Bleak stock returns and the interval of observation

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Abstract

We show, using data on U.S. market indices from 1832-2008, that longer intervals of observation, such as holding periods of 20 or more years, demonstrate significantly lower risk than shorter ones. As such, the interval of observation that we measure risk over is highly relevant to any discussion of stock market risks and of prospects for the stock market. Very long intervals of observation mask out much of the riskiness of stocks and leave investors with, at worst, reasonable rates of return. Very long intervals of observation also reveal that some of the 'traditional' drivers of bleak investment periods in the short term, such as rising unemployment levels or commodities price deflation, are no longer of the same negative influence.

1. Introduction

How bad can it get when investing in stocks? This is a question investors ask themselves and they know for short time horizons it can get very bad. For the S&P500 index in the US during the 'great depression' the annualised real return was -43.7 percent from August 1929 to May 1932; during the 1973 oil crisis the annualised real return was -32.9 percent from December 1972 to September 1974; and during the credit market financial crisis of 2008 the annual real return was -38.9 percent to the end of October, 2008.

For long time horizons the story is not as bad. Siegel (1992; 2002) shows the probability the real return on U.S. stocks is negative is zero for time horizons of 17 years or more. For time horizons of 30 years or more, the probability the real return on stocks is less than the real return on bonds or bills is almost zero as well. Many other studies also support the view that long term investing has potential benefits for investors; for instance see Connelly (1996), Malkiel, (2003), Reichenstein & Dorsett (1995), and Thorley (1995).

Despite this, investors seem reluctant to commit to investment for the long term. Quill (2001) calculates from mutual funds redemption data that investors are, if anything, shortening their holding periods. Quill shows the average holding period in the US based mutual funds dropped from 5.5 years in 1996 to 2.9 years in 2000. It is undoubtedly difficult to hold on to stocks, no matter what the long term prospects are, when the immediate future looks imminently bleak. The reluctance to accept the 'buy-and-hold' view is also reflected in the literature. Works by Samuelson (1969,1994), Bodie (1995), Jorion (2003), and Taleb (2005, 2007) challenge the concept that increasing the holding horizon reduces risk. It is argued that the riskiness of stocks and the impact of the highly improbable are not well understood. Taleb and Samuelson both suggest the historical record of stock performance is probably biased. Samuelson (1994, p.17) makes the point that even though recent historical returns on equities have been favourable "we have only one history of capitalism".

In this study we focus on and document the impact of the 'interval of observation' on the assessment and interpretation of stock market risk. There is an emerging focus in the finance literature on the importance of the holding horizon, or interval of observation, in the framing of empirical tests and the inferences that can be drawn in studies. Two examples of these developments are in long horizon event studies and return predictability studies. Long horizon event studies are increasingly using a technique known as the calendar time portfolio bucket method, see Boehme and Sorescu (2002). This procedure, instead of treating monthly event window returns data as if it were independently generated, pools together long time spans of monthly returns data, such as for periods of 1, 3 or 5 years before or after an event, and draws abnormal returns estimates from these pools of calendar time data. The long horizon estimates, it is argued, are better estimates of the impact of corporate events. The second example of a change in thinking with regard to the interval of observation is illustrated in the return predictability literature. A recent study by Jacobsen, Marshall, and Visaltanachoti (2008) shows how alternate interval of observation windows in tests of return predictability can significantly improve the degree of predictability in returns data. So for our case, by documenting the impact of various 'intervals of observation' on the assessment of stock market risk we seek to extend this concept into the investment literature.

We show, using data on U.S. market indices from 1832-2008, that longer intervals of observation, such as holding periods of 20 or more years, have significantly lower annualised standard deviations than shorter ones. Additionally we show that as the investment holding horizon is lengthened then even the most bleak investment periods (defined as those in the bottom $2^{1/2th}$ percentile or worse of the distribution of all outcomes for an interval of observation), such as those experienced during the great depression, yield annualised real returns that are statistically positive. For example, there were no cases where the index realised negative real returns, so long as the holding horizon exceeded 22 years. Alternately, at a holding horizon of 1 year there are cases where the index could realise losses of up to 65% of their capital.

We further extend the importance of the interval of observation by comparing the economic characteristics that prevail during bleak return periods compared to non-bleak return periods (bleak intervals are again defined as those periods in the bottom $2^{1/2th}$ percentile, or worse, of the distribution of all outcomes for an interval of observation). It is shown that the characteristics of bleak periods change as the interval of observation is increased. For instance, poor unemployment statistics and lower commodities prices tend to be more relevant to shorter term 'bear' markets and do not feature as strongly as a discriminator in long term 'bear' periods. The same is true for the prices of precious metals. Generally, as the interval of observation is increased the economic variables that discriminate between bleak and non-bleak periods become less important.

Overall, the research highlights how important the interval of observation is in considering the riskiness in stocks and why stocks suffer bleak periods. Very long intervals of observation mask out almost all the riskiness of stocks and leave investors with, at worst, quite reasonable rates of return. Despite this finding, there is a lot of risk masking in long intervals of observation.

In the next section further literature is reviewed. In section 3 we describe the data and methodology. In section 4 we present and discuss the results, and in section 5 we present the conclusions of this research.

1. Literature Review

2.1 The Time Diversification Debate

Time diversification is summarised as "the dual proposition that, over long periods of time stock market returns have dominated returns of less risky assets, and that negative returns tend to be offset by positive" [1] (Connelly, 1996, p. 20). Figure 2.1 shows a simulated distribution of this adapted from Dimson, Marsh & Staunton (2004). Based on this, investors are recommended to increase their portfolio's stock allocation as their time horizon increases (Malkiel, 2003; Siegel, 2002). Figure 2.2 shows a guide of this adapted from Malkiel (2003). These studies support the view that investing for long time horizons is beneficial for investors.

Figure 2.1 and 2.2 here

To reinforce this view Siegel (1992; 2002) uses US data to show as the interval of observation increases, the probability stocks outperform bonds and bills increases. For 1 year time horizons, the return on stocks is greater than the return on bonds and bills over 60 percent of the time. For 30 year time horizons, it is almost 100 percent of the time.

There is the other side to the debate as well. Samuelson's (1969) model shows time horizon cannot have any effect on an investor's portfolio proportions between riskless and risky assets. If an investor wants to maximise the expected value of their logarithm of

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[1] Note: This relates to mean reversion which is when returns move back to a common trend and this indicates risk decreases as the interval of observation increases (Jorion, 2003).

wealth outcomes then they will act to maximise the geometric mean of their terminal wealth in all its likely possible outcomes which leads to age and time horizon being ignored. The model assumes investors have a utility function which is risk-averse and displays constant relative risk aversion[2], and act to maximise the utility function's expected value. In addition, the model assumes investors face a probability process that is stationary and each period's probabilities are independent. A riskless asset is also assumed. Samuelson (1994) states some exceptions to the model:

- First, investors can invest more of their portfolio in stocks when they are young and they have plenty of time to work and save to compensate for losses in stocks.
- Second, if stock returns display mean reversion, then risk-averse investors should invest more in stocks when they are young.

In addition, Kritzman (1994) develops a model that states if an investor prefers a riskless asset to a risky asset over a short time horizon, then the investor should also prefer a riskless asset to a risky asset over a long time horizon. Kritzman's model shows that expected utility of the risky asset always remains constant; therefore, diversifying across time does not create additional satisfaction. Kritzman states some exception to this:

- if an investor believes the returns of an investment are random, they might accept more risk over longer time horizons than shorter time horizons as they can change their level of consumption and work.
- if an event can cause a bad outcome in the riskless asset the model is challenged.

[2] Note: Constant relative risk aversion: "Percentage invested in risky assets is unchanged as wealth increases" (Elton, Gruber, Brown & Goetzmann, 2003, p. 219).

These studies are criticised though. Van Eaton & Conover (1998) suggest the models are dependent on the inputs; and utility can be shown to increase, decrease and remain constant as time horizon increases. Both models assume a riskless asset exists as well. To lend support to the argument that time diversification reduces risk, Taylor & Brown (1996) use the Black-Scholes options pricing model to show as time horizon increases the cost of portfolio shortfall insurance decreases. This is demonstrated with an example in table 2.3 and figure 2.4[3].

Table 2.3 here

Using options as well, Merrill & Thorley (1996) use a self-funding collar-cap in which a collar-cap is an options strategy which guarantees a minimum rate of return by holding a put option, limits a maximum rate of return by writing a call option and is self-funding. As time horizon increases the maximum possible annual return increases and at the same time the minimum rate of return is guaranteed; therefore, it is less costly to insure against underperformance over a longer time horizon than a shorter one. "the lower cost of risk reduction suggests that risk itself is lower, consistent with the principles of time diversification" (Merrill & Thorley, 1996, p. 17).

Time diversification is examined in other countries as well as empirical studies had focused mainly on the US. "There are reasons to suspect that these estimates are subject to survivorship bias, as the US is arguably the most successful capitalist system in the world"

[3] This example assumes the annualised standard deviation of stock returns is 20 percent and it decreases as time horizon increases. *i* is a positive number equal to 0.05 and T=1. The cost of insurance is derived from a simplified Black-Scholes options pricing formula with the cost of insurance being independent of the riskless rate.

