4	15.4	47.8
1973 *	21.5[10]	23.3	33.8
1987	13.8	36.3[10]	44.1

Note: * indicates that the previous year is shown. [1], [5] and [10] are 1%, 5% and 10% one-tail test significance levels based on the model's residual mean and standard deviation from 1705 to 1913 and 1914 to 1987.

Chapter IV: Stock Prices and Tobin's Q

I. Introduction

Previous chapters have examined the autocorrelation properties of equity prices and the correlations of such variables with macroeconomic variables. In general, while significant relationships are found, thus underlining the importance of the real economy for stock price fluctuations, there is also widespread evidence of non-efficient market behaviour which remains broadly unexplained.

This chapter now turns to an examination of the effect of stock prices, via Tobin's Q, on corporate investment. The Q theory of investment has often been employed as an explanatory factor in the markets for physical capital and corporate control; in fact, it is widely thought that the stock market has its greatest impact on the economy through these sectors. The Q theory was of particular interest following the 1987 crash because of the rough positive correlation between movements in the stock market and corporate investment in the 1980s, therefore giving some reason to speculate a priori that investment might be equally affected following the equity market downturn.

With research now clearly focused on understanding the stock market, due to the crash, it is probably appropriate to ask whether the Q theory is still robust to the challenges issued from new theories and econometric techniques. A vast literature has developed in the last 5 years, for example, which questions the random walk theory and its implication that stock prices are not mean reverting over time.[1]

Following this line of inquiry, the present chapter surveys the most widely used macroeconomic Q measures in order to address two issues. First, it considers whether standard empirical studies of investment using Q satisfy basic statistical properties of stability, appropriate specification and minimal explanatory power. Secondly, given that these static formulations are inappropriate, it considers the relative merits of two types of dynamic models.

The chapter reaches a number of conclusions. First, static Q theory is not empirically valid. Second, a dynamic approach, incorporating lags of Q transformed to first differences, resolves these empirical problems. Third, an error correction model is superior to a VAR representation of the dynamic process. Fourth, Q is more highly correlated to investment than are real stock prices, the primary determinant of fluctuations in Q; this offers support for empirical applications of Q theory using a reformulated approach. However, the generally low explanatory power of investment equations using Q alone suggests that other relevant variables may add additional information, an issue which is directly examined in Chapter V below. Fifth, there appear to be substantial differences between the relationship of stock prices and investment in Japan and West Germany, in comparison to the U.S. and the U.K.; this issue is also taken up in the next chapter.

The outline of the rest of this chapter is as follows. In Section II, the theoretical arguments made in support of the Q theory of investment are presented, along with several criticisms. Reference is made to Appendix II which outlines the functional forms of the 52 Q measures used here. Section III examines the Qs in some detail using various descriptive statistics and orders of integration tests. The analysis is focused on four countries in Section IV where standard Q investment equations are examined for structural stability, autocorrelation in residuals and explanatory power. These results are contrasted with two other models: an error correction mechanism and a vector autoregression. Section V, following on recent work by Barro (1989), examines the influence of real stock prices on investment and compares these results with those of Section IV. Finally, Section VI concludes the chapter with a summary of the investigation.

II. Theoretical Issues

The Q theory of investment has recently become an alternative to the traditional cost of capital approach for analyzing private business investment.[2] The primary advantage of the theory is that it implicitly accounts for the expectations used by economic agents when making a decision to invest. Since the theory uses a cost/benefit framework which compares asset replacement cost to the market value of the firm, and the latter incorporates expectations of the future profitability of the firm by informed market participants, Q is a forward-looking variable. The cost of capital approach, in contrast, does not include expectations directly.

Following Dinenis (1985), the Q relationship is derived by maximizing the firm's objective function subject to a capital accumulation constraint. Assume first that the firm maximizes the present value of net after-tax receipts, that the production function is characterised by constant returns to scale technology, that adjustment costs to changing the capital stock are an increasing and convex function of investment, and that factor and product markets are perfectly competitive. The firm will maximize

$$(1) \qquad V_t = E\left(\sum_{j=0}^{\infty}(1 + r_t)^{-(j+1)} R_{t+j}\right)$$

subject to

$$(2) \qquad K_t = I_t + (1 - \delta)K_{t-1}$$

where,

$$(3) \qquad R_t = (1 - \tau_t)\Pi_t + A_t - (1 - z_t)p_t I_t,$$

$$(4) \qquad \Pi_t = P_t(o_t - a_t) - W_t i_t$$

and

$$o_t = f(i_t, K_t) \quad o' > 0 \ , \ o'' < 0 \qquad a_t = g(I_t, K_t) \quad a' \ , \ a'' > 0$$

V is the net after tax present value of the firm, E is the expectations operator, r is the investors' required rate of return (or subjective discount rate), R is the net after tax value of the firm in every period, K is the capital stock, δ is the depreciation rate, I is investment, τ is the corporate tax rate, π is profits, A is the value of depreciation tax allowances on installed capital, z is the present value of future tax deductions per unit of new capital, p is the investment deflator, P is the output deflator, o is output, a is the adjustment cost to changing the capital stock, W is the input deflator, and i is input.

Substituting (3) and (4) into (1) and forming the Lagrangian yields the following first order conditions:

$$(5) \ i: \qquad (1 - \tau_t) o_i' = \frac{W_t}{P_t}$$

$$(6) \ K: \qquad \Omega = E\left(\sum_{j=0}^{\infty}(1 - r_t)^{-(j+1)}(1 - \delta)^j(1 - \tau_{t+j})P_{t+j}(o_K' - a_K')\right)$$

$$(7) \ I: \qquad (1 - \tau_t)P_t a_I' + (1 - z_t)p_t - \Omega = 0$$

where Ω is the Lagrangian multiplier. Equation (5) states that the marginal productivity of the inputs is equal to their real marginal costs, Equation (6) says that Ω is the net addition to the present value of the firm due to a unit of new capital and Equation (7) implies that the firm will invest until the marginal costs and benefits of such investment are equal.

Defining marginal Q as $q = \Omega/p$ and substituting the equation into (7), we have

$$a_I' = \frac{p_t\,(q_t - 1 + z_t)}{(1 - \tau_t)\,P_t} \tag{8}$$

and, given linear homogeneity of a_t with respect to its determinants I and K,

$$\frac{I_t}{K_t} = h(q_t) \tag{9}$$

That is, the investment-capital ratio is a function of marginal Q. In empirical work, this Q measure is unobservable and so, invoking the conditions established by Hayashi (1982) and formally derived for this specification by Dinenis (1985)[3], marginal Q can be set equal to average Q and we have

$$\frac{I_t}{K_t} = j(Q_t) \tag{10}$$

Ueda and Yoshikawa (1986) and Dinenis (1985) offer theoretical justifications for lagged Q terms affecting investment and have some success incorporating these terms empirically. Allowing for such lags in adjustment, delivery and implementation motivates the use of dynamic terms in the empirical investigation below, where Q_{t-k} are added to Equation (10).[4]

As noted in Appendix II, the simplest formulation of Q in empirical work is the market value of corporate debt and equity divided by the replacement cost of the corporate sector capital stock. More complex formulations are standardised in Appendix II, and these equations and the Q pseudonyms outlined there may be useful for interpreting later sections in this chapter. Note also that Equation (10) is referred to below as the traditional Q model.

A number of criticisms have been levelled at the Q theory. The first objection stems from the theoretical argument that marginal Q is the appropriate decision variable at the margin and, since most existing Q measures are calculated in average terms, the practical implementation of the theory is flawed.[5]

A second criticism of the Q theory concerns the measurement of the capital stock and the market value of the firm. The perpetual inventory method with straight-line depreciation, although widely used, is incorrect since varying rates of capital scrapping and depreciation imply that the forces shaping investment and the capital stock are different.[6] The existence of accounting depreciation rates which diverge from true economic rates and aggregation problems when dealing with a non-homogeneous capital stock are additional complicating factors.

A potentially more serious problem concerns the measurement of the market value of the firm, since a growing literature stresses the irrationality of speculative markets.[7] If it is true that the market does not value the business sector at the appropriate price, then there is an inefficiency in the allocation of resources in the economy but not necessarily an abrogation of the Q theory. The linkage between the theory and investment behaviour is weakened only if agents do not incorporate equity market prices into their decision framework.[8]

A final set of criticisms fall into the category of financial and tax factors affecting the firm. The taxation elements vary considerably across countries and assets and are, therefore, less amenable to generalisation across Q variables.[9] Although these elements ensure that Q more faithfully reflects the true incentives facing agents, this chapter suggests that the value of incorporating tax factors into investment equations varies considerably across countries.

In terms of financial factors, the endogenous nature of the choice of finance and the linkage between investment and finance must be considered. The value of the firm can be weighted by source of finance and the risk implicit in any particular financial policy, since Q measures of equal numerical value that are generated by divergent financial policies may have different implications for the firm's financial planning policy and horizon.[10]

Overall, the Q theory provides the framework for creating a relatively easily calculated measure of the costs and benefits of investment.[11] As shown in the following sections, once dynamic elements are introduced, Q variables are generally significant explanatory factors in corporate investment equations.

III. Statistical Properties of Q - International Comparison

This section presents summary statistics for the Q measures that are used in the rest of the chapter. Q values are presented for Belgium, Canada, Finland, France, West Germany, Japan, Sweden, the United Kingdom and the United States (and are shown in Diagrams 1 to 11 in Appendix II).

For analytical purposes, the Qs may be subdivided into various categories according to whether the Qs are average or marginal, tax adjusted or non tax adjusted, or derived at the macro or micro level of the economy. Certain tax adjusted Qs have been altered from the data given in published sources so that they can be consistently compared with the non-adjusted values.[12]

Table 1 shows the means and coefficients of variation of the Qs for identical subperiods within each country. The first point to note is that Q varies considerably from its equilibrium value of one; the main explanation for this is the presence of tax terms which introduce a wedge between market valuation of the firm and the replacement value of its assets.

A more serious shortcoming of the Q measures can be seen by comparing the coefficients of variation, which vary widely within each country. The usefulness of many of the Qs as indicators of movements in investment may, therefore, be hampered because of the relatively high ratio of noise to signal. In any case, the differences in means and coefficients of variation indicate that the Q measures within each country are rather dissimilar.

The fact that any particular Q may deviate from unity and exhibit relatively high volatility does not imply that Q theory is abrogated. A more important test of the theory is whether the measure is mean reverting over time. This is an important property since the theory postulates that fluctuations of Q above and below its equilibrium value will elicit investment responses in the physical capital market and on the stock market which will push the value of Q back to equilibrium. Classifying Q as a random walk is, therefore, tantamount to refuting standard Q theory as currently implemented.

Table 2 indicates that a unit root in Q can only be rejected for Japan and Canada (Other q13). All of the other Q measures follow time series patterns which are insignificantly different from random walks, as do the I/K measures for the U.S., U.K., Japan and West Germany. Table 3 demonstrates that stationarity is achieved in all of the series after first differencing, except for U.S. q7 which requires second differencing. It appears from these two tables that Q and I/K are generally integrated of order one, I(1), while the Japanese Q are I(0).[13] Q does not therefore generally revert to a mean value over time, although d(Q) does have this property.[14]

These results suggest that cointegration between Q and I/K, and therefore the existence of a long run relationship between the two, can be examined by using the augmented Dickey-Fuller methodology.[15] Table 4 accordingly shows the cointegration adjusted t-statistics for Japan, the U.K., the U.S. and West Germany; in column 5, additional Japanese results are given to accommodate the fact that Q is I(0) there.

The conclusions of the table are somewhat mixed. Cointegration between I/K and d(Q) cannot be rejected for Japan; as well, many of the U.S. Qs are cointegrated with I/K. For the U.K. and West Germany, however, many of the Qs are not cointegrated with I/K, although most of them are marginally significant. As well, with the exceptions of U.S. q13 and Japan q1 and q4, none of the tax adjusted measures are cointegrated. Contrary to theoretical requirements, it therefore seems that the more sophisticated tax adjusted Q measures are also those which statistically reject an equilibrium relationship with investment.

In conclusion, this section has a number of implications for modelling strategies involving Q. First, given the differences in mean values and volatility, it is difficult to specify a unique Q for use in empirical work; different formulations of Q are therefore needed to test model specification robustness in any investigation. Second, aside from Japan and Canada, Qs should be transformed to first differences in order to induce stationarity; this point also holds for I/K.[16] Third, the existence of cointegration between Q and I/K suggests that an error correction model (ECM) may be one (previously ignored) approach to modelling Q theory.

IV. Comparative Investment Models: Four Country Analysis

This section compares an error correction specification of Q theory with the traditional Q formulation and a VAR alternative. The traditional Q model is used to conform to accepted theoretical prescriptions and the VAR is employed to free the data from any imposed structure; the two models therefore represent opposite ends of the modelling spectrum.

The lack of success of traditional specifications of the Q theory is apparent from Tables 5 to 9. Table 5 shows coefficient estimates for the traditional static application of Q theory. The other tables show Durbin-Watson statistics, F-tests for the null hypothesis that the regressor coefficients are jointly zero, R-squared values, Chow F-tests for mid-sample structural change and LM(2) tests for autocorrelated residuals.[17] Each triplet of equations presents I/K on Q regressions in the first row, an unrestricted VAR of d(I/K) on lagged values of d(I/K) and d(Q) in row three and an unrestricted ECM similar to the VAR but incorporating an error correction term in row two. Column 7 tests the significance of the error correction term and column 8 does the same for the reverse regression of d(Q) on d(I/K).[18]

Looking to Table 5 and the first row of each Q variable in the other tables, one sees numerous insignificant or incorrectly signed coefficients, low DW values, low R-squared explanatory power, autocorrelated residuals and occasional structural breaks. These results indicate that the traditional Q specification is inappropriate. The major flaws are the exclusion of dynamic behaviour in the equations and the failure to transform Q to a differenced representation.

Turning to the U.K. results first, it appears that the ECM is generally superior to the VAR. While the VAR fails to reject the regressor F-test null hypothesis of no explanatory power for five of the Qs in Table 6, the ECM fails only for q4. The Chow and LM tests reject the null hypothesis of structural break and error correlation for each specification, thus supporting the need for including dynamics in the models, and the error correction term is either strongly or marginally significant in two-thirds of the equations; those rejecting the additional term are almost all tax adjusted Qs. There is also some support for thinking that the dynamic profile of Q is unaffected by the error correction term in column 7. Again, q4 is the exception and this result may be due to the dominance of tax terms in the variation of this Q over time.

The U.S. equations in Table 7 broadly reflect the U.K. results. The VAR specification indicates marginal residual autocorrelation in q4 and q15 while the ECM is universally free of such problems. As well, the regressor F-test fails to reject the null hypothesis of no significance more often for the VAR model than for the ECM. Six of the Qs indicate that an error correction term is not required and the reverse regression F-test shows that Q dynamics are unaffected by the long run relationship between Q and I/K. Once again, the Q variables rejecting the error correction specification are predominantly tax adjusted measures. As in Table 6, there is a substantial increase in the explanatory power of the equations relative to the traditional Q specification in row one.

The results for West Germany in Table 8 again support the error correction specification. The VAR model fails to reject the regressor F-test null hypothesis for q11 while the ECM rejects for all three Qs. The error correction term is also marginally significant for the Q equations and, as with the other two countries, this term does not affect the time profile of Q. The increase in R-squared relative to the traditional Q equation is less marked than in the U.S. and the U.K..[19]

The error correction term in each of the ECM above can be interpreted as the degree to which the equation reverts to its long run equilibrium every period. For the United States, the coefficient estimates imply that I/K reverts to its equilibrium over a period of 3 to 7 years, while the German results indicate that this process takes place over 6 to 9 years. The U.K. implied reversion time varies widely across Qs, from 1 to 13 years, but the coefficients consistently increase in magnitude from the 1950s to the present; it therefore seems that equilibrium-inducing forces are much stronger in recent years.[20]

Turning now to Japan, this country presents a special problem for examining the ECM relative to a VAR. Since Tables 2 and 3 showed that Q is I(0) while I/K is I(1), it is not possible to obtain the error correction term for inclusion in an investment equation. Therefore, Table 9 examines the implications of regressing d(I/K) on Q itself rather that d(Q), since d(I/K) and Q are both I(0). The first row of each set shows the d(I/K) on Q equation and the second row shows an unrestricted VAR of d(I/K) on lags of d(I/K) and Q. Column 7 gives the F-test for adding current Q to the VAR and column 8 tests the restriction that Q can be transformed to d(Q).

The regressors F-test null hypothesis of no significance is not rejected for the contemporaneous Q equation, indicating that dynamics terms are important for empirically implementing Q theory; this is supported by the F-tests of column 7 which imply that current Q is generally significant only when lagged Qs are included in the equation. The regressors F-test for lagged Q fails to reject the null hypothesis of no significance for more than half of the Q variables. The last column indicates that restricting Q to a d(Q) form is not rejected and this latter formulation may be preferred for reasons of parsimony. Overall, the Japanese results are considerably weaker than those for the other three countries.

In summary, it appears that the ECM is preferable to an unrestricted VAR, and the latter model, in turn, is superior to the traditional Q equation. However, the low R^2 values for even the ECM variation indicate that the Q approach may not be optimal for explaining investment fluctuations over time.

Tax adjusted Qs seem to diminish the degree to which Q and I/K interact over the longer run, as evidenced by the general absence of cointegration shown in Table 4 and the insignificance of the error correction terms for these Qs in Tables 6 to 8. It may be that theoretical rigour demands the inclusion of tax variables which are imperfect representations of investors' decision sets; for example, expected tax rates serve as proxies for current tax rates in Q investigations.

Finally, the deviations from equilibrium embodied in the error correction terms, while generally significant, are nevertheless of long lasting duration. These delays in reestablishing equilibrium may be partially attributed to decision and implementation lags in investment and/or to the difficulty that investors may have interpreting movements in the equity market on a short term basis.

V. Stock Prices, Q and Investment

Previous sections have shown that static Q theory is inappropriate and have suggested that a particular dynamic respecification is in order. An alternative approach is to replace Q itself with one of its subcomponents which has better explanatory power. Although Qs are constructed with a number of different components, it is likely that stock market prices are the most volatile element. This section, therefore, looks at the importance of real stock price (R) fluctuations for investment and then compares the explanatory power of these prices with the respective Q variables.[21]

Table 10 repeats the integration tests of Tables 2 to 4, with the conclusion that real stock prices are I(1). The cointegrating equations indicate that real stock prices and investment are cointegrated in the U.S., the U.K. and West Germany (prior to the 1980s).[22] It should be noted that the sample sizes in the table are chosen, first, to exploit the maximum possible data range and, second, to match the sample ranges of the Q variables analyzed above.