(Jorion & Goetzmann, 1999, p. 953). In addition, as time horizon increases the number of independent observations decreases. Investigating time diversification in more countries increases the number of independent observations. Jorion & Goetzmann (1999) use a sample of 39 countries with monthly capital appreciation returns measured in nominal terms in the local currency, in real terms deflated by the Wholesale Price Index (WPI) and in US dollar returns, over most of the 20th century. Stock markets which survived, experienced temporary interruptions and experienced permanent interruptions are included. It is found from 1921 to 1996, US stocks have an annual real return of 4.3 percent compared to a median of 0.8 percent for other countries. It is concluded if only 'winner' stock markets are included and 'loser' stock markets are not, then a biased view of history is provided "which ignores important information about actual investment risks" (Jorion & Goetzmann, 1999, p. 979).

Jorion (2003) uses a sample of 30 countries with long return series. The data uses returns measured in real terms, deflated by the WPI, to adjust for the changing rates of inflation experienced by many countries over the long-term. Jorion finds the risk of investment in non-US stocks, measured by the probability of loss and 95 percent Value at Risk (VaR), is greater than the risk of investment in US stocks. It is concluded that "across-country diversification is more effective than across-time diversification" (Jorion, 2003, p. 25).

Dimson et al. (2004) study real stock returns in 16 countries from 1900 to 2002. All returns are deflated by the Consumer Price Index (CPI) and include reinvested dividends. It is shown in the US, real stock returns are higher and volatility is lower than in many other countries and therefore, this is a favourable history. It is stated that investors should be cautious about extrapolating these patterns into the future without consideration, because of survivorship bias and sampling error. It is argued the success of stocks in the US is an example of survivorship bias, and this is not typical of other countries or of the future. This survivorship bias is called a ‘success bias’. It is also argued there is sampling error as the number of historical outcomes is limited whereas the number of future outcomes is possibly infinite.

A number of interesting results are presented by Dimson et al. (2004). These include:

- Autocorrelation of annual real stock returns in the US over 103 years was 0.01 and therefore, they are actually independent, contrary to beliefs of mean reversion or mean aversion.
- The US, Canada, Australia and Denmark have never experienced a negative 20 year real stock return whereas Germany, Italy, Belgium, France and Spain have experienced a negative 20 year real stock return with a frequency of 1 in 4 or greater.
- Global diversification via a world index will lower US investor risk, but overseas stocks underperform US stocks; therefore, global diversification will also lower their return.
- The future distribution of real returns on stocks is explored under various assumptions as real stock returns are projected to be lower and the probability of a negative real return in stocks over long time horizons is ‘substantial’ regardless of the time horizon.
- Finally, it is stated “investors or corporations who assume… that stocks are safe, so long as they are held for 20 years are optimists. Their optimism is irrational” (Dimson et al., 2004, p. 24).

2.2 Factors which influence the return on stocks

We seek to characterise the factors that define bleak periods in the stock market and examine how these factors change as the interval of observation is increased. Studies that examine the economic determinants of stock returns are therefore relevant. Chen, Roll & Ross (1986) test whether economic factors have a systematic influence on stocks and find several to be significant in explaining expected returns. Shifts in macroeconomic factors are usually considered to cause a response in stock prices; however, the relationship is not exclusively in one direction (Chen et al., 1986). With monthly data spanning 1953 to 1983 the following macroeconomic factors are determined to be significant in explaining expected stock returns: industrial production, changes in the risk premium, changes in the yield curve, changes in expected inflation and unanticipated inflation; whereas real per capita consumption and oil price changes are not.

Fama & French (1992; 1993) use a three factor model to explain the returns on stocks. The three factors used are the excess return on the market portfolio of stocks, firm size and book-to-market equity. They show these three factors proxy for risk and explain average monthly returns on stocks.

Driesprong, Jacobsen & Maat (2008) investigate oil price changes and stock returns. They find changes in oil prices predict stock returns worldwide. Monthly stock data from 48 countries, a world market index and price series of several types of oil over almost 30 years are used to investigate whether changes in oil prices predict stock returns. The results show after oil price increases, stock returns are likely to be lower, and after oil price decreases, stock returns are likely to be higher. There is evidence "consistent with an under-reaction hypothesis, as it appears to take time before information about oil price changes becomes fully reflected in stock market prices" (Driesprong et al., 2008, p. 2). In addition, as stated in section 2.2, Jacobsen et al. (2008) examine the predictability of stock returns and find changes in the price of commodity factors predict returns on stocks.

3. Data and methodology

3.1 The interval of observation and the return on stocks

We calculate the return on stocks on a rolling monthly basis for interval of observations ranging from 1 to 30 year time horizons. All data used in this research are from Global Financial Data (GFD) and the frequency is monthly. The stock index is the 'S&P 500 Total Return Index with GFD extension' and begins in November 1832 and ends in March 2008. The data are deflated by the Consumer Price Index (CPI) and are gross of transaction costs and include reinvested dividends. This approach is consistent with Dimson et al. (2004) and allows for concerns about the effects of inflation distorting returns. To calculate the return on stocks for a range of intervals of observation, we use the following formulae:

$$R^a_{t-k,t} = \ln\left(P_t / P_{t-k} \right) / n \qquad (1)$$

and

$$R_{t-k,t} = \left(\frac{P_t}{P_{t-k}} \right) - 1 \qquad (2)$$

where

$R^a_{t-k,t}$ = the annualised return at time t over $t-k$
P_t = the value of a variable at month t
P_{t-k} = the value of a variable at month $t-k$
k = the interval of observation in months
n = the number of years in the interval of observation, i.e. $k/12$

$R_{t-k,t}$ = the total return at time t over $t-k$

We assess the risk in stocks by examining the both the worst returns on stocks and the annualised standard deviation of stocks returns. We calculate the 0^{th}, the $2½^{th}$ and the 5^{th} percentile of annualised stock returns for each interval of observation. In addition, we calculate the annualised standard deviation of stocks returns for each interval of observation. We test statistical significance with the t-test and Wilcoxon signed rank sum tests. The *t*-test is used to examine whether the annualised stock returns at the 0^{th}, the $2½^{th}$ and the 5^{th} percentile for the interval of observation are statistically significantly different from zero. The Wilcoxon signed rank sum test is also used to examine whether the annualised stock return at the $2½^{th}$ percentile is statistically significantly different from zero for each interval of observation. As these tests are parametric and non-parametric respectively, using both adds to the rigor of the testing. A limitation we face is that the statistical treatments assume the sample is independent, and the accuracy of this assumption is limited as the returns are calculated from overlapping periods; nevertheless, the monthly rolling window ensures that we capture virtually every investing experience in the data. We therefore use the significance tests as an indication of statistical significance.

To calculate the *t*-test, we use the following modified formula:

$$t = \frac{Percentile_n}{\left(s_n / \sqrt{N_n}\right)} \tag{3}$$

where

t = the *t*-test
n = the interval of observation in years

$Percentile_n =$ the annualised stock return at the 0^{th}, the $2½^{th}$ and the 5^{th} percentile for an n year interval of observation
$s_n =$ the annualised standard deviation of stock returns for an n year interval of observation
$N_n =$ number of observations at an n year interval of observation

In addition, we use a *t*-test to examine whether the annualised standard deviation of stock returns at a certain interval of observation is statistically different from the standard deviation of stock returns at a one year interval of observation. This test of statistical significance is used as an indication of how statistically different annualised standard deviations for an interval are from the one year standard deviation. We use the following formula:

$$t = \frac{s_1 - s_n}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_n^2}{N_n}}} \qquad (4)$$

where

$t =$ the *t*-test
$n =$ the interval of observation in years
$s_1 =$ the standard deviation of stock returns at a 1 year interval of observation
$s_n =$ the annualised standard deviation of stock returns at an n year interval of observation
$N_1 =$ number of observations at a 1 year interval of observation
$N_n =$ number of observations at an n year interval of observation

In the results, all tests in bold indicate statistical significance at the 5 percent level.

3.2 Factors that characterise the return on stocks

Our purpose in these tests is to assess whether there are any common characteristics in bleak investment periods and whether there is any variation in determinants as the interval of observation is changed. The worst stock market periods are defined as bleak investment periods and are classified as periods where returns are less than or equal to the 5th percentile[4]. We use the following algorithm:

$$\text{If} \quad R^{a}_{t-k,t} \le 5^{th}_{n} \quad \text{then} \quad R^{a}_{t-k,t} \equiv Bleak_{n} \qquad (5)$$

where

$R^{a}_{t-k,t} =$	the annualised return at time t over $t-k$
$k =$	the interval of observation in months
$n =$	the number of years in the interval of observation, i.e. $k/12$
$5^{th}_{n} =$	the annualised 5^{th} percentile return of an n year interval of observation
$Bleak_{n} =$	a dummy variable indicating if it is an n year bleak investment period

Factors which are thought to affect the return on stocks are used to characterise the bleak investment periods and to examine what relationships there are. We apply an algorithm which calculates the annualised change in the factors at time t over $t-k$ (using equation 1) when the return on stocks is classified as being in a bleak investment period at time t ($R^{a}_{t-k,t} \equiv Bleak_{n}$). As the interval of observation changes, we examine whether the relationships changes too.

[4] Note: The 5th percentile is the median risk measure from the literature reviewed in this research: Kritzman, (1994) uses a 95 percent confidence interval; Thorley (1995) uses the 10th percentile; Jorion (2003) uses 95 percent VaR; and Dimson et al. (2004) use the minimum and the 10th percentile. However, limiting the measure of risk to the 5th percentile is not appropriate as it ignores returns which are less than this; nevertheless, of concern; therefore, the risk measure is for returns which are less than or equal to the 5th percentile.

A control is necessary to determine what the effect from the interval of observation is. We define the control as non-bleak investment periods and they are classified as returns on stocks which are greater than the 5th percentile. We use the following algorithm:

$$\text{If} \quad R^{a}_{t-k,t} > 5^{th}_{n} \quad \text{then} \quad R^{a}_{t-k,t} \equiv Non-Bleak_{n} \tag{6}$$

where

$R^{a}_{t-k,t}$	=	the annualised return at time t over $t-k$
k	=	the interval of observation in months
n	=	the number of years in the interval of observation, i.e. $k/12$
5^{th}_{n}	=	the annualised 5^{th} percentile return of an n year interval of observation
$Non-Bleak_{n}$	=	a dummy variable indicating if it is an n year non-bleak investment period

Then we apply an algorithm which calculates the annualised change in the factors at time t over $t-k$ (using equation 1) when the return on stocks is classified as being in a non-bleak investment period at time t ($R^{a}_{t-k,t} \equiv Non-Bleak_{n}$).

The means of the annualised change in the factors at *k* length intervals of observation in bleak and non-bleak investment periods are compared to determine what relationships there are and a *t*-test of the difference between the means is calculated to assess the statistical significance of the difference.

A set of factors identified in the returns prediction literature which are thought to affect the return on stocks are assembled. All data are from GFD with a monthly frequency[5]

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[5] Note: Interpolation is necessary for some data: GDP data are annual from 1832 to 1920 and quarterly thereafter; CPI data are annual from 1832 to 1874; unemployment data are annual from 1890 to 1929; and butter data are annual from 1832 to 1890. The 'smoothing effect' of interpolation is less of a concern when the interval of observation is long.

and are deflated by the CPI to allow for the distorting effects of inflation[6]. Equation 1 is used to calculate the return on the factors as the interval of observation changes as stated[7]. The length of the data available differs on a factor by factor basis which means, in some cases, direct comparisons at the same point in time are not possible. However, the data are selected so the minimum sample length is at least 118 years which is over two thirds the stocks' sample length.

The economic factors include: Gross Domestic Product (GDP), Unemployment, CPI, Bonds, T-Bills and Oil. These factors are commonly cited in discussions on the economy. A summary of the variables, data length and the source name used by GFD is listed below.

Variable	**GFD Source Name**	**From**	**To**
GDP	United States Gross Domestic Product	11/1832	03/2008
Unemployment	United States Unemployment Rate	12/1890	03/2008
CPI	United States of America BLS Consumer Price Index	11/1832	03/2008
Bonds	USA 10-Year Government Bond Total Return Index	11/1832	03/2008
T-Bills	USA Total Return Commercial/T-Bill Index	12/1835	03/2008
Oil	West Texas Intermediate Oil Price (US$/Barrel)	01/1863	03/2008
Copper	Copper Electrolytic Wirebar Price (US Cents/Pound)	11/1832	04/2007
Gold	Gold Bullion Price-New York (US$/Ounce)	11/1832	03/2008
Lead	Lead Bar Spot Price	11/1832	03/2008
Silver	Silver Cash Price (US$/Ounce)	11/1832	03/2008
Steel	Heavy Melting Steel Scrap in Chicago Price (USD/Metric Ton)	09/1894	04/2007

[6] Note: The Unemployment data are not deflated by the CPI. Of course, neither is the CPI data.

[7] Note: The Unemployment data are a rate; therefore, a moving average is calculated.

Tin	Tin (Straits, Pigs) Prices (US Cents/Pound)	11/1832	03/2008
Zinc	Zinc Spot Price (USD/Ton)	01/1840	03/2008
Barley	Barley No.2 (Cents/Pound)	01/1886	01/2008
Butter	Butter, Average Price (Cents/Pound)	11/1832	02/2008
Cattle	Live Cattle Spot Price (US Cents/Pound)	01/1858	03/2008
Cocoa	Cocoa Spot Price (USD/Metric Ton)	11/1832	03/2008
Coffee	Brazil Santos Arabicas Spot Price (Cents/Pound)	11/1832	03/2008
Corn	Corn Spot Price (US$/Bushel)	01/1860	03/2008
Cotton	Cotton Spot Price (Cents/Pound)	11/1832	03/2008
Eggs	Eggs, Lage (Cents/Dozen)	01/1890	03/2008
Hides	Hides, Heavy Native Steers (Cents/Pound)	01/1890	05/2007
Hogs	Live Hog Prices (US Cents/Pound)	01/1886	03/2008
Lard	Lard, Average Wholesale Price (Cents/Pound)	01/1877	03/2008
Milk	Milk, Average Price to Farmers (USD/CWT)	01/1890	03/2008
Oat	Oat Spot Price (US$/Bushel)	11/1832	03/2008
Rubber	Rubber Spot Price (US Cents/Pound)	01/1890	03/2008
Rye	Rye, No.2, Minneapolis (Cents/Bushel)	01/1886	12/2005
Sheep	Sheep, Average Price (USD/CWT)	01/1874	03/2008
Sugar	Sugar #11 Spot Price (US Cents/Pound)	11/1832	03/2008
Wheat	Wheat #2 Cash Price (US Dollars/Bushel)	07/1841	03/2008
Wool	Wool, 64s, Staple 2¾ and Up US (Cents/Pound)	01/1890	03/2008

Three intervals of observation are examined in detail: 1 year time horizons, 10 year time horizons and 20 year time horizons. When studying the return on stocks and long intervals of observation, Jorion (2003) uses a 10 year time horizon and Dimson et al. (2004) use a 20 year time horizon. It is expected bleak investment periods are associated with bleak economic data and metal and agricultural prices.

4. Results

4.1 The interval of observation and the assessment of risk in stocks

Table 4.1 presents the summary statistics of annualised stock returns for different intervals of observation. As the interval of observation increases, the mean and median return remain constant as expected. Standard deviation decreases in a manner of exponential decay which is also expected. The range (the maximum return minus the minimum return) responds in a manner consistent with standard deviation. Skewness is negative over shorter intervals but approaches zero for periods of four years and over. Kurtosis is positive for time horizons of 1 to 4 years indicating a distribution with ‘fat tails’. For time horizons of 5 to 30 years, it is negative indicating a distribution with relatively ‘thin tails’ which implies the probability of an extreme return is less than for a normally distributed variable.

Figure 4.1 presents the distribution of annualised stock returns over intervals of observation of 5 to 30 years. The lowest dark area represents the returns that occur between the 0^{th} percentile and the 5^{th} percentile (returns less than or equal to the 5^{th} percentile); the highest dark area represents returns that occur 5 percent of the time (returns greater than or equal to the 95^{th} percentile); the light area represents returns that occur 90 percent of the time; and the black line in the middle represents the median return. As the interval of observation increases, the distribution of annualised returns decreases and converges towards the median. At the 5^{th} percentile, returns are greater than zero at intervals of observation of 15 years or more, and at the minimum, returns are greater than zero at intervals of observation of 22 years or more.

Figure 4.1 here

This indicates the risk in stocks, as measured by annualised return, decreases as the interval of observation increases. However, when the interval of observation is less than 15 years, the worst returns on stocks are negative.

Table 4.2 presents the summary statistics of the just the bleak period returns on stocks for each interval of observation from one year to 30 years. The worst returns are measured by the 5th, the 2½th and the 0th percentiles. At the 5th percentile, returns are less than zero at intervals of observation of up 15 years, at the 2½th percentile at intervals of observation of up to 16 years, and at the 0th percentile at intervals of observation of up to 22 years.

Table 4.2 here

Figure 4.2 presents the worst annualised returns on stocks at intervals of observation of 0 to 30 years. In the short term the worst returns can get very bad[8]. As the interval of observation increases, the worst returns improve and approach the median.

Figure 4.2 and 4.3 here

Figure 4.3 presents these details in graphical form. As the interval of observation increases, standard deviation decreases in a manner of exponential decay.

[8] Annualised returns are continuously compounded. The annualised return of the 0th percentile at an interval of observation of 1 year is -103.0 percent. This translates to a discrete return of -64.3 percent per annum.

Table 4.3 presents the summary statistics of total stock returns as the interval of observation changes. As the interval of observation increases, the mean, median, standard deviation and range of total returns increase in an exponential manner. In addition, the distribution of total returns expands, and this indicates the total risk in stocks increases as the interval of observation increases. However, the dispersion must be interpreted in the light of the median return. The skewness of total returns is positive 100 percent of the time, for time horizons of 1 to 30 years, which indicates a distribution with an asymmetric tail towards the positive. The kurtosis of total returns is positive 100 percent of the time too indicating a relatively flat distribution with 'fat tails'. This implies the probability of an extreme return is greater than for a normally distributed variable.

Table 4.3 here

Figure 4.4 presents the distribution of total stock returns over intervals of observation of 0 to 30 years. The lowest dark area represents returns that occur between the 0^{th} percentile and the 5^{th} percentile (returns less than or equal to the 5^{th} percentile); the highest dark area represents returns that occur 5 percent of the time (returns greater than or equal to the 95^{th} percentile); the light area represents returns that occur 90 percent of the time; and the black line in the middle represents the median return.

Figure 4.4 here

4.3 Tests of statistical significance and the interval of holding

Table 4.4 presents the *t*-test scores of the difference between the worst returns on stocks and zero real return for different intervals of observation. The 5th, the 2½th and the 0th percentiles of annualised returns are used to represent the worst returns. For the 5th percentile we see this measure is significantly less than zero at intervals of observation of 14 years or less; the 2½th percentile is significantly less than zero at intervals of observation of 15 years or less; the 0th percentile is significantly less than zero at intervals of observation of 20 years or less. However, what is clear is that as the interval of holding is increased the t statistics moves toward the positive. For a 30 year holding horizon every portfolio is experiencing significantly positive real returns.[9]

Table 4.4 here

Figure 4.5 presents these details in graphical form.