As in Tables 6 to 9, Table 11 summarizes traditional static equations, VARs and ECMs. Problems with error autocorrelation and structural break are seen in the first row of each triplet and, as before, this is corrected with the introduction of lagged regressors. The VAR fails to reject the regressor F-test null hypothesis of no significance for West Germany and the earlier Japanese sample period, while the ECM improves upon this by rejecting the test for the most recent German sample. The error correction term is strongly significant for the U.S., the U.K. and the earlier German period, mimicking the cointegration equations, and there is weak evidence that the long run relationship between R and I/K affects the dynamic movement of R over time.[23]

In general, movements in real stock prices contribute significantly to explaining investment. In order to compare the explanatory power of stock prices with Q, Tables 12 and 13 detail F-test results for joint encompassing tests; the equations regress d(I/K) on current values of d(Q) and d(R) and single lagged values of all three. Table 12 accommodates measurement error and response delays in I/K, Q and R by including current and lagged values, while Table 13 includes only variables in the investors' information set at time t. Contrary to the results of Barro (1989), there is conclusive evidence here that Q is a more important determinant of investment than R.

Turning to Table 12 first, all countries except West Germany support the encompassing nature of the Q variables. Even when the Q specification does not encompass R (ie: the statistics are not significant), the F-test values are generally higher towards supporting Q, rather than R, as the encompassing variable. The anomalous cases which designate R as the encompassing variable, (U.S. q7, q15 and q16 and the German Qs), are difficult to explain in terms of sample size, tax adjustment or micro/macro coverage.

The results for Table 13 are somewhat weaker than Table 12, indicating that the relative explanatory power in R is concentrated in the lagged rather than the contemporaneous variable; this result may seem odd given the strong role of expectations in driving stock price movements. Once again, most F-tests for including Q in the joint regression are larger than those for including R. The only tests which consistently suggest that R is encompassing are those for U.S. q15 and q16. This latter finding is directly related to the failure of these Qs to predict investment at all, as evidenced by their poor explanatory power shown in Table 7. Other (West Germany) q11 and U.S. q10 also marginally support R as the encompassing variable.

Overall, Q is superior to R as an explanatory factor for corporate investment. Although the static Q theory has major empirical shortcomings, the results of this and previous sections do not support using R in place of Q, as implied by Barro (1989), but rather suggest that a dynamic respecification may be appropriate. Finally, there exist marked differences in the correlation between stock prices and investment in Japan and West Germany, relative to the U.S. and the U.K..

VI. Conclusions

The preceding analysis has underlined the importance of reformulating Q to explain corporate investment. The random walk behaviour of Q and I/K and the cointegration generally found between the two variables suggests the potential importance of error correction modelling techniques. Statistical comparisons of such a model with the traditional Q formulation and an unrestricted VAR reflect the value of this reformulation.

Although Q is a superior determinant of investment relative to real stock prices, it seems that the tax adjusted figures are less successful than the simpler Qs. Theoretical injunctions and empirical findings therefore seem to be strongly at odds on this issue. A plausible explanation of the discrepancy is that true investment incentives are not properly captured with the real world variables. In any case, average Qs are everywhere substituted for the theoretically appropriate marginal Qs.

The success of the error correction model should not, however, be overemphasised, given its rather low explanatory power. As the next chapter of this thesis notes, there are numerous other explanations of investment which have a better predictive track record. As well, the long lasting deviations from the Q and I/K equilibrium are difficult to fully justify and the error correction model is not successful for all of the Qs examined here. Finally, the differences shown between the Q and R correlations with investment in Japan and West Germany, relative to the U.S. and the U.K., indicate the possible importance of institutional or other factors which vary across countries.

Appendix II - Q Variable Glossary

I. Common Glossary

The empirical derivation of Q varies considerably from study to study and it is sometimes difficult to distil the essential differences between Q values that purport to measure the same phenomena. This glossary alleviates some of the confusion that can emerge in a comparative exercise involving Q by standardizing all of the terminology and variables.

The most commonly used Q components are as follows:

E - market value of equity
D - market value of debt
K - replacement cost of the capital stock
δ - depreciation rate of the capital stock
$V = E + D$ - market value of the firm
$b = D/V$ - fraction of new capital that is debt financed
$e = E/K$
$d = D/K$
$q = V/K$ - the simple Q measure

P - output price deflator
p - investment price deflator
A - present value of tax deductions for installed capital
$a = A/K$
s - present value of tax incentives and deductions for new capital per unit of investment (U.K.)
z - present value of tax deductions for new capital per unit of investment
k - investment tax credit rate (U.S.)
j - rate of first year investment write-offs (U.K.)
N - value of inventories multiplied by time dummies for periods of tax relief (U.K.)
c - capital gains tax rate

m - dividend income tax rate
τ - corporate income tax rate
ϕ - capitalization factor - tax disincentive for dividend payout
R - maximum interest rate deduction - tax free reserves (Japan)
S - amount of corporate enterprise tax (Japan)
$\Theta = (1-m)\phi/(1-c)$ - relative tax weighting of dividends and capital gains for the investor

The market variables E and D are usually calculated by taking dividend and interest payments by firms and capitalising them using yields on equity and debt; net financial assets are sometimes deducted from the resulting V value. In many cases, the market value of D is approximated by its book value. The capital stock is typically measured net of depreciation while the associated investment measure is usually in gross terms.[24] The simple Q measure, while only a rough approximation to the actual relative price signals underlying the investment decision, is nevertheless used as the empirical Q value in approximately half of the studies surveyed here.

Tax components vary across countries according to the relevant national institutional arrangements but are broadly used in the same way when calculating Q. Depreciation allowances are separated for new and installed capital in order to replicate the implicit value of the firm embodied in future tax deductions accruing to existing and potential capital stock. Tax factors which impinge on the firm in an indirect manner through distribution policy are incorporated in Θ.

II. Methods of Constructing Q

Each Q measure is shown below in a single equation form using the variables which were defined above in the common glossary. Following each equation is a short note on the definitions used for the replacement value of the capital stock, the sector that the Q value represents and the sample period for which the Q was constructed. The equations are subdivided into national categories and listed alphabetically by source; a Q pseudonym is also shown which is used elsewhere in the chapter to identify the measures. For the purposes of this section, q denotes the q defined in the common glossary while Q defines the equation derived in each of the relevant sources; Q^T is a transformation of Q which is not used in the comparative analysis of this chapter[25]. All variables are contemporaneous unless otherwise indicated.

1. United States

* Abel and Blanchard (1986) - **q16**

$$Q = \frac{q}{(1 - k - z)\frac{p}{P}}$$

K (gross): plant and equipment
Sector: manufacturing
Sample: 1948:2 to 1979:3
Note: Quarterly values are annualized as in q5 below. The simple q used (denoted **q15** here) is the marginal measure where $M = M^u$, $\alpha = 0.5$ and $\Omega = \Omega^s$.

* Brainard, Shoven and Weiss (1980) - **q12**

$$Q = q$$

K (net): plant, equipment, land and inventories
Sector: micro data on 187 firms from the Compustat tape
Sample: 1958 to 1977
Note: V is calculated less net short term assets.

* Chan-Lee (1986) - **q4**

$$Q = q$$

K (net): total assets
Sector: non financial corporations
Sample: 1955 to 1983
Note: q is taken from Council of Economic Advisors estimates.

* Ciccolo (1975) - **q8**

$$Q = q$$

K: not given
Sector: not given
Sample: 1960 to 1974
Note: The equivalent tax adjusted measure from Ciccolo (1979), with sample 1960 to 1977, is denoted **q13**.

* Hayashi (1982) - **q6**

$$Q = \frac{q - a}{1 - k - z}$$

K: corporate capital stock less land and inventories
Sector: corporate
Sample: 1952 to 1978
Note: The q used is q5 from Von Furstenberg (1977).

* Holland (1986) - **q9, q10, q11**

$$Q = q$$

K (gross): q9, q11 - inventories, plant and equipment
q10 - as above plus land and net monetary assets
Sector: q9, q10 - non financial corporations
q11 - manufacturing corporations
Sample: q9, q10 - 1947 to 1981
q11 - 1948 to 1981

* Lindenberg and Ross (1981) - **q14**

$$Q = q$$

K (net): total assets, plant and inventories
Sector: microdata on 246 industrial firms and utilities
Sample: 1960 to 1977
Note: q is defined as the unadjusted average from the paper.

* Summers (1981) - **q2**

$$Q^T = \frac{\frac{(E-A)(1-c)}{K(1-m)} - 1 + b + k + z}{1 - \tau}$$

K: equipment, structures and inventories
Sector: non financial corporations
Sample: 1931 to 1978
Note: The pseudonym for the non tax adjusted q used here is **q1**.

The q2 measure used elsewhere in the chapter is

$$Q = \frac{\frac{(E-A)(1-c)}{K(1-m)} + b + k + z}{1 - \tau}$$

See Endnote 25 for more information on this adjustment.

* Tobin and Brainard (1977) - **q7**

$$Q = q$$

K: book value of V adjusted by the ratio of replacement cost to book value
Sector: microdata on 384 industrial firms
Sample: 1960 to 1974
Note: q is defined as the annual average.

* Von Furstenberg (1977) - **q5**

$$Q = q$$

K (gross): net fixed capital, inventories, land and net non interest bearing financial assets
Sector: non financial corporations
Sample: 1952:1 to 1976:4
Note: The quarterly values are annualized using a simple arithmetic average over the four quarters within any given year.

2. United Kingdom

* Bank of England (1987) - **q2**

$$Q = \frac{V}{(1 - s)K + (1 - \tau)N}$$

K (net): total capital stock
Sector: industrial and commercial companies
Sample: 1966:4 to 1986:4
Note: V is calculated as in q1 but without ratio adjustment. The Q values are annualized using the same method as U.S. q5. A measure from Chan-Lee (1986), denoted as **q3** here with sample period 1964 to 1984, differs from q2 by a scale factor.

* Dinenis (1985) - **q8, q9, q10, q11**

$$Q^T = \frac{p}{(1 - \tau)P}(q - a - 1 + s) = q8$$

$$Q = \frac{q - a}{(1 - s)} = q9$$

$$Q^T = \frac{p}{(1 - \tau)P} \left(\frac{e}{\theta} + d - a - 1 + s\right) = q10$$

$$Q = \frac{\frac{e}{\theta} + d - a}{(1 - s)} = q11$$

K (net): total capital stock plus inventories

Sector: manufacturing business sector

Sample: 1950 to 1980

Note: The non tax adjusted measure (denoted as **q13** here) is defined as q-a. The measures used elsewhere in the chapter are as follows:

$$Q = \frac{p}{(1 - \tau)P} (q - a + s) = q8$$

$$Q = \frac{p}{(1 - \tau)P} \left(\frac{q}{\theta} + d - a + s\right) = q10$$

q9 , q11 - as above

See Endnote 25 for more information on this adjustment.

* Flemming et al (1976) - **q1**

$$Q = \frac{V}{(1 - s)K + (1 - \tau)N}$$

K (gross): total capital stock
Sector: industrial and commercial companies
Sample: 1960 to 1975
Note: V is calculated less net liquid assets and includes the value of bank loans and commercial bills. It is adjusted by the before tax ratio of domestic to total income.

* Holland (1986) - **q6**

$$Q = q$$

K (gross): inventories, plant and equipment
Sector: non financial corporations
Sample: 1963 to 1980

* Oulton (1981) - **q7**

$$Q = \frac{q}{(1 - s)}$$

K (gross): fixed assets and inventories
Sector: industrial and commercial companies
Sample: 1960:4 to 1977:2
Note: The Q values are annualized as in U.S. q5. V is augmented by the value of profits due abroad and is adjusted by the after tax ratio of domestic to total income and the after tax ratio of financial to total assets.

* Poterba and Summers (1983) - **q4, q5**[26]

$$Q^T = \frac{(\frac{E - A}{K_{t-1}}) + b - 1 + z + j}{1 - \tau} = q5$$

$$Q^T = \frac{\frac{1}{\theta}(\frac{E - A}{K_{t-1}}) + b - 1 + z + j}{1 - \tau} = q4$$

K (net): total capital stock plus inventories

Sector: industrial and commercial companies

Sample: 1949 to 1980

Note: E is adjusted to correspond to domestic earnings. The q measure (denoted as **q12**) is calculated as e-a.

The measures used elsewhere in this chapter are

$$Q = \frac{(\frac{E - A}{K_{t-1}}) + b + z + j}{1 - \tau} = q5$$

$$Q = \frac{\frac{1}{\theta}(\frac{E - A}{K_{t-1}}) + b + z + j}{1 - \tau} = q4$$

See Endnote 25 for further details concerning this adjustment.

3. Japan

* Chan-Lee (1986) - **q3**

$$Q = q$$

K (net): depreciable assets

Sector: manufacturing

Sample: 1955 to 1981

Note: This q is similar to q2 with the addition of a scale factor.

* Hayashi (1985) - **q1**

$$Q^T = \left(\frac{V - A + S - R_{t-1}}{K_{t-1}} - 1 + z\right) \frac{p}{(1 - \tau)P}$$

K (net): total capital stock
Sector: manufacturing
Sample: 1956 to 1981
Note: V is reduced by the value of land and inventories. As well, the non tax-adjusted Q value (denoted as **q2** here) is defined as q(p/P).

The q1 measure used elsewhere in this chapter is

$$Q = \left(\frac{V - A + S - R_{t-1}}{K_{t-1}} + z\right) \frac{p}{(1 - \tau)P}$$

See Endnote 25 for further information concerning this adjustment.

* Holland (1986) - **q6, q7, q8, q9**

$$Q = q$$

K (gross): q6 - inventories, plant, equipment, land and net liquid assets
q7 - as q6 less land
q8 - as q6 less net liquid assets
q9 - as q6 less land and net liquid assets
Sector: microdata for 848 non financial companies
Sample: 1965 to 1981

4. Other Countries

i) Finland

* Holland (1986) - **q5, q6**

$$Q = q$$

K (gross): plant, equipment, inventories and net financial assets
Sector: manufacturing
Sample: 1961 to 1980
Note: V adjustment is the same as q2 and q3. q5 is supplemented by the value of K less the adjusted E measure.

* Koskenkyla (1985) - **q1, q2, q3, q4**

$$Q = q$$

K (gross): fixed assets, inventories and net financial assets
Sector: q2, q3 - manufacturing
q4 - residual
q1 - aggregate
Sample: 1961 to 1980
Note: The E used as the numerator of q2 is calculated by multiplying the ratio of market to book value for listed firms by the book value of the entire sector. The E values in the other Qs are calculated by multiplying this ratio by the capital stock less debt and deferred tax credits; V is augmented by the value of deferred tax credits for these Qs.

ii) Germany

* Chan-Lee (1986) - **q11**

$$Q = q$$

K: not given
Sector: private enterprises

Sample: 1966 to 1980

* Holland (1986) - **q9, q10**

$$Q = q$$

K: inventories, equipment, plant, net liquid assets and land
Sector: q9 - manufacturing
q10 - non financial corporation
Sample: q9 - 1961 to 1981
q10 - 1961 to 1979
Note: E is basic capital multiplied by a stock price index.

iii) Sweden

* Holland (1986) - **q7, q8**

$$Q = q$$

K: q7 - inventories, equipment, plant and land
q8 - inventories, equipment, plant, land and net liquid assets
Sector: business groups
Sample: 1966 to 1980

iv) Belgium

* Chan-Lee (1986) - **q12**

$$Q = q$$

K: not given
Sector: not given

Sample: 1964 to 1983

Note: The q value is an index where 1975 = 1.

v) Canada

* Chan-Lee (1986) - **q13**

$$Q = q$$

K: total capital employed

Sector: non financial corporations

Sample: 1966 to 1981

vi) France

* Chan-Lee (1986) - **q14**

$$Q = q$$

K: not given

Sector: non financial corporations and quasi-corporate enterprises

Sample: 1971 to 1983

A number of remarks can be made about the equations outlined above.

First, the equations found in the papers by Summers (1981), Poterba and Summers (1983), Dinenis (1985) and Hayashi (1985) have been adjusted prior to using them here for the reasons outlined in Endnote 25. This adjustment generally entailed adding a non-linear component to each Q formula, except for the non tax adjusted measures.

Second, two of the Japanese Qs, q1 and q2, have been supplemented by two transformed measures, q4 and q5. The transformation replaced Hayashi's equity series with that of Holland (1986). This was done due to the lack of correlation between the former series and other measures of Japanese equity prices and market valuations.

Third, there is considerable variability in the construction of the Qs. The source of these differences stem mainly from the treatment of tax variables. It should be stressed, however, that different models of optimising behaviour can lead to different specifications of Q; this is especially relevant to the case of U.K. q9 and q11 which are based on a unique specification of adjustment costs.

1. See Poterba and Summers (1987), Fama and French (1988) and Kim et al (1989) on this issue.

2. An early exposition of the cost of capital approach can be found in Jorgenson (1971), while two recent survey articles are Chirinko (1986) and Galeotti (1984).

3. See Endnote 5.

4. Ueda and Yoshikawa (1986) note that when delivery lags are incorporated into the Q theory, I/K depends on expectations of Q, rather than Q itself. If the information set of asset-holders includes Q and lagged Q, then these variables properly enter the estimation equation. The authors also motivate the success of the accelerator model of investment (in Chapter V below) by noting that profits (and output) are dominated by permanent components which involve multiple period expectations and, hence, mimic the lagged structure of Q under an assumption of non-negligible delivery time.

5. Marginal Q measures an increment to the capital stock at the relevant marginal replacement and market prices; the value of installed capital is therefore not of interest when deciding to invest in new assets. Average Q, in contrast, aggregates over all existing assets. Hayashi (1982) enumerates the three conditions that are required for marginal Q to be equal to average Q: the firm faces perfectly competitive markets, its production technology is homogeneous of degree one and its capital depreciates at a geometric rate.