Figure 4.5 here

A non-parametric Wilcoxon signed rank sum test is also used to examine the difference between the annualised stock return of the 2½th percentile and zero as the interval of observation changes[10]. Table 4.4 presents the Wilcoxon signed rank sum test results. It is seen that as the interval of observation increases, the Wilcoxon signed rank sum test score

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[9] This test of statistical significance is an indication of how statistically significant the results would be if the samples were independent.

[10] Only the 2½th percentile is examined with the Wilcoxon signed rank sum test.

increases, and after 17 years the 2½th percentile is significantly greater than zero. The results from this test of significance support the results from the *t*-test.

Table 4.5 presents the *t*-test of the significance of the difference between the annualised standard deviation at an interval of observation of one year and the annualised standard deviation of intervals greater than one year. It is seen that as the interval of observation increases beyond one year, the annualised standard deviation becomes statistically significantly less than the one year standard deviation.

Table 4.5 here

4.4 Factors that characterise the return on stocks in bleak periods

Tables 4.6, 4.7 and 4.8 present the results from the analysis of the interval of observation in relation to rates of change in economic factors. In Table 4.6 we see at an interval of observation of one year that bleak investment periods in stocks tend to occur during periods having significantly lower rates of GDP growth, higher rates of inflation, and lower returns on bonds and bills compared with non-bleak investment periods in stocks. Unemployment statistics and oil price inflation, while showing marked differences between the market types, are not significant. In Table 4.7 we see the effects when the interval of observation is increased to 10 years. Over this interval we see bleak investment periods being characterised by low GDP growth, high inflation and oil price inflation, and bond and bill yields are low. Interestingly, unemployment figures tend to be lower during these bleak periods. In Table 4.8 we see the effects when the interval of observation is increased to 20 years. Again, over this interval all the variables that characterise bleak investment periods in the 10 year measures remain significant. For 20 year bleak markets we see that the economy has lower GDP growth, lower unemployment, higher inflation and oil price inflation, and bond and bill yields are lower.

Table 4.6 4.7, 4.8 here

Figures 4.6, 4.7 and 4.8 present the means for the economic factors in bleak and non-bleak investment periods in stocks at intervals of observation of 1, 10 and 20 years.

Figure 4.6, 4.7, 4.8 here

Tables 4.9, 4.10 and 4.11 present the summary statistics from the analysis of the interval of observation at 1, 10 and 20 years, and the mean annualised rate of change in metal factors. At an interval of observation of 1 year, the bleak investment periods in stocks are characterised with lower rates of price growth in metals compared with non-bleak investment periods in stocks. For copper and zinc the differences are large: 13.5 and 19.8 percent.

Table 4.9 here.

As the interval of observation increases to 10 years, in Table 4.10, the relationship completely changes and bleak investment periods are characterised with higher rates of price growth in metals. Copper and zinc are the exceptions. For gold and silver the difference are large: 4.7 and 4.2 percent.

Table 4.10 here

As the interval of observation increases to 20 years, bleak investment periods are characterised with higher rates of price growth in gold, silver and tin; and lower rates of price growth in copper, lead, steel and zinc, compared with non-bleak investment periods.

Table 4.12 here

Figures 4.9, 4.10 and 4.11 present these results graphically.

Figure 4.9, 4.10, 4.11 here

Tables 4.12, 4.13 and 4.14 present the analysis in relation to agricultural factors. At an interval of observation of 1 year, the bleak investment periods in stocks are characterised with lower rates of price inflation in agricultural products for 16 out of 19 factors compared with non-bleak investment periods in stocks, with barley, rye and sugar being the exceptions. For hides and rubber the differences are large: 22.7 and 32.2 percent.

As the interval of observation increases to 10 years, the relationship changes and the bleak investment periods are characterised with higher rates of price growth in agriculture for 16 out of 19 factors compared with non-bleak investment periods. The exceptions are butter, cattle and rubber. For rubber and sugar the differences are large: 4.9 and 6.7 percent.

As the interval of observation increases to 20 years, the bleak investment periods are characterised with higher rates of price growth in agriculture for 15 out of 19 factors compared with non-bleak investment periods. The exceptions are cattle, cocoa, cotton and rubber. For rubber and sugar the differences are large: 2.0 and 3.0 percent.

Table 4.12, 4.13, 4.14 here

Figures 4.12, 4.13 and 4.14 present these results for agricultural products graphically

Figures 4.12, 4.13 and 4.14 here

2. Conclusions

In this study we document the impact of the 'interval of observation' on the assessment and interpretation of stock market risk. We show, using data on U.S. market indices from 1832-2008, that longer intervals of observation, such as holding periods of 20 or more years, demonstrate significantly lower risk than shorter ones. As the investment holding horizon is lengthened then even the most bleak investment periods yield annualised real returns that are statistically positive. We also show that the economic characteristics of bleak periods in the stock market shift as the interval of observation is extended. Short term bleak stock market periods (one year bear markets) are characterised as having lower GDP growth, high unemployment, high inflation, low bond and bill returns, oil price inflation, metals price deflation, and commodities price deflation. When we look at longer term bleak markets periods (for instance, 20 year bear markets) we note that the 'unemployment' factor flips over, so unemployment is lower during bleak periods compared with non-bleak periods; the commodities factor flips over as well, and long term bear markets experience higher commodities price inflation. They also tend to experience precious metals and oil price inflation as well. So there are a number of notable factor shifts as we move the interval of observation outward to the longer term.

Overall, the analysis shows that the definition of the interval of observation is highly relevant to any discussion of stock market risks and prospects for a decline in the stock market. Very long intervals of observation mask out much of the riskiness of stocks and leave investors with, at worst, quite reasonable rates of return. Very long intervals of observation also reveal that some of the 'traditional' drivers of bleak investment periods in the short run, such as rising unemployment levels or commodities price deflation, are no longer of the same negative nature.

Finally, despite the finding that long horizon investing down-side risk characteristics are more favourable than short term ones, there is a lot of risk masking in long intervals of observation. Unfortunately, investors have to grapple with real time market volatility and negative sentiment on a day-to-day basis, and in bleak times this can severely test their faith in the wisdom of a long term commitment to the stock market.

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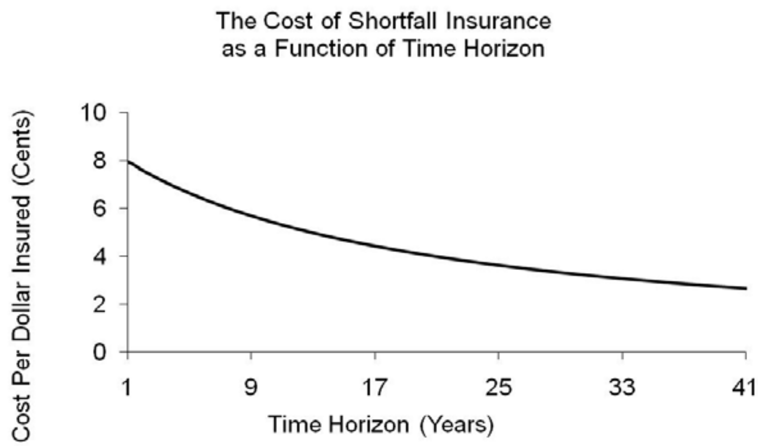
Tables

Time Horizon	Cost per Dollar Insured in Cents
1 Year	7.97
5 Years	6.64
10 Years	5.50
20 Years	4.09
30 Years	3.26
50 Years	2.31
75 Years	1.70
100 Years	1.34

Table 2.3 An Example of the Cost of Shortfall Insurance as a Function of Time Horizon[e]

Figure 2.4 An Example of the Cost of Shortfall Insurance as a Function of Time Horizon[e]



[e] adapted from Taylor & Brown, 1996.

Table 4.1 The Summary Statistics of Annualised Stock Returns

Time Horizon	Mean	Median	Standard Deviation	Range	Skewness	Kurtosis	N
1	0.0630	0.0713	0.1871	2.0565	-0.38	1.74	2094
2	0.0630	0.0662	0.1304	1.1356	-0.45	1.40	2082
3	0.0625	0.0621	0.1013	0.8174	-0.34	1.10	2070
4	0.0625	0.0615	0.0865	0.6103	-0.04	0.12	2058
5	0.0629	0.0638	0.0758	0.4495	-0.01	-0.19	2046
10	0.0650	0.0685	0.0464	0.2300	-0.14	-0.54	1986
15	0.0645	0.0656	0.0360	0.1733	-0.07	-0.49	1926
20	0.0638	0.0630	0.0275	0.1360	0.02	-0.49	1866
30	0.0634	0.0642	0.0163	0.0990	-0.07	-0.35	1746

Table 4.2 The Worst Returns on Stocks Annualised

Time Horizon	5th Percentile	2½th Percentile	0th Percentile
1	-0.2588	-0.3239	-1.0302
2	-0.1580	-0.2098	-0.6858
3	-0.1049	-0.1355	-0.4798
4	-0.0763	-0.1026	-0.2699
5	-0.0637	-0.0874	-0.1582
10	-0.0166	-0.0272	-0.0470
15	0.0030	-0.0049	-0.0271
20	0.0183	0.0119	-0.0063
30	0.0353	0.0311	0.0106