In terms of empirical research, Connolly and Lacivita (1985) claim to provide evidence for different autocorrelation properties between marginal and average Qs, thus highlighting the unique nature of each definition. In fact, their analysis confuses marginal Q with tax adjusted average Q and, as a result, their paper actually examines only average Q values. Abel and Blanchard (1986) calculate a marginal Q measure from first principles but discover that it is not significantly different from the average Q found in Von Furstenberg (1977).

6. Wadhwani and Wall (1986) discuss the implications of capital scrapping rates for measures of the capital stock and Chirinko (1986) provides references to the theoretical work on the capital stock measurement problem.

7. Starting with contributions by Shiller (1981), and backed by the earlier judgment of Keynes (1936), a number of researchers have examined the issue of excess volatility of speculative market prices. Discussion of dynamic pricing behaviour anomalies, such as the January effect, the day-of-the-week effect and the tendency of share prices to revert to mean values, can be found in Poterba and Summers (1987). In addition, the issues concerning market myopia are summarized and empirically tested by Nickell and Wadhwani (1987).

A related literature deals with the poor performance of the stock market under inflationary conditions; explanations based on economic and tax factors do not seem to fully explain the phenomena and some measure of market inefficiency may therefore be involved. Modigliani and Cohn (1979), Hendershott (1981) and Brainard, Shoven and Weiss (1980) are important references on this issue.

8. Fischer and Merton (1984) provide an extended discussion of this point and give examples of its implications for investment behaviour. The Q theory might also be modified to account for the short-term noise in the market that is presumably not used by agents when making real decisions. Two examples using spectral filtering to separate the signal from the noise in stock prices and Q are found in Engle and Foley (1975) and Poterba and Summers (1983).

9. As well, Robson (1988) points out that anticipated tax changes affect the optimal timing of investment expenditures in the United Kingdom. Expectations of shifts in the tax regime are, therefore, critical components of Q.

10. While acknowledging the theoretical rigour underlying the financial policy neutrality theorem of Modigliani and Miller (1958), it does seem that the debt to equity ratio matters statistically in empirical investment equations. Chapter V of this thesis and Auerbach and Reishus (1987) assign an important role to the debt/equity ratio in explaining corporate mergers and investment.

11. By implication, the Q measure can also be used for evaluating financial investment in the market for corporate control. King (1987) gives the theoretical justification for a Q theory of takeovers and examines the empirical case for the United Kingdom.

12. See Endnote 25 for further details on this adjustment.

13. It is somewhat puzzling that the order of integration should differ only for Japan and Canada. The latter result may stem from small sample bias but the former seems to be a robust finding. A visual examination of Diagrams 1 to 11 in Appendix II does confirm, however, that the Japanese Qs appear to mean revert more frequently over the sample period than do those of other countries. With a longer series of data, say one hundred years or more, more Q variables might exhibit I(0) behaviour than is the case here.

14. This conclusion is supported by univariate ARIMA specifications of the Q time series properties. The Qs can be subdivided into three categories: those characterised by AR(1) processes, those emulating an ARMA(1,1) process and those following a higher order process. The following summary gives the breakdown of Qs by category:

AR(1) - **U.S.** q4, q5, q6, q7, q12; **U.K.** q2, q7; **Japan** q1, q2, q3, q4, q5; Other **(Finland)** q2, q3, q5, q6; Other **(West Germany)** q9, q11; Other **(Belgium)** q12; Other **(Canada)** q13.

ARMA(1,1) - **U.S.** q8, q10, q11, q15, q16; **U.K.** q4, q5, q12; Other **(Finland)** q1, q4; Other **(Sweden)** q7, q8; Other **(West Germany)** q10; Other **(France)** q14.

Higher Order - **U.S.** q1, q2, q3, q9, q13, q14; **U.K.** q1, q3, q6, q8, q9, q10, q11, q13; **Japan** q6, q7, q8, q9.

Each of these specifications produces white residuals. It should also be noted that in each case, the AR(1) coefficient is insignificantly different from unity. First differencing is therefore appropriate to achieve stationarity in the Qs prior to econometric analysis.

15. Cointegration is a concept applied to economic time series which are individually I(d) but jointly I(d-1). It is especially important for the case where series are individually I(1), since their representation in levels exhibits infinite variance and therefore violates one of the assumptions of classical econometric analysis. The formal derivation of the conditions is found in Granger (1981) and critical values for the augmented Dickey-Fuller test are in Fuller (1976). A comparison of the various integration tests is found in Engle and Granger (1987) where general support is given for the augmented Dickey-Fuller approach used here.

16. The use of first differences or deviations relative to trend values of Q has been popularised recently as an alternative to employing the level of Q as an indicator of investment incentives. Malkiel, Von Furstenberg and Watson (1979) were the initiators of this approach and it has been empirically tested by Chappell and Cheng (1982) on microlevel data for manufacturing firms.

Prof. L. Summers, in his comments on Barro (1989), questions the use of differenced variables by asking what it is that is being examined. To address this point, note that the standard Q theory compares Q to I/K, the change in the capital *stock* as a proportion of the total capital stock. In contrast, d(I/K) measures the change in capital *flows* relative to the total capital stock (or accumulated capital flows). Mathematically, and ignoring time t subscripts for simplicity,

$$d\left(\frac{I}{K}\right) = \frac{I}{K} - \frac{I_{t-1}}{K_{t-1}} \qquad (11)$$

and from Equation (2),

$$d\left(\frac{I}{K}\right) = \frac{I}{I + (1-\delta)K_{t-1}} - \frac{I_{t-1}}{I_{t-1} + (1-\delta)K_{t-2}} \qquad (12)$$

By recursive substitution,

$$d\left(\frac{I}{K}\right) = \frac{I}{\sum_{k=0}^{\infty}(1-\delta)^k I_{t-k}} - \frac{I_{t-1}}{\sum_{k=0}^{\infty}(1-\delta)^k I_{t-k-1}} \qquad (13)$$

The equivalent equation for d(Q) is

$$d\left(\frac{V}{K}\right) = \frac{V}{K} - \frac{V_{t-1}}{K_{t-1}} \qquad (14)$$

and from Equation (1) and (2),

$$d\left(\frac{V}{K}\right) = \frac{E\left(\sum_{j=0}^{\infty}(1+r)^{-(j+1)} R_{t+j}\right)}{\sum_{k=0}^{\infty}(1-\delta)^k I_{t-k}} - \frac{E\left(\sum_{j=0}^{\infty}(1+r)^{-(j+1)} R_{t+j-1}\right)}{\sum_{k=0}^{\infty}(1-\delta)^k I_{t-k-1}} \qquad (15)$$

Thus, the ECM and VAR models used below correlate changes in expectations of future profitability (relative to changes in the capital stock) to changes in the flow of capital (relative to changes in the capital stock).

17. Coefficient values and standard errors have not been replicated here for the dynamic specifications in the interest of keeping the analysis manageable. Given that there are 44 Q variables, 3 types of models, and a constant and lagged variables in each equation, the reader would have to wade through over 450 coefficient estimates. An appendix giving the data base is, however, available upon request from the author.

18. This latter regression examines whether deviations from the long run equilibrium relationship between I/K and Q have explanatory value for the dynamic path of Q.

19. The R^2 values for all four countries examined here are, in any case, rather low in *absolute* terms; this therefore brings into question the utility of the Q framework for explaining investment. The next chapter shows more rigorously that once other explanatory factors are introduced to the estimation equation, the Q variable generally adds no additional independent explanatory power.

20. The error correction term coefficient estimates for an ECM with lag one variables are: **U.S.** q1 (-.29), q2 (-.38), q3 (-.59), q4 (-.51), q5 (-.32), q6 (-.31), q7 (-.52), q8 (-.21), q9 (-.40), q10 (-.47), q11 (-.38), q12 (-.37), q13 (-.31), q14 (-.18) and q16 (-.14); **U.K.** q1 (-.37), q2 (-.77), q3 (-.30), q4 (-.20), q5 (-.26), q6 (-.63), q7 (-.69), q8 (-.14), q9 (-.14), q10 (-.14), q11 (-.14), q12 (-.21), q13 (-.15); **West Germany** q9 (-.27), q10 (-.30), q11 (-.37). Column 7 in Tables 6 to 8 show which of these estimates are significantly different from zero. The low values for U.K. q9 and q11 are likely the result of the dominance of taxation terms in these Q variables.

21. The equations for Japan use ln(R) in place of R in order to account for the accelerating nature of Japanese stock prices in the 1980s.

22. The Japanese and West German cases appear to differ markedly from the Anglo-Saxon experience. The relative degree of managerial autonomy from stock price fluctuations, explored in Chapter V, is one explanation of such differences.

23. Again, the weak VAR evidence shown here for Japan and West Germany is examined in a different context in Chapter V, in terms of stock price correlations with both investment and output.

24. If the gross capital stock is denoted K, then this means that the net measure will be calculated as $K(1-\delta)$. The convention of using the net measure of the capital stock is followed throughout this chapter.

25. Starting with Summers (1981), many researchers have adopted the convention of altering Q by subtracting the value one from the component q; for our purposes, this new value of Q is denoted Q^T. The transformation is justified by appealing to the long-run equilibrium condition where the replacement and market values of capital are the same (i.e., the value of q equals one). In a tax-free world devoid of any imperfections in measuring the relevant Q components (and with fundamental values faithfully reflected in speculative market prices), such an adjustment would simply scale q (and

Q) from an equilibrium value of one to zero. However, when this transformation is used in practice, the Q^T values are distorted because the tax and other components are multiplied in a non-linear fashion with q. The non-homogeneous nature of the adjustment means that Q^T must be transformed to a Q form in order to properly compare it with other Qs.

26. It should be noted that q4 and q10 are not equivalent measures even though they are calculated to capture the same components. This can be shown if we define the following:

$$X_1 = \frac{1}{1 - \tau}$$

$$X_2 = \frac{p}{(1 - \tau)P}$$

$$z_1 = z + j \quad ; \quad z_2 = s$$

$$b_1 = b \quad ; \quad b_2 = d - a$$

Substituting these variables into the two Q measures yields:

(16) $$q4 = X_1\left(\frac{1}{\theta}(e - a) + b_1 - 1 + z_1\right)$$

(17) $$q10 = X_2\left(\frac{1}{\theta}(e) + b_2 - 1 + z_2\right)$$

Since e and θ are the most volatile elements of the equations, the inclusion or exclusion of a from the two formulas will produce substantially different Q variables.

Table 1: Descriptive Statistics: Mean and Coefficient of Variation								
Q	U.S.		U.K.		Japan		Other	
	Mean	C.V.	Mean	C.V.	Mean	C.V.	Mean	C.V.
1	1.15	0.14	0.90	0.36	1.78	0.31	1.57	0.19
2	3.51	0.16	NA	NA	1.69	0.14	1.12	0.04
3	1.11	0.14	1.06	0.20	1.65	0.12	1.47	0.19
4	1.32	0.16	3.15	0.28	0.59	0.05	1.64	0.20
5	0.89	0.13	2.53	0.23	1.12	0.07	1.29	0.05
6	1.04	0.15	1.18	0.22	0.72	0.06	1.46	0.14
7	2.09	0.21	1.16	0.26	1.73	0.11	0.62	0.12
8	1.31	0.18	1.69	0.32	0.81	0.22	0.50	0.11
9	1.16	0.16	0.99	0.56	1.71	0.24	1.19	0.11
10	0.88	0.15	1.83	0.29			1.20	0.10
11	1.23	0.23	1.15	0.52			2.63	0.34
12	1.39	0.20	0.60	0.43			1.03	0.13
13	1.47	0.23	0.53	0.42			1.04	0.12
14	1.64	0.16					0.67	0.24
15	0.87	0.10						
16	1.43	0.10						

Note: Sample sizes are as follows: U.S. 1960-1974; U.K. 1964-1975; Japan 1965-1981; Other (Finland) q1-q6 1961-1980; Other (Sweden) q7-q8 1966-1980; Other (West Germany) q9-q11 1966-1979; Other (Belgium) q12 1964-1983; Other (Canada) q13 1966-1981; Other (France) q14 1971-1983.

Table 2: Augmented Dickey-Fuller Test for 1 Unit Root

Q	U.S.	U.K.	Japan	Other
1	-1.46	-1.59	-3.52 **	-2.54
2	-1.61	-2.26	-3.11 **	-1.84
3	-1.03	-1.90	-3.47 **	-2.40
4	-1.06	-2.03	-2.80 ***	-2.49
5	-2.10	-2.28	-2.39	-1.98
6	-1.91	-1.75	-3.31 **	-2.31
7	0.09	-0.50	-3.04 **	-2.14
8	-1.18	-2.54	-3.10 **	-2.00
9	-0.98	-2.41	-3.10 **	-1.52
10	-1.32	-2.35		-1.61
11	-1.32	-2.13		-1.91
12	-0.52	-2.25		-2.15
13	-1.19	-2.11		-3.17 **
14	-0.24			-2.48
15	-0.36			
16	-1.74			
I/K	-2.04	-2.51	-1.12	-1.42

Table 3: Augmented Dickey-Fuller Test for 2 Unit Roots

Q	U.S.	U.K.	Japan	Other
1	-4.12 *	-6.44 *	-3.70 *	-3.33 **
2	-5.48 *	-3.88 *	-3.93 *	-2.66 ***
3	-4.10 *	-4.48 *	-3.47 **	-2.76 ***
4	-4.03 *	-4.20 *	-4.02 *	-3.32 **
5	-3.95 *	-4.64 *	-4.13 *	-3.11 **
6	-4.26 *	-4.21 *	-6.19 *	-2.90 ***
7	-2.55	-4.77 *	-5.19 *	-8.87 *
8	-3.10 **	-5.71 *	-5.64 *	-9.31 *
9	-4.26 *	-6.86 *	-4.89 *	-4.51 *
10	-4.20 *	-5.89 *		-4.49 *
11	-4.62 *	-6.75 *		-3.31 **
12	-4.24 *	-5.35 *		-3.89 *
13	-4.44 *	-7.08 *		-2.91 ***
14	-3.86 *			-2.96 **
15	-4.19 *			
16	-4.87 *			
I/K	-4.65 *	-5.09 *	-5.58 *	-3.99 *

The test statistic for 3 unit roots in U.S. q7 is -3.87 **.

Note: * - significant at 1%
** - significant at 5%
*** - significant at 10%

Table 4: Augmented Dickey-Fuller Test for Cointegration

Q	U.S.	U.K.	Japan I/K	Japan d(I/K)	Germany
1	-2.70 ***	-2.76 ***	-1.00	-6.26 *	
2	-2.54	-3.75 *	-0.97	-5.63 *	
3	-3.33 **	-3.22 **	-0.55	-5.78 *	
4	-3.48 **	-2.41	-1.51	-5.78 *	
5	-2.54	-2.45	-1.83	-5.47 *	
6	-2.45	-4.37 *	-0.91	-2.89 ***	
7	-1.53	-3.31 **	-0.64	-2.74 ***	
8	-2.59	-2.22	-0.95	-2.93 ***	
9	-2.37	-2.21	-0.77	-2.78 ***	-2.57
10	-3.10 **	-2.13			-2.73 ***
11	-3.15 **	-2.21			-2.01
12	-3.23 **	-2.10			
13	-3.15 **	-2.27			
14	-2.92 ***				
15	-3.25 **				
16	-2.50				

The test statistic for cointegration between U.S. I/K and U.S. dq7 is -1.66.

Note: * - significant at 1%
** - significant at 5%
*** - significant at 10%

Table 5: Static Q Theory Estimated Coefficients

Q	U.S. α	U.S. β	U.K. α	U.K. β	Japan α	Japan β	Germany α	Germany β
1	9.77 (15.9)	2.17 (3.5)	7.70 (12.3)	0.71 (1.2)	16.36 (6.5)	2.90 (2.2)		
2	9.73 (17.3)	0.72 (3.9)	6.25 (13.7)	1.73 (3.9)	8.42 (1.5)	7.92 (2.3)		
3	8.09 (9.7)	3.70 (4.6)	5.51 (8.5)	2.78 (4.1)	17.69 (5.2)	4.97 (1.2)		
4	8.94 (16.8)	2.48 (5.3)	6.14 (6.4)	0.51 (1.6)	14.65 (6.8)	3.61 (3.5)		
5	8.83 (9.5)	3.78 (3.4)	3.99 (4.8)	1.53 (4.4)	3.34 (0.8)	10.56 (4.3)		
6	9.65 (15.3)	2.53 (3.7)	6.71 (13.6)	1.55 (3.6)	55.26 (3.0)	-60.5 (1.9)		
7	10.46 (9.3)	0.84 (1.6)	7.38 (10.3)	0.85 (1.5)	19.41 (1.3)	0.34 (0.1)		
8	9.88 (7.9)	1.78 (1.9)	8.46 (10.5)	-0.44 (1.1)	52.77 (3.5)	-45.7 (2.2)		
9	9.96 (19.9)	1.94 (3.8)	7.54 (14.7)	0.05 (0.1)	21.61 (2.0)	-1.05 (0.2)	1.94 (2.3)	3.57 (5.5)
10	9.68 (17.0)	2.88 (3.9)	8.91 (10.6)	-0.62 (1.6)			0.97 (0.7)	4.47 (4.0)
11	10.30 (29.7)	1.62 (4.7)	7.77 (14.2)	-0.14 (0.3)			4.72 (8.3)	0.54 (2.6)
12	9.26 (11.4)	2.05 (3.3)	5.76 (11.7)	3.65 (4.0)				
13	9.40 (12.1)	1.83 (3.4)	7.95 (13.2)	-0.60 (0.6)				
14	8.92 (9.5)	1.95 (3.2)						
15	12.98 (10.7)	-1.26 (0.9)						
16	12.81 (10.3)	-0.63 (0.8)						

Note: Equations are of the form $I/K = \alpha + \beta Q$. t-statistics are shown in parentheses.

Table 6: Regression Results Summary - United Kingdom

Q	DW	Regressors F-test	R2	Chow	LM	U hat F-test	F-test
q1	0.80	1.33	0.09	0.15	3.96 **		
dq1	2.79	12.82 *	0.79	0.22	3.47	4.27	1.46
dq1	2.60	13.18 *	0.71	0.42	2.26		
q2	1.20	14.97 *	0.45	2.25	4.95 **		
dq2	1.86	8.95 *	0.66	1.86	0.03	15.28 *	1.32
dq2	1.90	2.97	0.28	2.42	0.78		
q3	0.89	17.19 *	0.48	1.09	5.54 **		
dq3	1.85	3.23 **	0.59	1.09	0.01	0.85	1.86
dq3	1.86	3.87 **	0.56	1.29	0.06		
q4	0.22	2.42	0.08	0.92	57.05 *		
dq4	2.01	2.59	0.37	0.32	0.20	3.06	4.19
dq4	1.94	2.27	0.28	0.49	0.05		
q5	0.45	19.74 *	0.41	2.21	20.26 *		
dq5	2.13	3.11 **	0.41	0.32	0.55	4.25 **	2.42
dq5	1.94	2.47	0.30	0.49	0.11		
q6	1.48	12.63 *	0.44	0.58	1.92		
dq6	1.79	9.40 *	0.70	1.22	0.16	8.14 **	3.10
dq6	2.09	6.47 *	0.50	1.09	0.06		
q7	0.79	2.15	0.13	0.34	3.77		
dq7	2.41	9.46 *	0.74	0.66	1.86	13.69 *	1.31
dq7	1.77	3.41	0.38	0.08	0.02		
q8	0.25	1.24	0.04	1.96	64.92 *		
dq8	2.02	3.86 **	0.47	0.96	0.70	2.91	1.18
dq8	2.02	3.78 **	0.40	1.23	1.41		
q9	0.19	0.01	0.00	3.03 **	80.85 *		
dq9	2.01	5.83 *	0.57	0.88	0.50	4.17	0.52
dq9	1.96	5.49 *	0.49	1.29	1.35		
q10	0.29	2.58	0.08	1.37	55.33 *		
dq10	1.91	3.60 **	0.45	0.91	0.44	2.81	0.95
dq10	1.93	3.53 **	0.38	1.20	1.11		
q11	0.20	0.12	0.00	2.18	80.64 *		
dq11	1.88	5.35 *	0.55	0.87	0.24	4.27 **	0.33
dq11	1.87	4.92 **	0.46	1.29	1.11		
q12	0.37	15.98 *	0.36	2.49	26.74 *		
dq12	2.14	2.95 **	0.40	0.53	0.24	3.71	1.81
dq12	1.98	2.46	0.30	0.80	0.20		
q13	0.21	0.40	0.01	1.68	73.98 *		
dq13	2.03	5.14 *	0.54	0.58	0.30	3.01	0.52
dq13	2.01	5.22 **	0.48	0.82	0.95		

Note: * - significant at 1%
** - significant at 5%

Table 7: Regression Results Summary - United States

Q	DW	Regressors F-test	R2	Chow	LM	U hat F-test	F-test
q1	0.67	12.38 *	0.31	3.99 **	10.04 *		
dq1	2.07	10.49 *	0.72	0.44	3.20	5.26 **	0.22
dq1	1.80	9.80 *	0.65	0.64	0.03		
q2	0.51	15.35 *	0.36	3.05 **	14.82 *		
dq2	1.94	1.14	0.22	0.70	0.13	2.58	0.77
dq2	1.92	0.72	0.12	0.79	0.10		
q3	1.05	20.72 *	0.48	0.36	4.26 **		
dq3	1.59	6.73 **	0.69	0.68	1.05	6.24 **	0.27
dq3	1.43	5.16 **	0.56	1.21	1.58		
q4	0.98	28.50 *	0.51	0.58	6.46 *		
dq4	1.86	6.58 **	0.62	0.63	0.98	8.55 *	0.00
dq4	1.71	4.48 **	0.46	0.89	3.87		
q5	0.80	11.24 *	0.33	3.68 **	5.90 *		
dq5	1.89	5.47 **	0.63	0.81	3.70	2.24	0.93
dq5	1.82	5.85 **	0.58	0.73	1.13		
q6	0.42	13.56 *	0.37	2.02	15.67 *		
dq6	1.96	0.90	0.22	0.78	0.46	0.89	0.64
dq6	1.87	0.91	0.18	0.33	0.65		
q7	0.95	2.49	0.16	0.18	2.33		
dq7	2.23	11.97 *	0.80	NA	NA	11.93 *	0.20
dq7	1.67	5.73 **	0.53	NA	0.09		
q8	0.98	3.55	0.21	0.22	2.58		
dq8	1.67	9.74 *	0.76	NA	NA	1.02	0.54
dq8	1.87	14.07 *	0.74	NA	0.37		
q9	0.91	14.67 *	0.33	3.02	6.24 *		
dq9	1.88	4.79 **	0.51	0.56	0.86	4.90 **	0.29
dq9	1.92	4.10	0.41	0.81	0.33		
q10	1.06	14.89 *	0.33	2.90	4.19 **		
dq10	1.96	4.27 **	0.48	0.40	2.20	5.82 **	1.64
dq10	1.99	3.23	0.35	0.61	2.22		
q11	0.86	21.74 *	0.42	2.52	7.25 *		
dq11	1.93	9.89 *	0.68	0.62	0.45	10.12 *	0.74
dq11	1.83	7.13 **	0.54	0.97	0.65		
q12	1.01	11.21 *	0.41	0.26	3.14		
dq12	2.47	19.67 *	0.83	1.67	3.23	7.39 **	0.36
dq12	2.35	17.31 *	0.73	1.25	0.43		
q13	1.16	11.23 *	0.41	0.27	2.25		
dq13	2.13	16.10 *	0.80	1.96	0.22	3.53	0.69
dq13	2.27	18.74 *	0.74	1.95	0.36		
q14	1.02	10.46 *	0.40	0.32	2.89		
dq14	2.28	14.60 *	0.78	0.75	2.51	10.50 *	0.00
dq14	1.91	9.62 *	0.60	0.59	0.16		
q15	0.64	0.87	0.03	6.42 *	13.18 *		
dq15	1.72	2.35	0.37	1.32	2.31	1.19	0.30
dq15	1.68	2.62	0.33	1.55	3.57 **		
q16	0.62	0.58	0.02	6.32 *	14.44 *		
dq16	1.62	2.01	0.33	1.64	2.53	0.32	2.46
dq16	1.61	2.51	0.32	1.54	2.06		

Note: * - significant at 1%
** - significant at 5%

Table 8: Regression Results Summary - West Germany							
Q	DW	Regressors F-test	R2	Chow	LM	U hat F-test	F-test
q9	1.02	29.84 *	0.61	1.88	2.98		
dq9	2.02	4.59 *	0.66	1.28	2.48	3.42	0.71
dq9	2.27	4.12 **	0.56	0.14	2.79		
q10	1.04	16.09 *	0.49	1.59	3.11		
dq10	1.88	7.47 *	0.65	1.38	0.27	4.92 **	0.94
dq10	2.20	6.71 *	0.51	0.39	0.34		
q11	0.89	6.66 **	0.34	7.73 **	2.15		
dq11	1.51	4.03 **	0.57	0.86	NA	5.73 **	0.21
dq11	1.46	2.16	0.30	0.23	3.21		

Note: * - significant at 1%
** - significant at 5%

Table 9: Regression Results Summary for d(I/K) - Japan							
Q	DW	Regressors F-test	R2	Chow	LM	q F-test	dq F-test
q1	1.61	2.65	0.10	0.23	3.14	12.37 *	0.17
q1 lags	1.74	2.87 **	0.38	0.97	0.30		
q2	1.58	0.63	0.03	0.27	3.16	9.54 *	1.28
q2 lags	1.69	2.17	0.31	0.85	0.42		
q3	1.59	0.84	0.03	0.26	3.23	8.47 *	1.36
q3 lags	1.76	2.30	0.33	1.17	0.32		
q4	1.64	2.72	0.10	0.19	2.60	6.20 **	0.18
q4 lags	1.55	3.99 **	0.46	0.78	0.88		
q5	1.60	0.81	0.03	0.23	2.83	4.84 **	1.16
q5 lags	1.46	3.15 **	0.40	0.62	1.21		
q6	1.23	0.42	0.03	0.65	1.39	0.01	0.13
q6 lags	1.16	3.47 **	0.35	0.17	3.15		
q7	1.29	0.09	0.01	0.68	0.90	0.01	3.23
q7 lags	1.43	0.80	0.11	0.04	2.05		
q8	1.24	0.72	0.05	0.78	1.43	0.18	0.35
q8 lags	1.18	3.41	0.34	0.23	3.00		
q9	1.28	0.00	0.00	0.54	1.02	0.02	2.12
q9 lags	1.43	0.80	0.11	0.03	2.13		

Note: * - significant at 1%
** - significant at 5%

Table 10: Augmented Dickey-Fuller Tests for Integration
Real Stock Prices

R	Sample	1 Root	2 Roots	Cointegration
U.K.	1952-1986	-2.33	-5.67 *	-2.93 ***
U.S.	1952-1986	-2.00	-4.65 *	-3.00 **
Japan	1952-1986	1.62	-2.19	-2.56
	1955-1981	-1.47	-5.12 *	-2.03
Japan ln(R)	1952-1986	-1.42	-5.27 *	-2.56
	1955-1981	-2.19	-4.57 *	-2.03
West Germany	1961-1986	-2.41	-5.11 *	-0.99
	1961-1981	-2.13	-10.23 *	-3.90 *

Table 11: Regression Results Summary - Real Stock Prices

R	DW	Regressors F-test	R2	Chow	LM	U hat F-test	F-test
U.K.	0.47	17.97 *	0.35	1.05	19.26 *		
1952-1986	2.06	5.10 *	0.50	0.63	0.77	8.38 *	1.73
	1.93	3.36 **	0.33	0.57	0.06		
U.S.	0.79	10.54 *	0.24	1.13	9.08 *		
1952-1986	1.85	7.31 *	0.58	0.91	0.23	9.36 *	4.30 **
	2.06	5.19 *	0.43	1.05	0.78		
Japan	0.49	22.31 *	0.40	4.06 *	25.48 *		
1952-1986	1.85	3.29 **	0.39	0.92	0.24	1.28	0.32
	1.87	3.75 **	0.36	0.90	0.18		
1955-1981	0.58	8.47 *	0.25	4.39 *	10.52 *		
	1.73	1.93	0.35	0.89	0.84	0.70	2.83
	1.76	2.29	0.33	0.93	0.31		
West	0.35	16.69 *	0.41	4.05 **	28.51 *		
Germany	2.03	2.93	0.46	0.89	1.57	3.45	0.00
1961-1986	1.96	2.46	0.35	0.30	0.03		
1961-1981	1.01	46.58 *	0.71	0.63	5.85 **		
	1.95	7.16 *	0.75	0.30	0.42	14.75 *	1.20
	1.79	2.56	0.44	0.21	0.21		

Note: * - significant at 1%
** - significant at 5%
*** - significant at 10%

Table 12: Non-nested Model Comparisons: Real Stock Prices and Q
Current and Lagged Values F-test

Q	U.S.		U.K.		Japan		West Germany	
	R	Q	R	Q	R	Q	R	Q
1	0.98	2.12	1.18	8.42 **	2.88	4.46 **		
2	0.77	1.46	0.14	0.10	3.26	4.62 **		
3	0.49	1.93	0.35	1.79	2.72	3.27		
4	0.09	0.80	1.44	1.00	1.49	3.69 **		
5	0.96	0.87	0.25	5.94 *	1.73	2.77		
6	0.29	6.83 *	1.22	5.66 **	2.18	4.23 **		
7	10.38 *	3.14	1.13	5.01 **	0.93	2.18		
8	0.01	4.24	0.62	3.69 **	3.13	5.60 **		
9	0.81	0.59	0.28	5.23 **	1.48	2.82	5.10 **	1.79
10	2.37	0.40	0.52	4.21 **			5.66 **	2.10
11	0.61	4.72 **	0.65	5.83 *			4.09 **	0.01
12	0.37	1.76	0.49	1.40				
13	0.66	4.94 **	0.08	1.77				
14	1.99	0.85						
15	6.43 *	3.57 **						
16	6.46 *	1.69						

Table 13: Non-nested Model Comparisons: Real Stock Prices and Q
Lagged Values F-test

Q	U.S.		U.K.		Japan		West Germany	
	R	Q	R	Q	R	Q	R	Q
1	1.31	4.53 *	0.14	14.62 *	0.04	0.02		
2	17.86 *	0.06	0.36	0.21	0.14	1.46		
3	0.13	3.62	0.00	2.00	0.08	0.70		
4	0.01	2.72	5.75 **	0.22	0.00	0.09		
5	0.95	1.62	5.36 **	0.12	0.14	0.28		
6	19.28 *	0.68	0.00	3.63	4.01	19.97 *		
7	2.83	0.60	0.00	1.63	6.46 **	13.85 *		
8	0.54	4.76	0.68	4.90 **	3.08	18.85 *		
9	1.49	1.70	0.02	9.20 *	5.95 **	14.44 *	0.04	3.93
10	5.12 *	1.09	0.65	4.52 **			0.00	3.41
11	0.37	7.70 *	0.01	7.87 *			3.67	0.10
12	0.01	5.10 **	8.85 *	2.93				
13	0.00	6.11 **	0.31	5.00 **				
14	1.59	1.10						
15	8.75 *	3.71						
16	11.56 *	2.79						