Table 4.3 The Summary Statistics of Total Stock Returns

Time Horizon	Mean	Median	Standard Deviation	Range	Skewness	Kurtosis	N
1	0.0835	0.0740	0.2005	2.434	0.67	3.85	2094
2	0.1722	0.1416	0.2982	2.205	0.57	0.83	2082
3	0.2616	0.2047	0.3787	2.516	0.73	0.69	2070
4	0.3629	0.2790	0.4824	3.564	1.02	1.53	2058
5	0.4716	0.3756	0.5731	3.838	1.08	1.68	2046
10	1.1269	0.9834	0.9768	5.608	0.92	0.84	1986
15	2.0344	1.6771	1.6495	8.303	1.08	0.73	1926
20	3.1630	2.5251	2.3603	12.517	1.19	0.97	1866
30	6.5238	5.8541	3.7321	25.477	1.14	1.50	1746

Table 4.4 The *t*-test and Wilcoxon test of the difference between the worst returns on stocks and zero

Time Horizon	5th Percentile *t*-test	2½th Percentile *t*-test	0th Percentile *t*-test	Wilcoxon Signed Rank Sum Test
1	**-63.29**	**-79.23**	**-251.99**	**-2782**
2	**-55.29**	**-73.42**	**-239.95**	**-2782**
3	**-47.11**	**-60.87**	**-215.54**	**-2730**
4	**-40.06**	**-53.86**	**-141.62**	**-2678**
5	**-37.99**	**-52.12**	**-94.39**	**-2678**
10	**-15.92**	**-26.10**	**-45.08**	**-2525**
15	**3.71**	**-5.97**	**-33.07**	**-1961**
20	**28.69**	**18.66**	**-9.88**	**2170**
30	**90.57**	**79.92**	**27.32**	**1958**

Table 4.5 The *t*-test of the difference between the annualised standard deviation of stock returns

Time Horizon	*t* Statistic
1	0.00
2	**-11.36**
3	**-18.43**
4	**-22.31**
5	**-25.18**
10	**-33.34**
15	**-36.24**
20	**-38.57**
30	**-41.59**

Table 4.6 The Summary Statistics of Economic Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 1 Year

Investment		Mean	*t*	Standard Deviation	Skewness	Kurtosis	N
GDP	Bleak	0.0250		0.1353	-0.70	-0.22	105
	Non-Bleak	0.0552	**-2.03**	0.0719	-0.85	5.23	1989
Unemployment	Bleak	0.0756		0.0489	1.01	-0.28	75
	Non-Bleak	0.0663	1.37	0.0426	1.92	3.73	1322
CPI	Bleak	0.0462		0.0915	-0.18	-1.00	105
	Non-Bleak	0.0195	**2.66**	0.0500	0.16	1.87	1989
Bonds	Bleak	-0.0133		0.1004	-0.13	-1.15	105
	Non-Bleak	0.0290	**-3.68**	0.0767	0.34	2.25	1989
Bills	Bleak	0.0118		0.0905	-0.51	-0.85	101
	Non-Bleak	0.0297	-1.74	0.0562	0.39	2.17	1955
Oil	Bleak	0.0407		0.3516	0.38	2.05	86
	Non-Bleak	-0.0029	1.13	0.2926	0.21	2.79	1645

Table 4.7 The Summary Statistics of Economic Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 10 Years

Investment		Mean	*t*	Standard Deviation	Skewness	Kurtosis	N
GDP	Bleak	0.0222		0.0112	-0.75	0.08	100
	Non-Bleak	0.0332	**-7.38**	0.0157	0.83	2.27	1886
Unemployment	Bleak	0.0599		0.0220	4.02	16.40	96
	Non-Bleak	0.0653	-1.69	0.0301	2.06	3.74	1073
CPI	Bleak	0.0612		0.0215	-2.38	6.79	100
	Non-Bleak	0.0186	**15.53**	0.0258	0.05	-0.56	1886
Bonds	Bleak	-0.0229		0.0261	1.43	2.79	100
	Non-Bleak	0.0295	**-15.55**	0.0329	-0.10	-0.69	1886
Bills	Bleak	-0.0051		0.0208	2.20	7.00	100
	Non-Bleak	0.0288	**-11.76**	0.0345	0.06	0.00	1848
Oil	Bleak	0.0797		0.0464	-0.62	0.25	96
	Non-Bleak	-0.0121	**14.63**	0.0603	-0.15	1.53	1527

Table 4.8 The Summary Statistics of Economic Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 20 Years

Investment		Mean	*t*	Standard Deviation	Skewness	Kurtosis	N
GDP	Bleak	0.0265		0.0066	-1.32	1.50	94
	Non-Bleak	0.0331	**-7.30**	0.0092	-0.16	0.66	1772
Unemployment	Bleak	0.0621		0.0192	1.76	1.55	94
	Non-Bleak	0.0663	-1.64	0.0192	1.00	-0.08	1075
CPI	Bleak	0.0444		0.0155	-0.78	-0.64	94
	Non-Bleak	0.0204	**11.55**	0.0199	0.19	-0.68	1772
Bonds	Bleak	-0.0087		0.0142	0.71	-0.56	94
	Non-Bleak	0.0268	**-17.16**	0.0251	-0.10	-1.01	1772
Bills	Bleak	0.0034		0.0077	-0.25	0.13	94
	Non-Bleak	0.0265	**-15.63**	0.0284	0.17	-0.44	1734
Oil	Bleak	0.0251		0.0348	-0.43	-1.05	94
	Non-Bleak	-0.0061	**6.89**	0.0350	-0.30	0.20	1409

Table 4.9 The Summary Statistics of Metal Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 1 Year

Investment		Mean	*t*	Standard Deviation	Skewness	Kurtosis	N
Copper	Bleak	-0.1335		0.2571	0.10	-0.91	105
	Non-Bleak	0.0012	**-4.59**	0.1911	0.05	1.37	1978
Gold	Bleak	-0.0330		0.1876	-0.68	3.16	105
	Non-Bleak	0.0019	-1.65	0.1293	1.19	8.43	1989
Lead	Bleak	-0.0599		0.2513	0.49	1.55	105
	Non-Bleak	0.0013	**-2.11**	0.1997	0.23	2.34	1989
Silver	Bleak	-0.0598		0.1994	-0.20	1.99	105
	Non-Bleak	-0.0041	**-2.35**	0.1891	0.64	9.34	1989
Steel	Bleak	-0.0352		0.3283	0.70	-0.17	74
	Non-Bleak	0.0027	-0.82	0.2893	0.03	0.38	1266
Tin	Bleak	-0.0518		0.2799	-0.26	0.48	105
	Non-Bleak	0.0042	-1.75	0.2082	0.07	2.21	1989
Zinc	Bleak	-0.1909		0.2384	0.08	1.07	94
	Non-Bleak	0.0076	**-6.53**	0.2538	1.01	4.67	1913

Table 4.10 The Summary Statistics of Metal Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 10 Years

Investment		**Mean**	***t***	**Standard Deviation**	**Skewness**	**Kurtosis**	**N**
Copper	Bleak	-0.0274		0.0315	0.25	-0.48	100
	Non-Bleak	-0.0112	**-5.15**	0.0359	-0.36	0.95	1875
Gold	Bleak	0.0413		0.0866	-0.34	-1.61	100
	Non-Bleak	-0.0054	**5.39**	0.0418	1.69	5.71	1886
Lead	Bleak	-0.0072		0.0345	0.15	-0.76	100
	Non-Bleak	-0.0090	0.55	0.0351	0.50	1.31	1886
Silver	Bleak	0.0288		0.0497	0.02	-0.61	100
	Non-Bleak	-0.0130	**8.41**	0.0430	-0.04	4.45	1886
Steel	Bleak	-0.0002		0.0451	0.14	-1.19	96
	Non-Bleak	-0.0075	1.58	0.0445	-0.11	-0.29	1136
Tin	Bleak	0.0121		0.0576	-0.76	-0.46	100
	Non-Bleak	-0.0044	**2.85**	0.0458	-0.62	0.34	1886
Zinc	Bleak	-0.0089		0.0415	-0.50	-0.72	100
	Non-Bleak	-0.0068	-0.51	0.0407	-0.08	1.19	1799

Table 4.11 The Summary Statistics of Metal Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 20 Years

Investment		**Mean**	***t***	**Standard Deviation**	**Skewness**	**Kurtosis**	**N**
Copper	Bleak	-0.0300		0.0219	-0.28	-0.72	94
	Non-Bleak	-0.0107	**-8.54**	0.0247	-0.07	-0.34	1761
Gold	Bleak	0.0120		0.0488	-0.06	-1.71	94
	Non-Bleak	-0.0036	**3.09**	0.0286	0.77	0.94	1772
Lead	Bleak	-0.0133		0.0266	0.54	-0.71	94
	Non-Bleak	-0.0087	-1.69	0.0214	0.42	0.76	1772
Silver	Bleak	0.0032		0.0394	0.52	-0.28	94
	Non-Bleak	-0.0130	**4.00**	0.0289	0.54	2.18	1772
Steel	Bleak	-0.0199		0.0231	0.42	-0.13	94
	Non-Bleak	-0.0055	**-6.05**	0.0262	0.38	-0.36	1018
Tin	Bleak	-0.0036		0.0296	0.02	-1.11	94
	Non-Bleak	-0.0038	0.07	0.0320	-0.63	0.27	1772
Zinc	Bleak	-0.0106		0.0240	-0.09	-0.62	94
	Non-Bleak	-0.0060	-1.85	0.0243	0.20	0.97	1685

Table 4.12 The Summary Statistics of Agricultural Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 1 Year