Note: * - significant at 1%
** - significant at 5%

Diagram 1: Q Variables in the United States

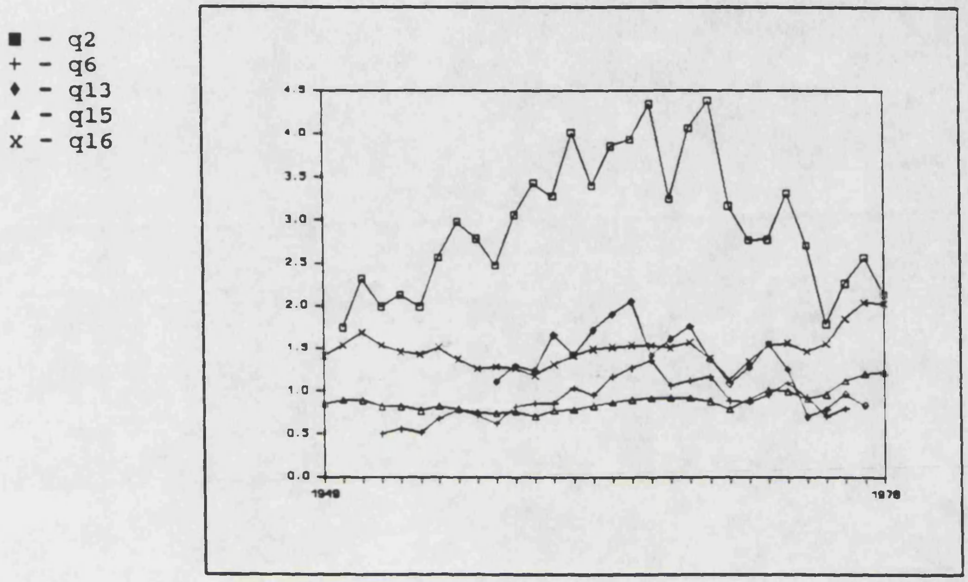


Diagram 2: Q Variables in the United States

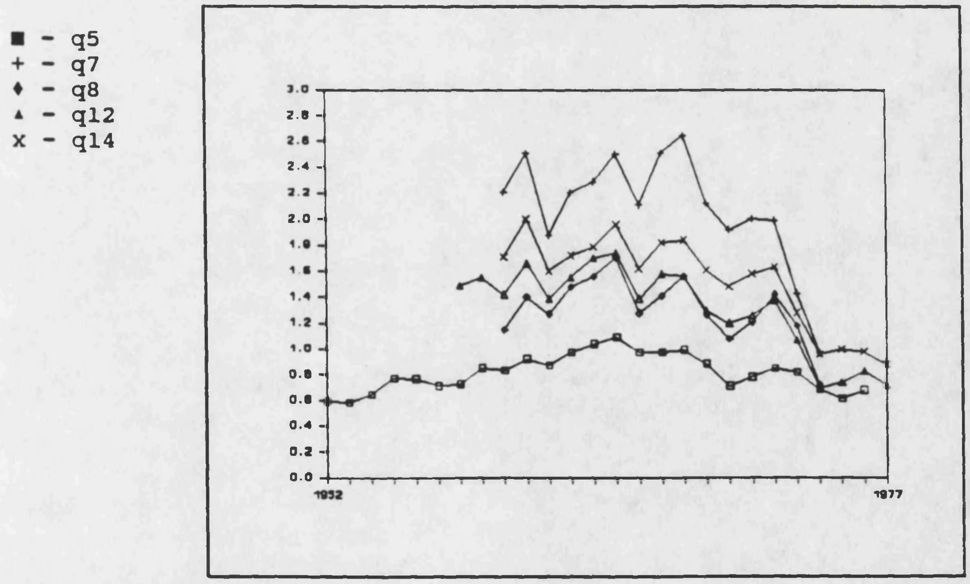


Diagram 3: Q Variables in the United States

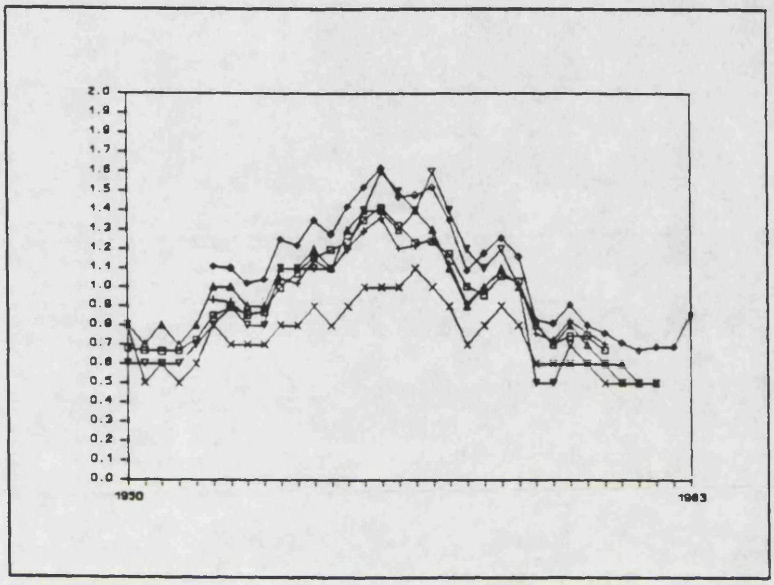


Diagram 4: Q Variables in the United Kingdom

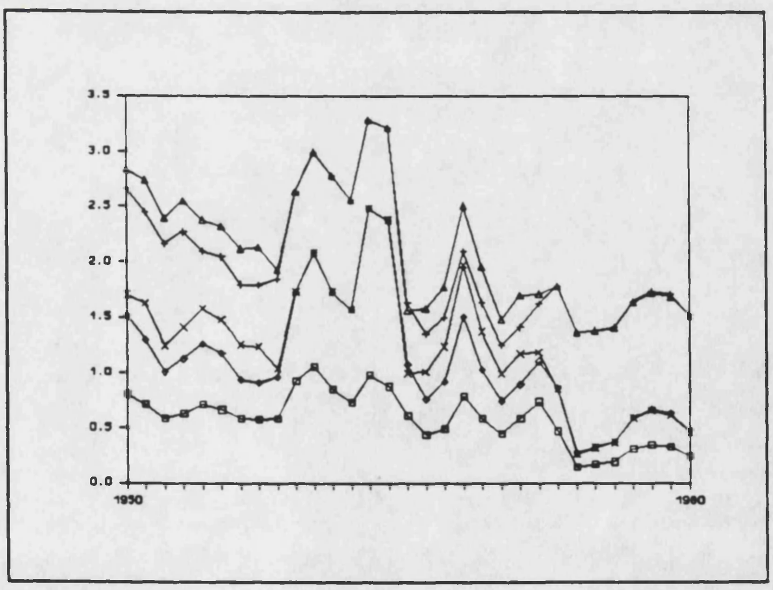


Diagram 5: Q Variables in the United Kingdom

■ - q1
\+ - q2
♦ - q3
▲ - q6
x - q7

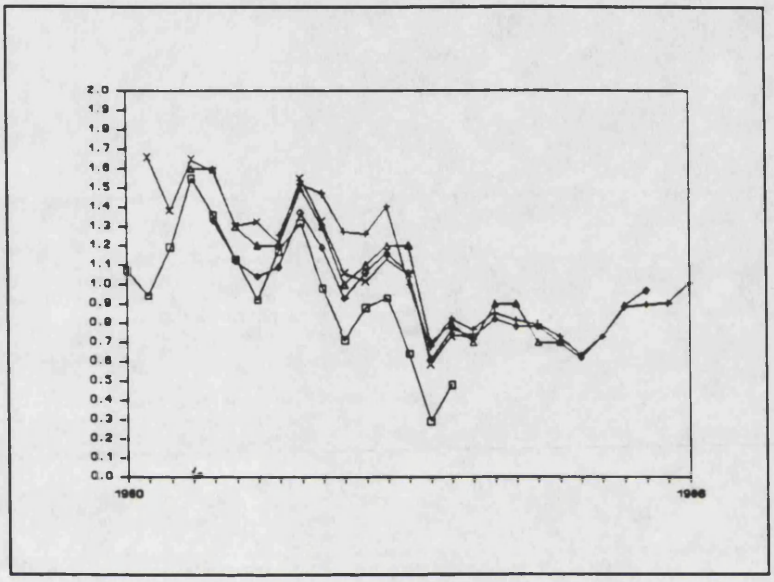


Diagram 6: Q Variables in the United Kingdom

■ - q4
\+ - q5
♦ - q12

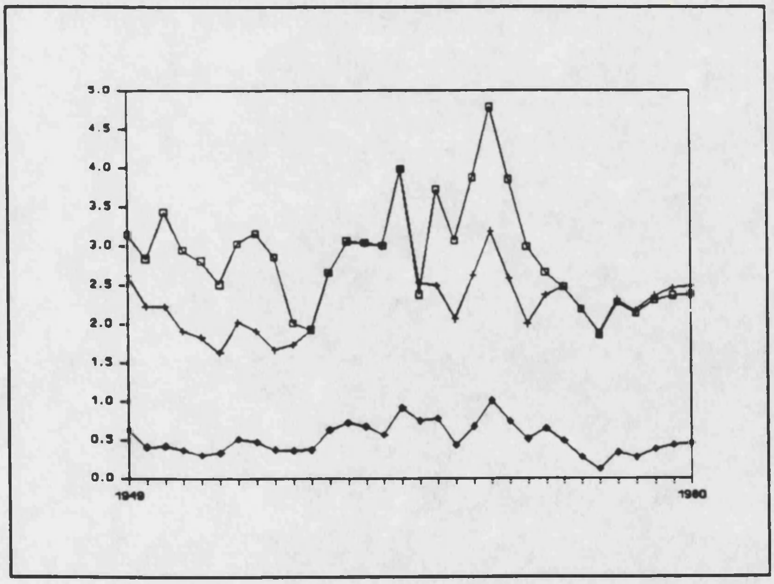


Diagram 7: Q Variables in Japan

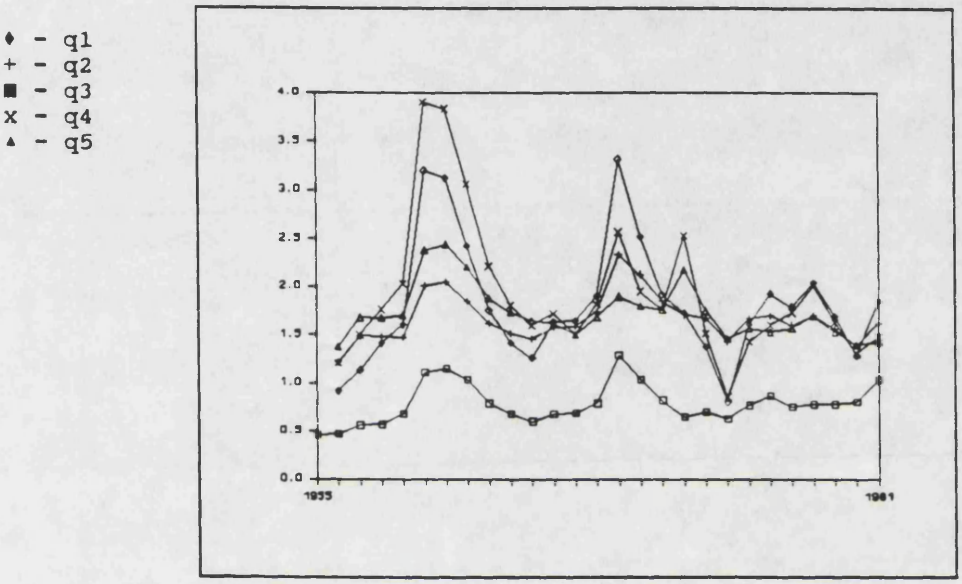


Diagram 8: Q Variables in Japan

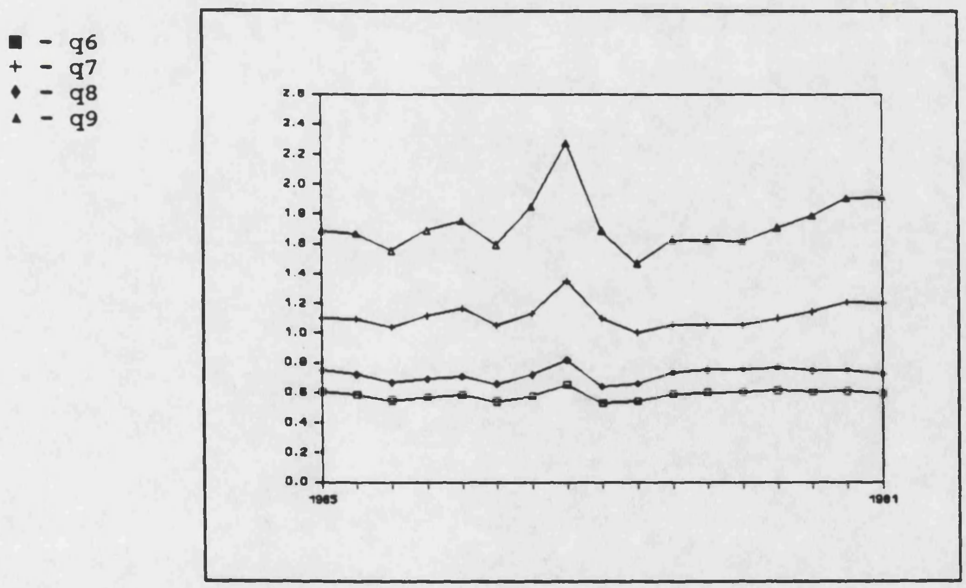


Diagram 9: Q Variables in Finland

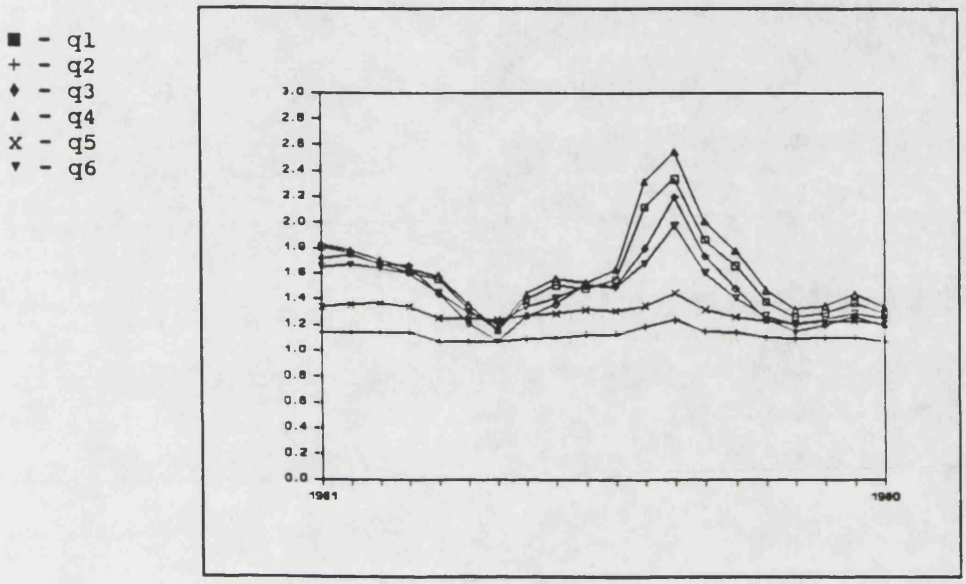


Diagram 10: Q Variables in West Germany

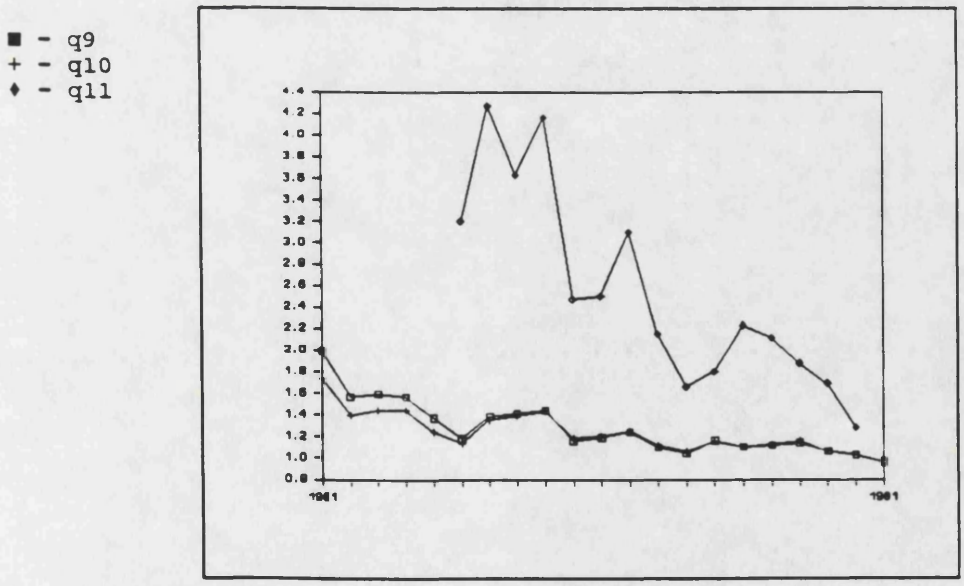
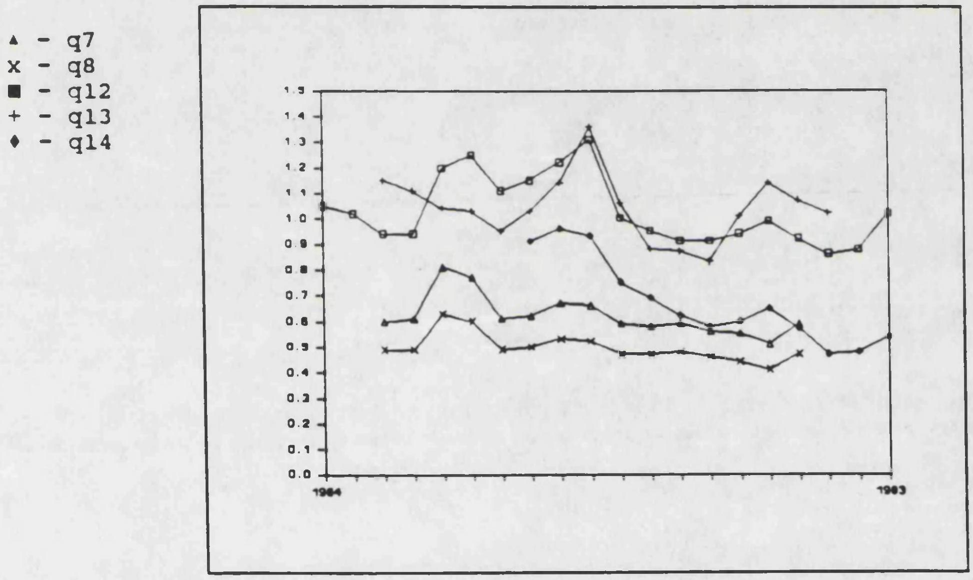


Diagram 11: Q Variables in Other Countries



Chapter V: Stock Prices and Corporate Investment

I. Introduction

Chapter IV came to the conclusion that specifying Q in first differences as an error correction model is one solution to the empirical problems thrown up by static Q theory. However, the generally low explanatory power of Q equations and the cross-country differences identified in the chapter suggest that there may be other important omitted explanatory variables. The bivariate framework previously employed is, therefore, extended in this chapter by including other determinants of investment, such as interest rates and real output. As well, cost of capital measures and debt-equity ratios are employed to introduce other means by which stock prices affect corporate investment.

The present chapter, motivated by the crash of 1987, examines whether exogenous events whose only direct effect is to change stock prices can indirectly affect corporate investment through the stock price mechanism. Empirically, aggregate stock prices are a leading indicator used to predict cyclical changes, even though, in the U.S., they are regarded to have predicted "thirteen of the last five recessions". However, this does not necessarily provide any evidence for the stock market playing a structural role.

It is therefore argued here that the actual 'structural' effect of share price changes on investment will depend on managerial autonomy; in turn, such autonomy depends, in part, on the use of the takeover mechanism, the size of the quoted sector, gearing ratios, and the role of employees in corporate decision-making. In general, the prominence of these institutional factors implies that the importance of the stock market will vary considerably across countries. In particular, one expects the stock market to be less influential in Japan or Germany, when compared with the U.S. or the U.K., respectively. All this is the subject of Section II.

Some evidence is provided in this regard by estimating flexible accelerator investment equations which are modified to allow for a richer set of financial factors (motivated by a fear of bankruptcy). These estimates (presented in Section III) and some non structural VARS, do bear out an a priori view that the stock market is more important in the Anglo-Saxon economies.

As well, this fact may go some way to explaining other differences between these four countries. For example, it may be one reason why the Japanese and Germans invest more, and it may also help explain why higher inflation appears to be associated with higher declines in output in the Anglo-Saxon countries. These issues are discussed in Section IV, along with other conclusions to the chapter.

II. Theoretical Considerations

IIa. Stock Market Influences on Investment

This chapter asks whether exogenous events whose only direct effect is to change stock prices can indirectly affect corporate investment through the stock price mechanism. The standard theoretical answer to this question is yes (see, e.g., Fischer and Merton (1984), who provide the following example).

Consider an initial equilibrium where the expected return on the market and the yield on the firm's marginal new investment are both 15 percent. Suppose that an exogenous increase in aggregate risk aversion causes share prices to decline to the point where they now yield an expected return of 20 percent, while the marginal investment project still continues to yield only 15 percent. Now, managers who act in the interests of their existing shareholders will cancel all planned investments with expected returns less than 20 percent. This argument would continue to hold even if the reduction in share prices were caused by an irrational change in investors' perceptions of the future. Thus, Fischer and Merton conclude that "... actions by rational and informed managers will not offset the effects of irrational investors on investment."

However, the above argument relies on a number of simplifying assumptions. For example, it is well known that under conditions of uncertainty, shareholders will not generally be unanimous about the best policy for the firm to pursue.[1] These differences in opinion between shareholders can create some discretionary power for management to pursue their own goals. Therefore, it is possible that managers may choose to assign less weight to share prices when formulating investment decisions than they would if they were acting purely in the interests of the existing shareholders.

There are also other possible reasons why managers may not seek to pursue share price maximisation. According to Leontief (1946), for example, if employment is set as the result of a bargain between firms and unions, rather than on the basis of profit (share price) maximisation conditional on wages, both the employer and the union can be made better off. Therefore, considerations of internal efficiency suggest that managers may deviate from share price maximisation when choosing the appropriate level of employment and investment.

Another reason why share prices may be partially ignored by managers is if the market is widely perceived to be myopic and, hence, unreliable as a guide to efficient managerial decision-making. For example, one industrial survey in the U.K. found that 85 per cent of managers felt that the market took too short term a view of their investment decisions. Also in the U.K., the Bank of England's former executive director responsible for the securities market and former Chancellor Lawson apparently share the view that " big institutional investors nowadays increasingly react to short-term pressure on investment performance ... (they) are unwilling to countenance long-term investment or a sufficient expenditure on research and development".[2]

The preceding discussion is consistent with the available survey evidence (presented below) which suggests that maximisation of the firm's share price is not perceived to be the most important managerial objective. Given this assumption regarding managerial behaviour, international differences in the extent of managerial power will, therefore, influence the extent to which the stock market affects investment. It is to this that we turn next.

IIb. Institutional Differences Across Countries

There is some empirical support for the view that managers pay less attention to the stock market in Japan than in the U.S. in the form of survey evidence, which is presented in Table 1. Notice that while securing a capital gain for shareholders is the second most important objective for American managers, it is the least most important objective for their Japanese counterparts. This difference may be at least partly explicable in terms of the cross-country institutional factors discussed below, which are set out to differentiate Japanese and German institutional behaviour from that of their Anglo-Saxon counterparts.

The first institutional difference is that takeovers are relatively rare in Japan or Germany, in contrast to the Anglo-Saxon economies. In the case of Japan, a recent Hi Tech Dictionary listing under Takeover bids describes American practice and goes on to say that "Japanese law was changed in 1972 to permit similar bid proceedings in this country, but the idea of taking over a company simply by the power of money seems too dorai (dry) to us Japanese, and in practice it never happens."[3] While cultural differences do not necessarily explain the absence of hostile takeovers (the close links between banks and industry, and the fact that banks will replace inefficient managers must surely play a part), the empirical absence of such takeovers suggests that at the minimum, shareholders do not exercise one of the usual methods of ensuring that managers obey their wishes.[4]

Turning to Germany, hostile takeovers are also relatively rare, but this fact should be set in the context of a quoted sector that is, by international standards, very small. For example, Table 2 shows that the ratio of market capitalization to GDP is about 25 per cent in Germany as compared to 80 per cent in Japan, 85 per cent in the U.K. and 76 per cent in the U.S.. In addition to the quoted sector being small, it has been estimated that only about 30 shares are actually actively traded (see BEQB (1984)) with the other shares being closely held and, therefore, less vulnerable to a takeover anyway.[5]

A second reason why managers might be able to pay less attention to shareholders in Japan and Germany, as compared to the U.S. or the U.K., is the fact that employees play a much larger role in decision making. In Germany, workers are represented on the supervisory council, with all actions of management being subject to the broad supervisory powers of this council.[6] In addition, the law also requires that employee representation in the form of works' councils be instituted in all establishments that normally have five or more permanent employees. These works' councils discuss a wide range of issues, including being consulted on investment and employment decisions.

Turning to Japan, most informed observers agree that permanent employees do have a say in the decisions of the firm - for example, Komiya and Yasui (1984) assert that "from the firm's perspective ... permanent employees represent more important assets than customers and stockholders ... It is not going too far to say that under Japan's lifetime employment system, a firm's regular employees are the firm itself."

There is less agreement about the role of employees in decision-making in the U.S. or the U.K.. There is now a sub-industry of papers that try to test whether or not firms and unions bargain over employment (e.g., Brown and Ashenfelter (1986)). Although these papers do not all agree on an answer, the very fact that this issue is controversial differentiates these Anglo-Saxon economies from either Germany or Japan.

A third reason why managers may be more anxious to maximise the share price in the Anglo-Saxon economies is the fact that a part of their remuneration is often directly linked to the stock market. Such share option schemes are virtually unknown in either Germany or Japan.

Finally, a fourth reason why the stock market may exert a smaller influence in Germany or Japan is the well-known fact that gearing ratios are much higher in these countries when compared with the Anglo-Saxon economies. Table 3 presents evidence on these differences in gearing.[7] A higher gearing ratio means that managers need not concern themselves too much with the wishes of the shareholders, provided that they command the confidence of their bankers.

So, to sum up, the relative absence of takeovers, the higher gearing ratios, the greater importance accorded to employees in decision-making and the lesser importance of stock market related managerial remuneration, all make it more likely that managers are able to pay less attention to the stock market in Germany or Japan, as compared to the Anglo-Saxon countries.

So far, reasons have been put forth to explain why the stock market may not significantly affect investment in Japan or Germany. However, none of this should be interpreted as implying that managers in the Anglo-Saxon countries give as much weight to the stock market as textbook models imply.

In fact, survey evidence for the U.K. does suggest that practice departs significantly from the textbook ideal.[8] This impression also appears to have been borne out by the fact that the 1987 stock market crash has failed to affect investment intentions in the U.K., with only 4% of business men saying that the crash represented "a genuine deterioration in the world economic outlook" - the vast majority of survey respondents believing instead that it represented "the inevitable puncturing of a speculative boom".[9]

The arguments presented above provide some reasons to think that managers in Japan and West Germany are able to pay less attention to share price movements. Little has been said thus far, however, about *why* managers might wish to ignore fluctuations in share prices when formulating investment decisions. This issue will now be briefly discussed.

IIc. Managerial Incentives to Ignore Stock Prices

The survey evidence given above supports the view that, contrary to the textbook ideal, maximising the share price is not the most important managerial goal. There may be several reasons for this including the fact that managers may derive utility from the size of the firm per se, and may not want to be deflected from this goal by the wishes of stockholders.

Another reason why managers might not want to be overly influenced by the stock market is if the market were myopic, in the sense of attaching too high a weight to current dividends relative to future dividends (see Nickell and Wadhwani (1987)). In this case, a project (e.g. R&D spending) which yields negative returns in the early years, but is a positive NPV project overall, will depress the share price today. If managers feel that the project is important for the long-term survival of the company, they would want to go ahead with it provided that they can ignore their shareholders.

A third relevant consideration already mentioned is managerial remuneration - as shown above, managers in Japan are more concerned with fluctuations in earnings (to which their pay is linked) than in share prices.

However, it should be stressed that it is possible to conceive of circumstances where the relationship between the extent of shareholder control over management and the influence of share prices on investment may not be monotonic. In other words, the absence of shareholder control may actually strengthen the linkage between investment and stock market fluctuations.

To illustrate this, consider the following example where the stock market is temporarily overvalued, so that the return on a marginal investment project, r_I, exceeds the required return on equity, r_E, but the long-run return on equity equals r_I. If managers only care about their existing shareholders, then, as Fischer and Merton (1984) point out, the firm will undertake further investment.

However, suppose that investment is irreversible so that the firm will be stuck with investments which will fail to earn the future long-run required rate of return. In this case, rational managers who are not perfectly controlled by existing shareholders, but fear the possibility of a future takeover, might be deterred from investing today. On the other hand, managers who have some discretion but do not fear future takeovers might still invest today because, surely, this is a way of obtaining "cheap money" in order to further their ambitions for the growth of the firm.[10]

So, in the "cheap money" scenario, we appear to have an example where the absence of hostile takeovers may actually make investment more responsive to share prices. However, this example probably has less relevance to the present international comparison, for although we do not see hostile takeovers in Japan or Germany, managers still run the risk of being replaced as a result of actions initiated by banks. A manager who undertook an investment project just because the market was temporarily overvalued would run the risk of being perceived as being plainly inefficient when the investment turns sour in the future. So, he too would be deterred from responding to the high share price today. Since banks in Japan and Germany probably represent a more direct and tangible disciplinary force than the fear of a future takeover in the Anglo-Saxon world, it seems that even here the stock market will exert a smaller influence in Germany and Japan.[11]

We now turn to consider whether the econometric evidence is consistent with the view that exogenous movements in the stock market are less important in influencing corporate investment decisions in either Japan or Germany.

III. Econometric Evidence

This chapter is primarily interested in whether exogenous changes in stock prices affect investment. Therefore, the approach will be to assess whether share prices provide any additional explanatory power for investment, once we have controlled for the conventional determinants of investment - e.g. output, interest rates, taxes etc. Estimates of a simple investment - Q relationship are not reported here, because it does not, of itself, answer the question that is of interest. One may, after all, observe a positive relationship between investment and Q which disappears once output or some other variable has been entered in the regression.[12]

As a preliminary to examining the formal econometric evidence, and following on the analysis of Chapter IV above, Table 4 presents some simple correlations between I/K and Q. At first glance, the numbers are actually higher for Germany and Japan over the entire period. However, a division of the sample to account for the recent international bull market in equities shows that the correlations in these two countries are actually negative after 1979. Such instability indicates that the I/K and Q correlation is probably not structural and may arise from the fact that other relevant determinants of investment are omitted here. For this reason, the next section examines a model of investment where Q is only one of many possible explanatory factors.

IIIa. The Basic Model

There is a huge literature on investment equations, but for our purposes we shall use a modified version of the flexible capital stock adjustment model developed by Jorgenson (1963), and used by many others, as the test-bed. Of course, this model is not without its problems (for an extensive discussion of them, see, e.g., Nickell (1978)). The model specifies the profit-maximising level of the capital stock,

$$(1) \qquad K^* = \phi(C/P, Y) \qquad \phi_{C/P}' < 0, \phi_Y' > 0$$

where C is the annual cost of capital, P is the price of output and Y is the level of output. Assuming that investment is subject to delivery and installation lags, and that the existing capital stock decays at the depreciation rate δ,

$$(2) \qquad I_t = \sum_{j=0}^{T} w_j(K^*_{t-j} - K^*_{t-j-1}) + \delta K_{t-1}$$

where I_t is gross investment and K_{t-1} is the level of the capital stock.

The modification to the model made here is to assume that managers maximise profits net of expected bankruptcy costs, and so the desired level of the capital stock (K^*) will depend on variables that affect the probability of bankruptcy.[13]

Assume that firm i finances its capital stock by, in part, borrowing a sum of money which has to be repaid with interest at the end of the first period; denote the total sum to be repaid as D_i. However, because the return to this investment is uncertain, there is some risk that the firm will not make sufficient profits to meet its commitments, a situation where profits (π_i) are less than D_i - of course, π_i depends on I. Assume also for simplicity that the liquidation value of the capital stock is zero, possibly because it is highly product-specific. Denote the value of the firm if it stays in existence by V_i.

Now, suppose at the end of the period it becomes clear that $\pi_i + V_i < O$. Then, in a complete information world, shareholders and bondholders will wish to wind up the business. Although this may be the optimal course from the point of view of the shareholders and bondholders, it is possible that managers might not prefer this outcome, and hence the initial investment decision may be partially conditioned by its effect on the probability that $\pi_i + V_i < O$.

In addition, in a world with asymmetric information, where shareholders know the true value of the firm but bondholders do not, bankruptcy may also occur when $V_i > O$, but $\pi_i + V_i < D_i$, where π_i denotes the actual profit for the year (see, on this, Webb (1987)). This occurs because bondholders are imperfectly informed about whether or not $V_i > 0$, and may find it worthwhile to force the firm into bankruptcy in an attempt to discover the true state of affairs.

So, to summarise, bankruptcies seem to occur when $\pi_i + V_i < 0$ or when $\pi_i + V_i < D_i$. Rescaling by K_i, a high V_i/K_i, low D_i/K_i, or high π_i/K_i all make bankruptcies less likely.

Now, for the purposes of the analysis here, it is assumed that the investment decision affects profits but, for simplicity, managers take D_i/K_i and V_i/K_i as fixed.[14] Therefore, we have

$$K^* = \Phi(D/K, V/K, C/P, Y) \qquad (3)$$
$$\phi_{D/K}', \phi_{C/P}' < 0; \phi_{V/K}', \phi_Y' > 0$$

instead of Equation (1). So, the optimal level of the capital stock may be influenced by the conventional variables, the debt ratio and Tobin's Q (defined as V/K). Further, as a practical matter, banks may look at book values of debt and equity, in addition to market values; therefore, the debt-equity ratio at book value (BDE) will be included in Equation (3). The modified framework used here accommodates the Q theory and the Jorgensonian cost of capital approach as special nested cases.

The cost of capital term (in the absence of taxes, for the moment) is

$$C = P_I (R + \delta) \qquad (4)$$

where P_I is the price of investment goods and R denotes the cost of funds. The empirical proxy used for R varies considerably across studies. For example, Hall and Jorgenson (1967) use a fixed nominal interest rate, Gorden and Jorgenson (1976) use the after-tax interest rate on long-term bonds, while Feldstein (1982) uses a weighted average cost of capital measure,

(5) $$C = \left\{\frac{D}{E+D}\right\}r_D + \left\{\frac{E}{E+D}\right\}r_E$$

where r_D is the real interest rate on debt and r_E is the real return on equity.

The appropriate way of measuring the cost of capital is, therefore, a controversial area and, since the purpose of this chapter is to determine the effect of the stock market on investment, it would be unwise to overly restrict the definition of the cost of capital.[15] Instead,

(6) $$C/P = \Theta(r_D, r_E, D/V, P_I/P)$$

here, where $V = D + E$, and each element is entered separately into the investment equations.

Finally, an implication of the foregoing analysis is that the debt-capital ratio, D_i/K_i, only affects the probability of bankruptcy if bondholders know less about the firm than shareholders. Since banks have especially close links with firms in Japan and Germany, it is unlikely that the probability of bankruptcy would be influenced by the debt-equity ratio - indeed, Corbett (1987) argues that the active role played by Japanese banks when firms experience financial distress implies that what " ... goes by the name of debt in Japan appears to have many features of the equity relationship".[16] This then implies that rises in debt-equity ratios should not lead to higher financial risk and lower investment in Germany or Japan (unlike the Anglo-Saxon countries) - this is something that will be tested empirically below.

IIIb. Estimated Model, Methodology, Data and Results

Having allowed for the existence of adjustment costs, habit persistence and decision lags, the regression equation takes the form:

$$\text{(7)} \qquad \begin{aligned} \alpha_1(L)\, I/K_t = {} & \alpha_2 + \alpha_3(L)\, dY_t + \alpha_4(L)\, r_{Dt} \\ & + \alpha_5(L)\, r_{Et} + \alpha_6(L)\, D/E_t + \alpha_7(L)\, BDE_t \\ & + \alpha_8(L)\, Q_t + \alpha_9(L)\, P_I/P_t \end{aligned}$$

where all variables have been defined previously, with details regarding sources and construction provided in Appendix III.

An issue of some importance is that the coefficients in Equation (7) are unlikely to be structural in nature because they reflect, in part, expectational considerations. Simultaneity bias may arise because of the absence of valid instruments and the 'Lucas critique' implies that the coefficients may be unstable over time. Sims (1980) recommends a shift to atheoretical VARs to address these problems. Unfortunately, such an approach precludes interpreting the estimated coefficients and, in any case, relies on a priori exclusion restrictions with regard to the appropriate right hand side variables.[17]

A more traditional estimation approach is, therefore, followed in the analysis below. The issue of simultaneity bias is resolved by relying on 'approximate identification', where variables are excluded from the equation on the grounds that they do not matter in a statistically significant fashion. Sargan's (1958) test of over-identifying restrictions is used to test for this directly. The 'Lucas critique' is a common problem for this approach and VARs alike, and is tested by employing Chow tests for structural break.

This treatment of expectations still means that any statistically significant relationship between investment and the stock market could be proxying for future expectations and may, therefore, lack a structural basis. If it is true, however, that the stock market matters in Anglo-Saxon countries but not in Japan or Germany, then this would be consistent with the market playing a structural role in the former pair of countries. The reason for such a conclusion is that the market should be significant for all four countries if it is acting as a proxy for expectations, and not just for the U.K. and the U.S. alone.

Equation (7) was estimated for all four countries. Initially, because of the dangers of overparameterisation of the equations, 7(L) and 9(L) were set to zero, and preferred versions of Equation (7) were obtained. Having done so, the excluded variables were added in turn. Recall that we are primarily interested in whether the stock market matters, i.e. in whether r_E, D/E or Q are significant - and are indifferent between which of these actually matters.

The preferred versions of equation (7) for the four countries are reported in Tables 5, 7, 9 and 11. These equations suggest some support for the basic hypothesis that the equity market directly affects investment in the U.S. and U.K. but not in Germany or Japan. Specifically, the stock market affects investment through the terms in r_{Et-1} and D/E_t in the U.K., while in the U.S., the stock market "matters" because of the $d(D/E)_{t-1}$ term.

Turning to the United Kingdom and Table 5 first, one sees that various cost of capital elements are statistically significant, as well as the accelerator (output) terms. The equation is reasonably well specified, with a Lagrangian Multiplier test against an AR(2)/MA(2) error term (denoted AR(2) here) suggesting no evidence of residual autocorrelation, while a mid-sample Chow test fails to reject the null hypothesis of coefficient stability. As well, the instrumental variable estimates of the preferred equation are quite similar to the OLS estimates; Sargan's test of over-identifying restrictions is also satisfied. Finally, it is interesting to note that a decline in the stock market which causes the debt-equity ratio to rise by 10% reduces I/K by 2.1% in the long run.

As noted in Table 6, neither tax adjusted nor non tax adjusted Q variables are statistically significant factors when added to the preferred investment equation. Even though Chapter IV demonstrated that Q is correlated to investment, it appears that this results from the exclusion of other relevant explanatory variables. It will be seen below that this conclusion holds for the other countries as well.

A number of other variables were added to the U.K. investment equation in Table 5. The cost of capital was entered as a single entity, rather than using its separate components as in the preferred specification. As seen in Table 6, this variable adds no additional explanatory power. Another variable which is considered is the level of the real money supply, as suggested by Gordon and Veitch (1987). Again, there is no additional explanatory power.

Finally, the effect of takeover activity on investment is considered in Table 6. As argued above, one possible reason for the influence of the stock market on investment is the role of hostile takeovers. Therefore, one might expect managers to pay more attention to stock prices when takeover activity is high. The ratio of the value of acquisitions to the capital stock is interacted with the two equity terms in the preferred equation to test for a positive influence between investment and takeover activity via the stock market. While the estimated coefficient has the anticipated sign, it is nevertheless statistically insignificant at conventional levels.

The U.S. results in Tables 7 and 8 show that accelerator and equity terms are significant factors in explaining investment, although none of the individual cost of capital elements remain in the equation. Like the results for the U.K., Tobin's Q, the integrated cost of capital term, the level of real money supply and the takeover interaction variables are not significant; in some cases, these variables are also incorrectly signed. The preferred equation is properly specified, according to the Chow and AR(2) test statistics, and the instrumental variable estimates are very close to the OLS coefficient estimates.

The preferred equations in Tables 9 and 11 for West Germany and Japan are rather similar. Both include accelerator terms and the real long term interest rate but neither show any stock market effect. As before, these equations do not exhibit structural break or autocorrelated residuals; they also have very similar OLS and IV coefficient estimates and satisfy the Sargan test for over-identification.

The German equity market terms (D/E, r_E and Q) are almost uniformly of the wrong sign and are all statistically insignificant. This is also the case for Japan, with the exception of d(Q). Even though the three Q terms are collectively insignificant at the 5% level, a further test was undertaken to test the robustness of d(Q) in Japan. Following Hayashi (1985), who argues that the relationship between Q and I/K appears to have broken down after 1974, d(Q) and Q_{t-2} were interacted with an appropriate dummy variable. The results shown in Table 12 support the exclusion of these variables from the preferred equation, as does the switch in sign of the post-1979 simple I/K and Q correlation shown in Table 4.