Investment		**Mean**	***t***	**Standard Deviation**	**Skewness**	**Kurtosis**	**N**
Barley	Bleak	0.0840		0.2567	-0.27	0.25	75
	Non-Bleak	-0.0157	**2.71**	0.2643	0.17	1.62	1378
Butter	Bleak	-0.0413		0.1674	0.60	3.53	105
	Non-Bleak	-0.0066	-1.76	0.1479	0.37	5.17	1988
Cattle	Bleak	-0.0806		0.1664	0.20	-0.47	87
	Non-Bleak	0.0060	**-4.04**	0.1487	-0.11	0.83	1704
Cocoa	Bleak	-0.0476		0.3689	0.76	1.17	105
	Non-Bleak	-0.0075	-0.96	0.2527	0.59	2.18	1989
Coffee	Bleak	-0.1158		0.2741	0.30	-0.16	105
	Non-Bleak	-0.0022	**-3.46**	0.2722	0.08	1.85	1989
Corn	Bleak	-0.1305		0.3970	-0.28	-0.95	87
	Non-Bleak	-0.0025	**-2.59**	0.2844	0.08	0.74	1680
Cotton	Bleak	-0.1830		0.3800	-0.51	1.59	105
	Non-Bleak	-0.0019	**-4.21**	0.2632	0.07	2.85	1989
Eggs	Bleak	-0.0832		0.1505	0.10	-0.55	75
	Non-Bleak	-0.0101	**-3.16**	0.2091	0.00	0.70	1332
Hides	Bleak	-0.2237		0.2902	-0.22	0.00	75
	Non-Bleak	0.0034	**-5.54**	0.2728	-0.22	2.85	1322
Hogs	Bleak	-0.1618		0.2616	0.28	-0.44	75
	Non-Bleak	0.0029	**-4.45**	0.2532	0.14	0.30	1380
Lard	Bleak	-0.0511		0.3815	0.21	-0.69	75
	Non-Bleak	-0.0134	-0.74	0.2617	0.17	1.00	1488
Milk	Bleak	-0.0503		0.1823	0.09	-0.67	75
	Non-Bleak	-0.0019	**-2.00**	0.1130	0.42	3.05	1332
Oat	Bleak	-0.0541		0.2753	-0.01	-0.55	105
	Non-Bleak	-0.0068	-1.44	0.2672	0.08	0.57	1989
Rubber	Bleak	-0.3307		0.2927	0.52	-0.11	75
	Non-Bleak	-0.0092	**-7.51**	0.3291	0.71	2.85	1332
Rye	Bleak	-0.0075		0.3088	-0.78	-0.07	75
	Non-Bleak	-0.0125	0.12	0.2713	0.35	1.11	1353
Sheep	Bleak	-0.1428		0.2221	-0.42	-0.45	80
	Non-Bleak	-0.0031	**-4.66**	0.2017	-0.24	1.56	1519
Sugar	Bleak	0.0595		0.3823	1.95	4.31	105
	Non-Bleak	-0.0241	1.90	0.2947	-0.50	4.28	1989
Wheat	Bleak	-0.0951		0.2752	-0.13	-0.85	94
	Non-Bleak	-0.0045	**-2.66**	0.2475	0.31	1.00	1895
Wool	Bleak	-0.0675		0.3346	0.38	0.03	75
	Non-Bleak	-0.0137	-1.17	0.2605	0.35	2.52	1332

Table 4.13 The Summary Statistics of Agricultural Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 10 Years

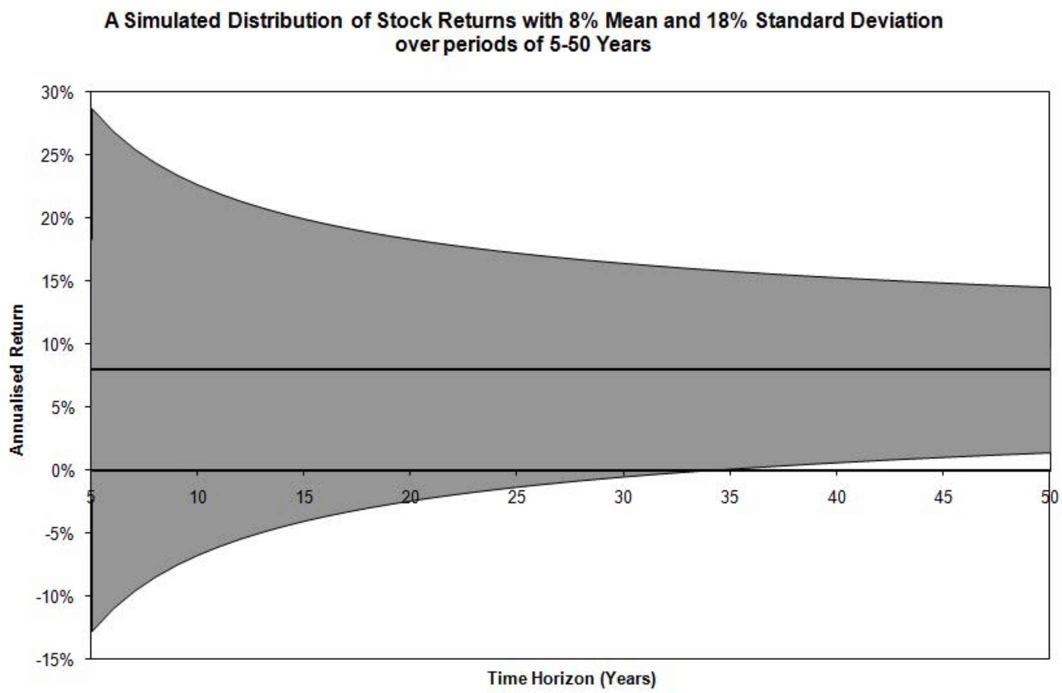
Investment		**Mean**	***t***	**Standard Deviation**	**Skewness**	**Kurtosis**	**N**
Barley	Bleak	-0.0061		0.0556	-0.79	0.52	96
	Non-Bleak	-0.0165	1.84	0.0437	-0.28	-0.02	1249
Butter	Bleak	-0.0140		0.0148	-0.65	0.69	100
	Non-Bleak	-0.0085	**-3.72**	0.0298	-0.80	2.28	1885
Cattle	Bleak	-0.0095		0.0204	0.02	-0.56	96
	Non-Bleak	0.0005	**-4.82**	0.0304	0.30	-0.53	1587
Cocoa	Bleak	0.0160		0.0823	-0.06	-1.32	100
	Non-Bleak	-0.0122	**3.43**	0.0563	0.41	0.68	1886
Coffee	Bleak	0.0029		0.0742	-0.48	-0.60	100
	Non-Bleak	-0.0096	1.68	0.0601	0.09	-0.28	1886
Corn	Bleak	-0.0025		0.0362	-0.78	0.64	96
	Non-Bleak	-0.0131	**2.89**	0.0419	0.12	-0.23	1563
Cotton	Bleak	0.0008		0.0351	-0.85	0.23	100
	Non-Bleak	-0.0122	**3.70**	0.0562	0.61	2.69	1886
Eggs	Bleak	-0.0064		0.0186	-0.57	0.57	96
	Non-Bleak	-0.0195	**6.92**	0.0311	0.28	-0.27	1203
Hides	Bleak	0.0095		0.0561	0.11	-0.92	96
	Non-Bleak	-0.0112	**3.61**	0.0463	-0.36	-0.23	1193
Hogs	Bleak	0.0040		0.0408	-0.08	-1.46	96
	Non-Bleak	-0.0076	**2.80**	0.0441	0.52	0.78	1251
Lard	Bleak	0.0100		0.0445	0.04	-1.45	96
	Non-Bleak	-0.0215	**6.95**	0.0444	0.07	-0.26	1359
Milk	Bleak	0.0052		0.0181	-2.24	8.05	96
	Non-Bleak	-0.0077	**6.97**	0.0253	-0.09	-0.62	1203
Oat	Bleak	-0.0048		0.0317	-0.59	0.06	100
	Non-Bleak	-0.0120	**2.29**	0.0402	-0.08	-0.09	1886
Rubber	Bleak	-0.0788		0.1180	-0.62	-1.37	96
	Non-Bleak	-0.0300	**-4.05**	0.0637	0.03	1.49	1203
Rye	Bleak	0.0093		0.0308	-0.99	0.81	96
	Non-Bleak	-0.0152	**7.76**	0.0492	-0.01	-0.43	1224
Sheep	Bleak	0.0077		0.0340	0.05	-0.88	96
	Non-Bleak	-0.0103	**5.17**	0.0397	-0.08	0.59	1395
Sugar	Bleak	0.0417		0.0897	0.20	-0.83	100
	Non-Bleak	-0.0249	**7.42**	0.0515	-0.56	5.17	1886
Wheat	Bleak	0.0073		0.0304	-0.04	-0.52	100
	Non-Bleak	-0.0129	**6.66**	0.0406	0.12	-0.37	1781
Wool	Bleak	-0.0093		0.0293	0.84	0.36	96
	Non-Bleak	-0.0206	**3.77**	0.0442	-0.50	0.97	1203

Table 4.14 The Summary Statistics of Agricultural Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 20 Years

Investment		**Mean**	***t***	**Standard Deviation**	**Skewness**	**Kurtosis**	**N**
Barley	Bleak	-0.0064		0.0212	-0.01	-0.93	96
	Non-Bleak	-0.0152	**4.04**	0.0258	0.10	-0.53	1129
Butter	Bleak	-0.0095		0.0103	0.05	0.79	100
	Non-Bleak	-0.0099	0.43	0.0179	-0.53	0.13	1765
Cattle	Bleak	-0.0090		0.0127	0.72	0.23	96
	Non-Bleak	-0.0001	**-6.89**	0.0201	0.30	-0.48	1467
Cocoa	Bleak	-0.0123		0.0433	-0.27	-1.18	100
	Non-Bleak	-0.0109	-0.32	0.0365	0.08	0.31	1766
Coffee	Bleak	-0.0040		0.0268	-0.31	-1.13	100
	Non-Bleak	-0.0073	1.25	0.0345	-0.17	-0.31	1766
Corn	Bleak	-0.0067		0.0229	0.12	-0.30	96
	Non-Bleak	-0.0117	**2.13**	0.0267	0.15	0.04	1443
Cotton	Bleak	-0.0104		0.0226	0.92	0.10	100
	Non-Bleak	-0.0101	-0.11	0.0331	0.49	2.20	1766
Eggs	Bleak	-0.0122		0.0130	0.00	-0.64	96
	Non-Bleak	-0.0202	**6.02**	0.0187	0.35	-0.45	1083
Hides	Bleak	-0.0001		0.0243	-0.46	-0.46	96
	Non-Bleak	-0.0113	**4.50**	0.0303	-0.09	-0.80	1073
Hogs	Bleak	0.0065		0.0215	-0.58	0.21	96
	Non-Bleak	-0.0081	**6.68**	0.0252	-0.07	-0.26	1131
Lard	Bleak	-0.0045		0.0246	-0.34	0.60	96
	Non-Bleak	-0.0211	**6.60**	0.0269	0.03	-0.13	1239
Milk	Bleak	0.0039		0.0077	-1.68	6.84	96
	Non-Bleak	-0.0077	**14.86**	0.0147	-0.25	-0.56	1083
Oat	Bleak	-0.0060		0.0163	-0.30	0.13	100
	Non-Bleak	-0.0126	**4.04**	0.0239	-0.07	-0.25	1766
Rubber	Bleak	-0.0546		0.0411	-0.67	-0.98	96
	Non-Bleak	-0.0346	**-4.76**	0.0493	-0.69	1.60	1083
Rye	Bleak	-0.0023		0.0157	-1.23	2.26	96
	Non-Bleak	-0.0150	**7.91**	0.0291	0.35	-0.30	1104
Sheep	Bleak	-0.0023		0.0183	-0.42	0.01	96
	Non-Bleak	-0.0100	**4.11**	0.0234	0.05	0.95	1275
Sugar	Bleak	0.0072		0.0380	0.56	0.03	100
	Non-Bleak	-0.0227	**7.87**	0.0268	0.01	0.94	1766
Wheat	Bleak	-0.0114		0.0198	-0.07	-0.83	96
	Non-Bleak	-0.0119	0.27	0.0247	-0.13	-0.10	1665
Wool	Bleak	-0.0179		0.0139	0.44	-0.01	96
	Non-Bleak	-0.0192	0.90	0.0258	-0.59	1.22	1083

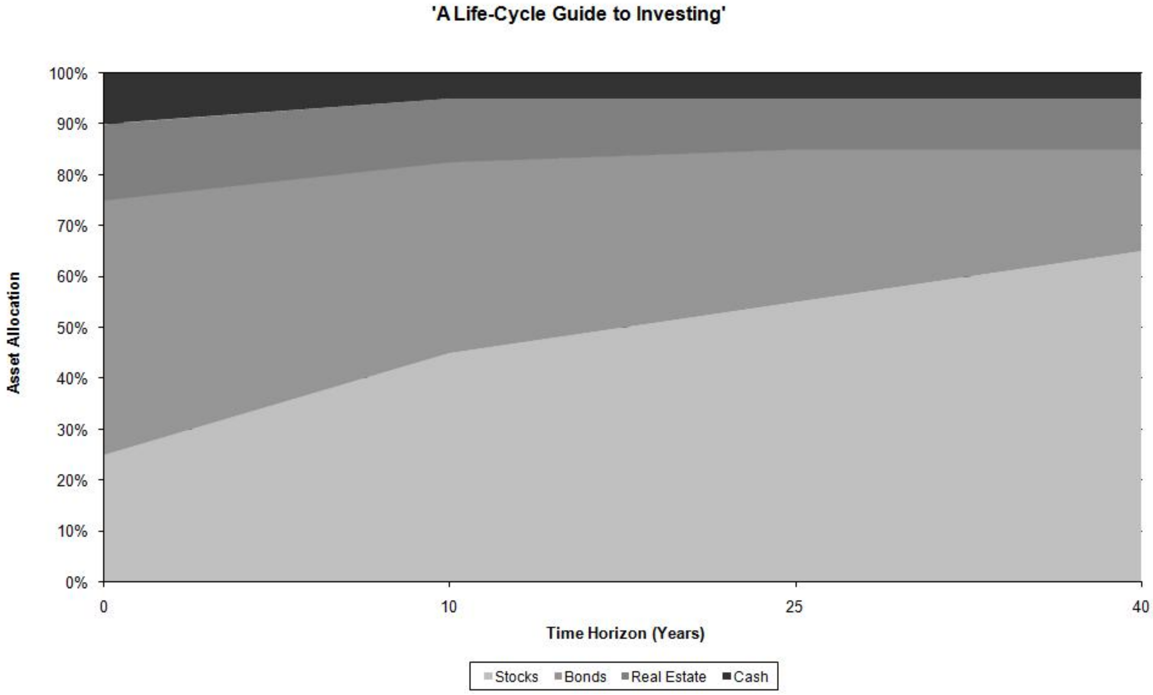
Figures

Figure 2.1 A Simulated Distribution of Stock Returns[a]



[a] adapted from Dimson et al. 2004

Figure 2.2 Recommended Asset Allocations[b]



[b] adapted from Malkiel, 2003.