Overall, these results are rather supportive of the view that the stock market has a direct effect on investment in the two Anglo-Saxon economies, but not in Germany or Japan.[18] Accelerator terms are the dominant determinants of investment and individual cost of capital elements are also important. Q is not important in any country, supporting the possibility that its significance as a lone explanatory factor in investment equations is due to the exclusion of other relevant variables. In this regard, the track record of Q as an explanatory variable is shown clearly in Table 13 where it is simultaneously the worst and the best of the elements under examination.

Finally, it is also of some interest that the debt-equity ratio affects investment in the U.S. and U.K. but not in Germany or Japan. This is consistent with the fact that banks have a closer relationship with firms in Germany and Japan, implying that bankruptcy risk need not rise with the debt-equity ratio.

IIIc. Some 'Non-Structural' Evidence

Thus far, evidence has been presented based on structural investment equations. However, many economists now prefer atheoretical VARS, so, in Table 14, some evidence is given on the effect of real share prices on output in each of the four countries.

The log of output is regressed on two lags of itself and lagged values of a host of other variables including the interest rate, inflation, competitiveness, real government expenditure, the real money supply and world trade. When the insignificant variables are deleted, one finds that the stock market has a positive and statistically significant effect on output in the U.S. and U.K., and no effect in Japan.[19] In Germany, the stock market exerts a negative effect on output (if these estimates are interpreted literally). In general, the coefficients of the restricted equations are sensible for all of the countries, aside from the positive effect of lagged inflation on output in West Germany.

So, the non-structural evidence is also consistent with one basic message - the stock market matters less in Germany and Japan than in the Anglo-Saxon countries.

IV. Conclusions and Implications

The fact that the stock market appears to affect investment less in Germany or Japan compared to the Anglo-Saxon countries may, in fact, have some important implications.

For example, there is some evidence that share prices in the post-World War II period fell due to 'irrational' valuation errors produced under inflationary circumstances (see e.g. Modigliani and Cohn (1979)). The stock market then acts as a channel through which higher inflation reduces investment in the U.S. and the U.K.. Table 15 shows that output and inflation are more negatively correlated in the Anglo-Saxon countries, which is consistent with, but not necessarily evidence of, a causal link from inflation to equity prices, and hence to investment and output.

Similarly, if the stock market is myopic, such "short-termism" is less likely to be translated into actual investment decisions in Japan and Germany, and this may partly explain their higher investment rates (shown in Table 16).

Finally, if the stock market exercises less control over corporate investment decisions, managers may pursue a goal of higher growth, even at the cost of profit maximisation. It has already been shown in Table 1 that Japanese managers assign a higher priority to growth-like objectives than their American counterparts. This manifests itself in the fact that the rate of return of capital in Japan is very low by international standards and is less than half the cost of capital (see Table 17). For Japan, the null effect of the stock market on investment may explain Hardie's (1982) observation that "... it remains one of the oddities of modern Japan that profit-making is neither in fact nor in ideology a critical part of what business and commerce are for."

As for the theory of investment, this chapter has presented a framework within which Tobin's Q is only one of several possible relevant variables. Moreover, empirically, it appears to have little additional explanatory power once other relevant variables like output and interest rates are included. As in previous chapters, the importance of institutional differences across countries highlights the notion that stock prices are influenced by more than the expectations and outturns of economic variables.

Appendix III: Four Country Data Sources

1. **K** - replacement cost of net capital stock for private sector.

K definition matches that for I below. In the case of Japan, a K series was generated using the 1956 K value found in Hayashi (1985), a depreciation rate of .089 and the I series. The resulting series correlated well with other estimates from the OECD and the Japanese Economic Planning Agency.

private sector:
U.S. non-financial corporations (NFC)
U.K. industrial and commercial companies (ICC)
JA private sector
GE company sector

2. **I** - investment.

U.S. NFC non-residential equipment and structure
U.K. ICC gross domestic fixed capital formation (GDFCF)
JA private sector GDFCF
GE company sector assets net of inventories

source:
U.S. Survey of Current Business
U.K. Blue Book
JA Bank of Japan Economic Statistics Monthly
GE Statistical Yearbook (Statistisches Jahrbuch, Bundesanstalt für Statistik)

3. **Q** - private sector tax-adjusted (TQ) and non-tax-adjusted (NTQ). NTQ is defined as the value of debt and equity divided by K. All three elements are at market or replacement cost, with the exception of debt in Germany, the U.K. and the U.S..

The debt and equity components are outlined as follows: for Japan, NTQ was calculated using spliced series from Holland (1984) and Hayashi (1985). For Germany, NTQ was formed using data from Holland (1984) and the Bundesbank. For the U.K., NTQ was calculated using data supplied by E. Dinenis and updated by splicing data from the Bank of England. TQ is the QR measure from Poterba and Summers (1983). For the U.S., data from Holland (1984) was updated using information from the Survey of Current Business. TQ is the series from Summers (1981).

4. r_E - dividend yield plus three-year moving average of real growth in dividends.

source:
U.S. S&P 500 Index (Survey of Current Business)
U.K. FT 500 Index (Financial Statistics)
JA, GE - Goldman, Sachs & Co.

5. **DOK** - value of debt divided by K.

6. **D/E** - as above divided by market value of equity.

7. r_D - government bond yield (long interest rate) - IMF International Financial Statistics (IFS hereafter).

8. P_I - investment deflator (IFS).

9. **P** - GDP deflator (IFS).

10. **C** - cost of capital:

U.S.:

$$C = \frac{1-z-k}{1-\tau}\left[\frac{D}{E+D}(i-\Pi) + \frac{E}{E+D}\frac{DIV}{P} + \delta_{US}\right]$$

U.K.: $$C = \frac{1-z-k}{1-\tau}\left[\frac{D}{E+D}(i-\Pi) + \frac{E}{E+D}\frac{DIV}{P} + \delta_{UK}\right]$$

JA: $$C = \frac{(1-z)P_I}{(1-\tau)P}\left[(1 + i)\frac{P_I}{P_{I_{t+1}}} - 1 + \delta_{JA} - X_1\right]$$

GE: $$C = X_2(i + \delta_{GE} - \frac{d(P_I)}{P_I})$$

where

z - discounted present value of depreciation allowances per unit of investment

k - tax credit per unit of investment

D - value of debt

E - value of equity

i - nominal interest rate

DIV/P - dividend price yield

δ - depreciation rate

π - inflation rate

P_I - investment price

P - output price

τ - corporate tax rate

X_1 - Japanese tax term dealing with reserves:

$$X_1 = \frac{\tau i}{(1-\tau z)(1+i)}\frac{R}{aK}$$

where

R - tax-free reserves

aK - nominal capital stock

z - P.V. of depreciation allowances in new investment

X_2 - German combined tax term including income tax, franchise tax, property tax and land tax. Tax laws are not investment neutral, therefore $X_2 > 1$.

1. See King (1977) for an extensive discussion of these issues.

2. Walker (1985) and Nickell and Wadhwani (1987).

3. See Nikkei (1984).

4. Note, however, that managers cannot ignore shareholders altogether since the latter may exert some influence through the *possibility* of take-over bids. While the fear of takeover will not necessarily induce share price maximisation (as the production plan which maximises the share price is not the same as that which minimises the risk of being taken over - see King (1977)), it will at least ensure that managers do not entirely ignore the wishes of shareholders.

5. Similarly, substantial cross holdings of corporate equity in Japan are used to reinforce long-term business relationships and are rarely traded on the market. The oligopolistic nature of brokerage in Japan, where four large firms dominate the market, and the substantial influence of German universal banks on the German equity markets, are other factors which may drive a wedge between stock price fluctuations and corporate behaviour in these countries.

6. Since the 1976 Co-determination Act, all corporations employing more than 2000 workers must have a supervisory council with 50 per cent representation of employee representatives.

7. The differences in the Table 3 ratios across countries are substantial and cannot be explained away by divergent accounting practices in each country (see Kuroda and Oritani (1980) on this issue). Corbett (1987) and BEQB (1984) offer detailed comparisons of financing practices in the four countries under study here.

8. Carsberg and Hope (1976), for example, found that only 21 percent of respondents allowed movements of the equity market to influence their choice of discount rate. Moreover, a majority of these respondents were only influenced by some smoothed return on equity measure. In the sample as a whole (including those who did not look at the equity market), over half had not even altered their discount rate in the preceding three years - this, in a period (1971-1973) when the earnings yield had varied between 4.95% and 11.55%.

9. See 3i Enterprise Barometer.

10. I am grateful to Stanley Fischer for making this point.

11. Of course, all this is predicated on firms in Germany and Japan continuing to be so dependent on their banks. See Mayer (1988) for an exploration of this and related issues.

12. As Chapter IV noted, traditional static Q regressions manifest various signs of misspecification - parameter instability, serial correlation and the like. In addition, as will become clear below, the Q terms do not survive the introduction of other relevant terms.

13. Such models are now commonly used (see Greenwald and Stiglitz (1987) or Wadhwani (1987) and references therein). Since costly bankruptcy does not occur in a

world with complete information and rational agents, as in Haugen and Senbet (1978), an assumption of missing markets is also needed to motivate the presence of bankruptcy.

14. It might seem somewhat curious that V_i is fixed when the manager is maximising π_i, for, under the Efficient Markets Hypothesis, the two are intimately related. However, this analysis is conducted on the premise that managers do not believe the EMH to the extent that it influences their own firm's share price - this assumption is amply supported by the empirical evidence. So, instead, managers just view V_i as a constraint on their behaviour.

15. See Auerbach (1983) for a survey of these issues.

16. Corbett (1987), p.54.

17. In any case, the available degrees of freedom in the data would not support VARs of sufficient size to include numerous variables and lags.

18. The results are also, broadly speaking, in accordance with the work using micro-data of Blundell et al (1987) and Hayashi and Inoue (1987).

19. The lagged output term in the Japanese restricted equation is constrained to a value of unity. This is done because the estimated coefficient in the general specification is greater than one, implying that output is oscillating away from a long-term equilibrium value over time. This constraint has no qualitative effect on the value or significance of the estimated real share price variable coefficients.

Table 1

RELATIVE IMPORTANCE OF MANAGERIAL GOALS

GOALS	U.S.A.	JAPAN
Return on investment	2.43	1.24
Capital gain for stockholders	1.14	0.02
Increase in market share	0.73	1.43
Efficiency of logistic activities	0.46	0.71
New product ratio	0.21	1.06
Public image of the company	0.05	0.20
Quality of working conditions	0.04	0.09
Equity/debt ratio	0.38	0.59
Improvement of product portfolio	0.50	0.68

Source: Kagono et.al. (1984)

Table 2

THE RELATIVE SIZE OF THE QUOTED SECTOR

	West Germany	Japan	U.K.	U.S.A.
Number of listed companies (in 1986)	492	1499	2101	6437*
Market capitalisation as a % of GDP (1986)	25.7%	87.8%	85.1%	75.6%
Market capitalisation as a % of private sector net capital stock (1986)	6.7%	59.0%	46.7%	39.9%

Sources: International Federation of Stock Exchanges Annual Report (various years), Federation of the German Stock Exchanges Annual Report 1986, IMF International Financial Statistics, capital stock sources listed in the data appendix.

* - figure for the U.S. is for 1985.

Table 3

SOME ESTIMATES OF COMPARATIVE GEARING RATIOS

	U.S.A.	U.K.	JAPAN	GERMANY
Book value				
Corbett (1987) for 1981	0.37	0.54	0.83	n.a.
BEQB (1984) for 1982	n.a.	0.25	n.a.	0.60
a) 1965-78 Average*	0.35	n.a.	0.70	0.65
Market value				
Corbett (1987)	0.30	n.a.	0.56	n.a.
b) 1965-80 Average*	0.27	0.10	0.53	0.46

* Authors' calculations. The ratios shown are

a) book value of debt to book value of debt and equity

b) book value of debt to book value of debt and market value of equity

Table 4

CORRELATIONS BETWEEN (I/K) AND Q

COUNTRY	WHOLE SAMPLE	PRE-1979	POST-1979
GERMANY	0.80	0.77	-0.32
JAPAN	0.69	0.56	-0.38
U.K.	0.50	0.45	0.39
U.S.	0.60	0.59	0.23

Table 5

INVESTMENT EQUATIONS FOR THE U.K., 1955-86

Dependent Variable: $(I/K)_t$

INDEPENDENT VARIABLES	OLS	IV
$(I/K)_{t-1}$	0.63 (6.78)	0.65 (6.36)
$\Delta \ln Y^*_t$	20.84 (5.18)	15.29 (2.27)
$\Delta \ln Y_{t-1}$	17.17 (4.03)	15.76 (3.26)
$\Delta \ln Y_{t-2}$	20.83 (3.54)	17.47 (2.18)
$r_{D,t-2}$	-0.16 (-3.80)	-0.13 (-2.39)
$(D/E)^*_t$	-6.16 (-2.46)	-6.45 (-1.78)
$\Delta r_{E,t-1}$	-0.06 (-3.56)	-0.05 (-2.57)
$\Delta\left(P_I/P\right)_t$	-12.03 (-2.92)	-9.20 (-1.86)
$\left(P_I/P\right)_{t-2}$	-9.46 (-3.38)	-8.63 (-2.66)
Constant	11.56 (3.66)	10.86 (3.05)
R^2	0.887	-
CHOW F	1.71 ($F_{0.05}(10,12)=2.75$)	-
AR(2)	3.39 ($\chi^2_{0.05}(2)=5.99$)	-
SARGAN TEST	-	10.71 ($\chi^2_{0.05}(6)=12.59$)

Notes:

(i) t-ratios in parentheses

(ii) * - denotes variables treated as endogenous. Additional instruments used are two lags of world manufacturing output, world trade, world trade in manufacturing, debt-equity ratio.

Table 6

RESULTS OBTAINED BY ADDING VARIOUS VARIABLES TO THE U.K. INVESTMENT EQUATION

Adding Non-tax adjusted 'Q':

Q_t	-0.32	(-0.64)
Q_{t-1}	-0.27	(-0.39)
Q_{t-2}	-0.24	(-0.41)
	$F(3, 19) = 1.13$	$(F_{0.05}(3, 19) = 3.13)$

Tax-adjusted 'Q':*

TQ_t	-0.02	(-0.15)
TQ_{t-1}	0.17	(1.37)
TQ_{t-2}	-0.09	(-0.70)
	$F(3, 19) = 0.68$	$(F_{0.05}(3, 14) = 3.13)$

Tax-adjusted Cost of Capital

TCC_t	-1.93×10^{-2}	(-1.21)
TCC_{t-1}	1.90×10^{-1}	(1.30)
TCC_{t-2}	-1.78×10^{-1}	(-1.16)
	$F(3, 13) = 0.98$	$(F_{0.05}(3, 13) = 3.41)$

Real Money Supply

$(M1/P)_t$	3.18×10^{-5}	(0.90)
$(M1/P)_{t-1}$	1.44×10^{-5}	(0.24)
$(M1/P)_{t-2}$	-1.04×10^{-5}	(-1.57)
	$F(3, 19) = 1.71$	$(F_{0.05}(3, 19) = 3.13)$

Takeover Activity:**

$(A/K)_t(P/E)_t$	-67.33	(-1.18)
$(A/K)_{t-1}\Delta r_{E,t-1}$	-1.35	(-1.12)
	$F(2, 18) = 0.80$	$(F_{0.05}(2, 18) = 3.55)$

Notes:

(i) t-ratios in parentheses

(ii) * denotes only available over 1955-80
** denotes only available over 1955-84

Table 7

ESTIMATED INVESTMENT EQUATION FOR THE U.S., 1953-1986

Dependent Variable: $(I/K)_t$

INDEPENDENT VARIABLES	OLS ESTIMATES	IV ESTIMATES
$(I/K)_{t-1}$	0.75 (11.09)	0.75 (11.00)
$\Delta \ln Y^*_t$	18.26 (7.81)	16.99 (4.70)
$\Delta \ln Y_{t-1}$	10.05 (4.20)	9.99 (4.22)
$\Delta(D/E)_{t-1}$	-4.16 (-3.12)	-4.18 (-3.01)
R^2	0.898	-
CHOW	0.71 ($F_{0.05}(5,24)=2.62$)	-
AR(2)	1.58 ($\chi^2_{0.05}(2)=5.99$)	-
SARGAN TEST	-	6.58 ($\chi^2_{0.05}(6)=12.99$)

Notes:

(i) t-ratios in parentheses

(ii) * denotes variables treated as endogenous

(iii) Additional instruments used: two lags each of world trade, world output, world trade in manufacturing, and $\Delta \ln Y_{t-2}$.

(iv) Regressions include a constant term.

Table 8

RESULTS OBTAINED BY INCLUDING ADDITIONAL VARIABLES IN THE U.S. INVESTMENT EQUATION

Adding r_e:

r_{e_t}	1.7×10^{-3}	(0.11)
$r_{e_{t-1}}$	-3.4×10^{-3}	(-0.20)
$r_{e_{t-2}}$	1.10×10^{-3}	(0.71)

$F(3, 26) = .303 \quad (F_{0.05}(3, 26) = 2.98)$

Adding (Debt-Capital) ratio:

$(D/K)_t$	-2.28	(-0.82)
$(D/K)_{t-1}$	-4.51	(-0.78)
$(D/K)_{t-2}$	3.82	(0.94)

$F(3, 26) = 1.221 \quad (F_{0.05}(3, 26) = 2.98)$

Adding Q:

Q_t	0.15	(0.35)
Q_{t-1}	0.47	(0.64)
Q_{t-2}	-0.68	(-1.19)

$F(3, 26) = 0.54 \quad (F_{0.05}(3, 26) = 2.98)$

Adding Tax-adjusted 'Q':

TQ_t	0.27	(1.09)
TQ_{t-1}	-0.10	(-0.38)
TQ_{t-2}	-0.22	(-1.28)

$F(3, 18) = 0.98 \quad (F_{0.05}(3, 18) = 3.16)$

Table 8 (contd.)

Adding Interest Rate:

r_{D_t}	2.65×10^{-3}	(0.04)
$r_{D_{t-1}}$	2.08×10^{-3}	(0.03)
$r_{D_{t-2}}$	3.98×10^{-3}	(0.09)

$F(3, 26) = 0.03 \quad (F_{0.05}(3, 26) = 2.98)$

Adding Real Money Supply:

$(M1/P)_t$	-7.2×10^{-3}	(-1.88)
$(M1/P)_{t-1}$	1.5×10^{-2}	(1.63)
$(M1/P)_{t-2}$	-9.63×10^{-3}	(-1.38)

$F(3, 26) = 1.49 \quad (F_{0.05}(3, 26) = 2.95)$

Adding Tax-adjusted Cost of Capital:*

TCC_t	5.64×10^{-2}	(1.44)
TCC_{t-1}	-5.18×10^{-2}	(-0.99)
TCC_{t-2}	4.18×10^{-2}	(1.38)

$F(3, 20) = 1.37 \quad (F_{0.05}(3, 20) = 3.10)$

Adding Takeover Influences:

$(A/K)_{t-1}\Delta(P/E)_{t-1}$	0.61 (0.16)

Notes:

(i) t-ratios in parentheses

(ii) * denotes 1953-80 only

Table 9

ESTIMATED INVESTMENT EQUATION FOR WEST GERMANY, 1961-1986

Dependent Variable: $(I/K)_t$

INDEPENDENT VARIABLES	OLS ESTIMATES	IV ESTIMATES
$(I/K)_{t-1}$	0.81 (26.08)	0.81 (23.06)
$\Delta \ln Y^*_t$	14.41 (8.15)	13.00 (5.16)
$r_{D,t}$	-7.1×10^{-2} (-2.69)	-7.2×10^{-2} (-2.37)
R_2	0.982	-
CHOW	1.41 $(F_{0.05}(4,18) = 2.93)$	-
AR(2)	4.21 $(\chi^2_{0.05}(2)=5.99)$	-
SARGAN TEST	-	7.14 $(\chi^2_{0.05}(6)=12.59)$

Notes:

(i) t-ratios in parentheses

(ii) * denotes variables treated as endogenous

(iii) Additional instruments used: two lags of interest rate, world manufacturing output, world trade, world trade in manufactures

(iv) Regression includes a constant term.

Table 10

RESULTS OBTAINED BY INCLUDING ADDITIONAL VARIABLES IN THE GERMAN INVESTMENT EQUATION

Adding Debt-equity Ratio at Market Value: (Sample: 1962-1985)

$(D/E)_t$	0.12	0.72
$(D/E)_{t-1}$	0.05	(0.24)
$(D/E)_{t-2}$	-0.32	(-1.40)

$F(3, 17) = .690 \quad (F_{0.05}(3, 11) = 3.20)$

Adding Q: (Sample: 1962-1985)

Q_t	-2.04	(-0.75)
Q_{t-1}	1.37	(0.40)
Q_{t-2}	1.64	(0.56)

$F(3, 17) = 0.323 \quad (F_{0.05}(3, 17) = 3.20)$

Adding r_E: (Sample: 1965- 1986)

r_{E_t}	1.14×10^{-2}	(1.25)
$r_{E_{t-1}}$	1.68×10^{-2}	(1.80)
$r_{E_{t-2}}$	3.42×10^{-3}	(0.32)

$F(3, 15) = 2.17 \quad (F_{0.05}(3, 15) = 3.29)$

Adding TCC: (Sample 1963-1981)

TCC_t	6.38×10^{-2}	(0.55)
TCC_{t-1}	-2.54×10^{-2}	(-0.24)
TCC_{t-2}	-1.44×10^{-2}	(-0.16)

$F(3, 12) = 0.119 \quad (F_{0.05}(3, 12) = 3.49)$

Adding Real Money Supply: (Sample: 1961-1986)

$(M1/P)_t$	-6.1×10^{-2}	(-1.04)
$(ML/P)_{t-1}$	3.19×10^{-4}	(0.04)
$(M1/P)_{t-2}$	4.23×10^{-3}	(0.67)

$F(3, 19) = 0.57 \quad (F_{0.05}(3, 19) = 3.13)$

Adding Debt-Capital Ratio (Accounting values): (Sample: 1962-1985)

$(D/K)_t$	0.72	(0.03)
$(D/K)_{t-1}$	0.53	(0.01)
$(D/K)_{t-2}$	-15.77	(-0.69)

$F(3, 17) = 0.87 \quad (F_{0.05}(3, 17) = 3.20)$

Note: t-ratios in parentheses

Table 11

ESTIMATED INVESTMENT EQUATION FOR JAPAN, 1954-1986

Dependent Variable: $(I/K)_t$

INDEPENDENT VARIABLES	OLS ESTIMATES	IV ESTIMATES
$(I/K)_{t-1}$	0.76 (8.02)	0.72 (6.77)
$(I/K)_{t-2}$	-0.24 (-2.74)	-0.23 (-2.54)
$\Delta \ln Y_t$	62.68 (9.86)	71.64 (7.83)
r_{D_t}	-0.20 (-3.55)	-0.21 (-2.76)
R^2	0.960	-
CHOW	2.32 $(F_{0.05}(5,23)=2.64)$	-
AR(2)	1.65 $(\chi^2_{0.05}(2)=5.99)$	-
SARGAN	-	3.78 $(\chi^2_{0.05}(8)=15.51)$

Table 12

RESULTS OBTAINED BY INCLUDING ADDITIONAL VARIABLES IN THE JAPANESE INVESTMENT EQUATION

Adding (D/E) at market value: (Sample: 1958-1985)

$(D/E)_t$	-0.28	(-0.26)
$(D/E)_{t-1}$	0.51	(0.34)
$(D/E)_{t-2}$	0.40	(0.34)

$F(3, 20) = 0.33 \quad (F_{0.05}(3, 20) = 3.10)$

Adding Q: (Sample: 1958-1985)

Q_t	3.52	(1.35)
Q_{t-1}	-5.99	(-1.86)
Q_{t-2}	-0.75	(-0.29)

$F(3, 20) = 2.29 \quad (F_{0.05}(3, 20) = 3.10)$

Adding Q + (dummy Q):

ΔQ_t	3.44	(1.44)
Q_{t-2}	0.14	(0.06)
$\Delta Q_t \times D$	-0.81	(-0.11)
$Q_{t-2} \times D$	-3.54	(-2.03)

Adding Debt-capital Ratio:

$(D/K)_t$	8.42	(0.95)
$(D/K)_{t-1}$	-10.24	(-1.04)
$(D/K)_{t-2}$	6.44	(0.87)

$F(3, 20) = 0.66 \quad (F_{0.05}(3, 20) = 3.10)$

Adding Tax-adjusted Q: (Sample: 1958-1981)

TQ_t	0.44	(1.11)
TQ_{t-1}	-0.47	(-0.95)
TQ_{t-2}	-0.12	(-0.29)

$F(3, 16) = 0.89 \quad (F_{0.05}(3, 16) = 3.24)$

Table 12 (contd.)

Adding Tax-adjusted Cost of Capital: (Sample: 1958-1981)

TCC_t	44.03	(0.90)
TCC_{t-1}	-9.61	(-0.17)
TCC_{t-2}	-34.22	(-0.80)

$F(3, 16) = 0.49$

Adding Real Money Supply: (Sample: 1961-1986)

$(M1/P)_t$	5.1×10^{-5}	(1.01)
$(M1/P)_{t-1}$	-8.8×10^{-5}	(-1.16)
$(M1/P)_{t-2}$	7.3×10^{-5}	(1.21)

$F(3, 18) = 1.47$ $(F_{0.05}(3, 18) = 3.16)$

Source	Cost of Capital	Accelerator	Liquidity	Q	Other
1) Jorgenson and Siebert (1968)	1	2	2/3	-	4
2) Jorgenson et al (1970)	2	3	3/6	5	1/4
3) Bischoff (1971)	3	2	3	3	1
4) Gould and Waud (1973)	2	-	-	-	1/3
5) Engle and Foley (1975)	3	2	5	1/5	4
6) Kopcke (1977)	2	1	3	-	4
7) Clark (1979)	2	1	-	-	2/3
8) Jenkinson (1981)	2	3	-	1	-
9) Hendershott and Hu (1981)	2	1	-	3	1
10) Oulton (1981)	2	3	-	1	4/5
11) Kopcke (1982)	4	2	3	3	1
12) Kopcke (1985)	2	3	1	3	3
13) Mullins and Wadhwani (1989)	2	1	-	4	3

Table 13: Explanatory Factors in Investment Equations

Note: All papers examine the U.S. with the exception of Jenkinson and Oulton for the U.K. and Mullins and Wadhwani for four OECD countries. The rankings diminish in importance from 1 to n, where n is the number of different models that are compared in a particular paper; '-' indicates that the category was not used in the comparison. The 'other' category includes autoregressive models of investment, hybrid measures incorporating elements from the accelerator and cost of capital frameworks, and real money balances. The cost of capital category includes the ranking for each separate subcomponent.

Table 14a The effect of the stock market on output in the US and UK

Dependent variable: ln(Output)$_t$

VARIABLES	U.K. (1)	U.K. (2)	U.S. (3)	U.S. (4)
ln(Output)$_{t-1}$	0.41 (1.65)	0.57 (4.22)	0.44 (1.45)	0.62 (6.79)
ln(Output)$_{t-2}$	0.46 (1.94)	0.51 (3.59)	0.30 (1.08)	
ln(Real Share Price)$_{t-1}$	4.24×10^{-2} (1.93)	3.8×10^{-2}* (2.76) [covers $t-1$ and $t-2$]	5.80×10^{-2} (1.40)	5.80×10^{-2}* (2.27) [covers $t-1$ and $t-2$]
ln(Real Share Price)$_{t-2}$	-2.96×10^{-2} (-1.04)		-6.98×10^{-2} (-1.17)	
(Real Interest Rate)$_{t-1}$	-6.6×10^{-3} (-1.89)	-8.72×10^{-3} (-5.56)	-3.12×10^{-3} (-0.33)	-4.90×10^{-3} (-2.25)
(Real Interest Rate)$_{t-2}$	-1.46×10^{-3} (-0.31)		1.19×10^{-3} (0.13)	
(Inflation)$_{t-1}$	-6.24×10^{-3} (-1.73)	-8.76×10^{-3} (-5.71)	-1.28×10^{-3} (-1.53)	-9.97×10^{-3} (-2.57)
(Inflation)$_{t-2}$	-1.04×10^{-3} (-0.21)		-7.62×10^{-4} (-0.11)	
ln(Competitiveness)$_{t-1}$	3.45×10^{-2} (0.74)		0.245 (0.99)	
ln(Competitiveness)$_{t-2}$	-4.29×10^{-2} (-0.77)		-0.194 (-0.81)	
ln(Real Government Expenditure)$_{t-1}$	0.14 (0.82)		-1.06×10^{-3} (-0.06)	
ln(Real Government Expenditure)$_{t-2}$	-0.15 (-1.04)		1.16×10^{-2} (0.07)	
ln(Real Money Supply)$_{t-1}$	8.48×10^{-2} (1.03)		0.22 (0.85)	0.368* (2.07) [covers $t-1$ and $t-2$]
ln(Real Money Supply)$_{t-2}$	-9.64×10^{-2} (-0.78)		-0.43 (-1.46)	
ln(World Trade)$_{t-1}$	-8.62×10^{-3} (-0.06)		-0.29 (-1.23)	
ln(World Trade)$_{t-2}$	8.59×10^{-2} (0.62)		0.41 (1.69)	0.230 (4.59)
R^2	0.998	0.997	0.998	0.997
D.W.	2.843	2.198	2.771	2.337
Sample period	1953-86	1953-86	1953-86	1953-86
RESTR.F		0.71 $F_{0.05}(11,17)=2.38$		0.70 $F_{0.05}(10,17)=2.45$

Notes: (i) RESTR.F is an F-test of the restricted version against the more general specification

(ii) * denotes the use of Δ, e.g., Δln(Real Share Price)

Table 14b The effect of the stock market on output in Germany and Japan

Dependent variable: $\ln(\text{Output})_t$

VARIABLES	JAPAN (1)	JAPAN (2)	GERMANY (3)	GERMANY (4)
$\ln(\text{Output})_{t-1}$	1.18(4.91)	1.00	0.22 (0.57)	0.38 (4.72)
$\ln(\text{Output})_{t-2}$	0.10(0.30)		-0.08 (-0.23)	
$\ln(\text{Real Share Price})_{t-1}$	1.43×10^{-2} (0.33)	-5.31×10^{-3} (-0.20)	2.99×10^{-3} (0.15)	-4.45×10^{-2} (-4.09)
$\ln(\text{Real Share Price})_{t-2}$	-2.16×10^{-2} (-0.46)	1.60×10^{-2} (0.63)	-4.35×10^{-2} (-2.51)	
$(\text{Real Interest Rate})_{t-1}$	-2.12×10^{-2} (-3.00)	-2.12×10^{-2} (-4.79)	-5.19×10^{-5} (0.01)	
$(\text{Real Interest Rate})_{t-2}$	5.67×10^{-3} (0.89)	2.30×10^{-3} (1.84)	3.23×10^{-3} (1.09)	
$(\text{Inflation})_{t-1}$	-2.07×10^{-2} (-3.17)	-1.99×10^{-2} (-5.14)	7.07×10^{-3} (1.34)	4.93×10^{-3} (2.45)
$(\text{Inflation})_{t-2}$	5.39×10^{-3} (0.85)		2.58×10^{-3} (0.73)	
$\ln(\text{Competitiveness})_{t-1}$	0.18 (1.73)	0.239* (3.29)	9.09×10^{-3} (0.21)	
$\ln(\text{Competitiveness})_{t-2}$	-0.28 (-2.30)		5.04×10^{-2} (0.96)	6.23×10^{-2} (4.33)
$\ln(\text{Real Government Expenditure})_{t-1}$	-0.39 (-1.41)		-0.13 (-0.52)	
$\ln(\text{Real Government Expenditure})_{t-2}$	-0.10 (-0.58)		0.27 (1.86)	0.16 (2.63)
$\ln(\text{Real Money Supply})_{t-1}$	2.24×10^{-2} (0.19)		0.52 (4.40)	0.49 (7.92)
$\ln(\text{Real Money Supply})_{t-2}$	2.21×10^{-2} (0.16)		0.12 (0.77)	
$\ln(\text{World Trade})_{t-1}$	-3.58×10^{-2} (-0.19)		0.18 (1.23)	0.13 (2.21)
$\ln(\text{World Trade})_{t-2}$	-1.03×10^{-2} (-0.04)		-0.21 (-1.55)	-0.21 (-2.91)
R^2	0.999		0.999	0.999
D.W.	1.95	1.66	2.35	2.03
Sample period	1953-86	1953-86	1953-86	1953-86

Notes: As Table 14a

Table 15

RELATIVE EFFECTS OF INFLATION ON OUTPUT

COUNTRY	$\hat{\gamma}_1$		$\hat{\gamma}_2$ (x 10^{-2})	
GERMANY	0.95	(90.17)	-0.1	(-0.45)
JAPAN	0.97	(132.29)	-0.04	(-0.33)
UNITED KINGDOM	1.00	(64.40)	-0.21	(-3.36)
UNITED STATES	1.02	(55.15)	-0.54	(-2.49)

Sample period: 1954-1986

Estimates based on an equation of the form

$$\ln Y_t = \text{constant} + \gamma_1 \ln Y_{t-1} + \gamma_2 \dot{P}_t$$

(t-ratios in parenthesis)

Table 16

INVESTMENT-OUTPUT RATIOS

COUNTRY	TOTAL INVESTMENT / GDP	PRIVATE INVESTMENT / GDP
GERMANY	23.8%	19.2%
JAPAN	26.4%	22.9%
UNITED KINGDOM	17.7%	8.1%
UNITED STATES	19.3%	15.1%
SAMPLE PERIOD	1950-1983	1960-1986

Table 17

A COMPARISON OF THE COST OF CAPITAL AND RETURN ON CAPITAL, 1961-1981

COUNTRY	COST OF CAPITAL	RETURN ON CAPITAL
GERMANY	2.1	2.7
JAPAN	6.0	2.5
UNITED KINGDOM	5.4	6.1
UNITED STATES	7.5	6.9

Source: Holland (1984)

Conclusions

This thesis has investigated some determinants and consequences of aggregate stock market prices. Using data sources spanning 23 countries and almost three centuries, it is found that equity prices are correlated with real economic variables. There is, however, sufficient evidence of non-efficient market behaviour to reject the general applicability of the efficient markets hypothesis. Another broad conclusion is that institutional factors, both across countries and over time, contribute to accentuating or diminishing the linkage between such prices and the real economy.

In addition, the following detailed conclusions emerge from each chapter.

Chapter I examines stock price behaviour prior to the stock market crash of 1987. Using monthly and daily data from 23 stock markets, there is little support for the view that the recent crash was caused by a bursting bubble. However, there is evidence that equity prices have recently moved in a non-random manner on some of these exchanges.

Chapter II investigates the movements of stock prices in the United Kingdom from 1700 to 1987. A strong nominal interest rate effect on excess returns is found for the entire period, but it appears that inflation has a consistent, negative effect only after 1950. The changing influence of inflation on equity prices may be linked to Britain's adherence to the gold standard.

Chapter III analyzes major British financial crises since 1700. In the first part, using efficient and non-efficient market models, it is found that fluctuations in macroeconomic variables account for up to one half of equity price variation. In the second part, these models reveal that relatively few crises have been preceded by the excessive positive returns consistent with rational bubbles. The success of non-efficient market models in explaining equity returns does imply, however, that the efficient markets hypothesis does not strictly hold for this data set.

Chapter IV finds that Tobin's Q, the ratio of the market value of the corporate sector to the replacement cost of its capital, is inappropriately modelled within a static framework but is improved markedly using a dynamic error correction model. The Q measures are also superior to real stock prices as predictors of investment in the OECD countries under investigation. These results imply that Q, and hence stock prices, are correlated to investment. However, the relationship is relatively weak and depends on the exclusion of other relevant explanatory variables from the investment equation.

Chapter V compares the broader effects of equity prices on corporate investment and output in Japan, West Germany, the United Kingdom and the United States. It seems that the effect of the equity market is greater in the latter two countries for various institutional reasons having to do with the degree of managerial autonomy from stock price fluctuations.

Overall, then, it appears that aggregate stock market prices are significantly linked to the real economy. The instances of non-efficient market behaviour, in terms of unexplained stock returns prior to financial crises, the predictability of stock returns, the influence of lagged and nominal variables on the equity premium, and, possibly, the weak statistical relationship between stock market prices and corporate investment, do, however, offer support to a view of the stock market influenced not only by fundamental factors, but also possibly by social and psychological elements.

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