Figure 4.1 The Distribution of Annualised Stock Returns

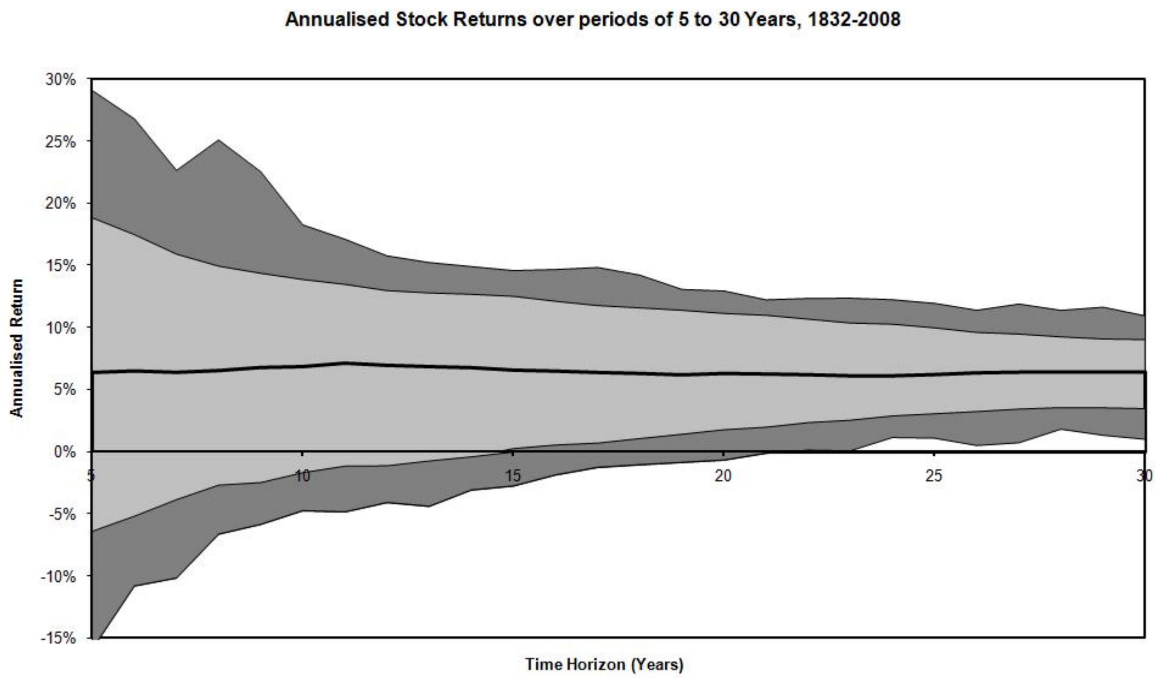


Figure 4.2 The Worst Returns on Stocks Annualised

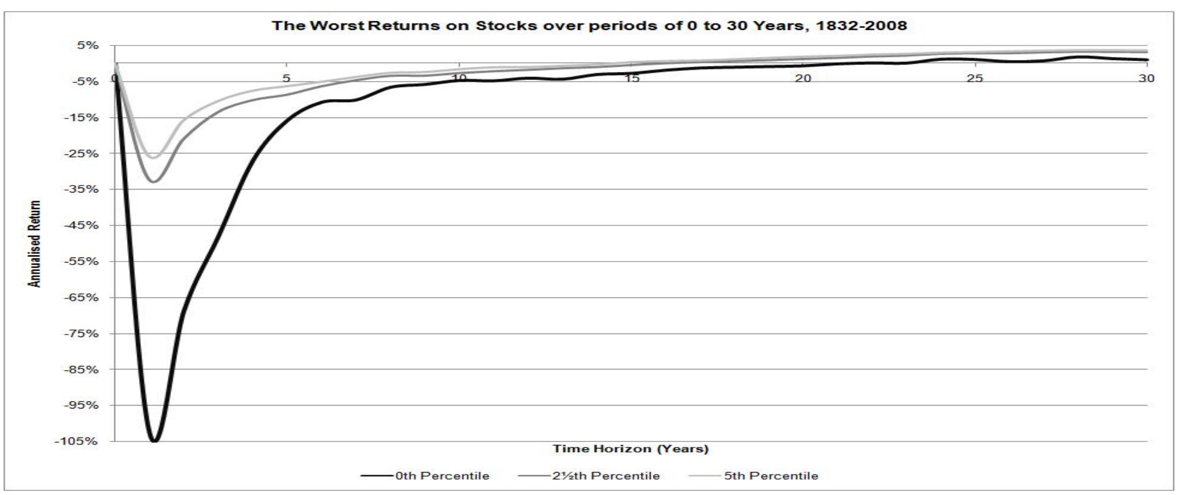


Figure 4.3 The Annualised Standard Deviation of Stock Returns

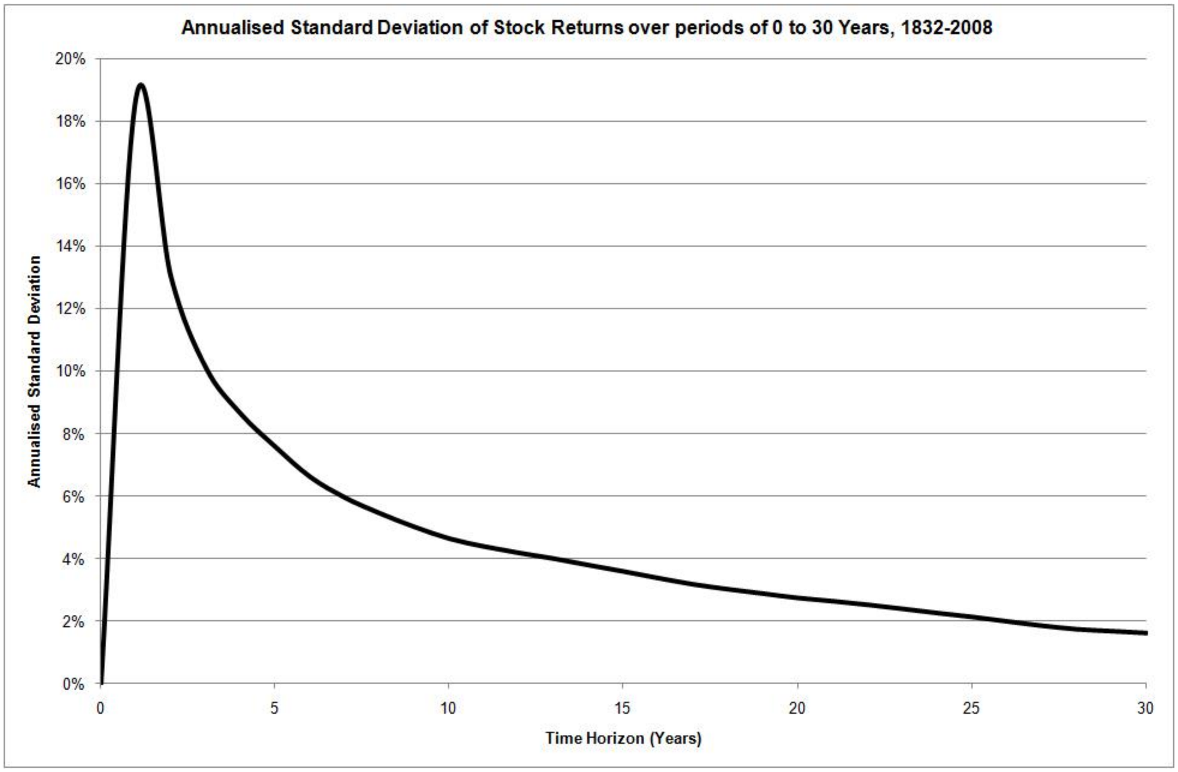


Figure 4.4 The Distribution of Total Stock Returns

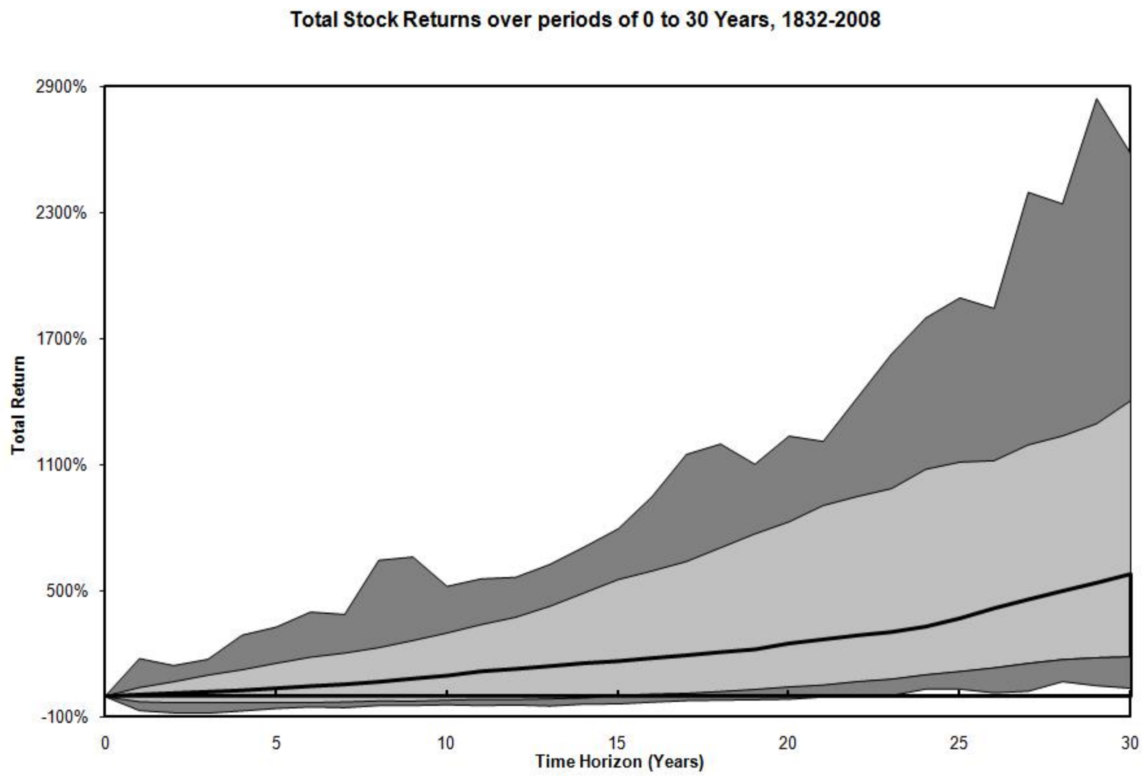


Figure 4.5 The *t*-test of the difference between the worst returns on stocks and zero

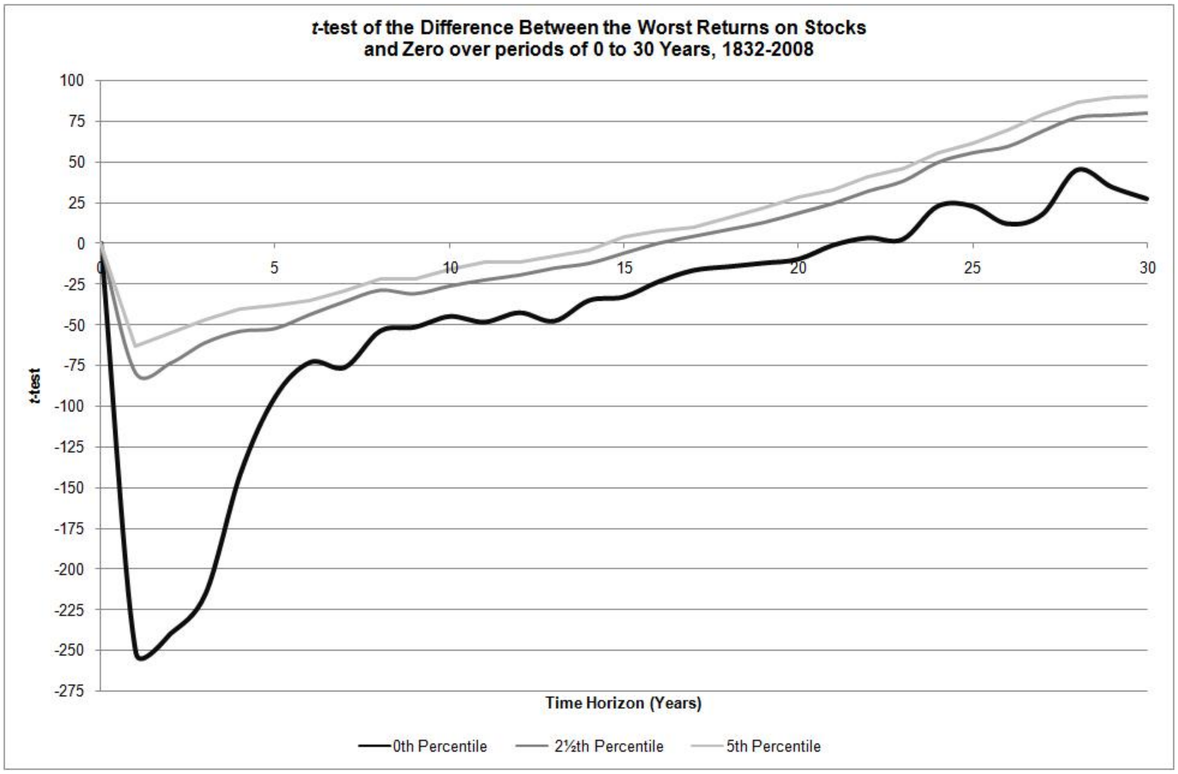


Figure 4.6 The mean annual rate of change in economic factors in bleak and non-bleak investment periods in stocks at intervals of observation of 1 year

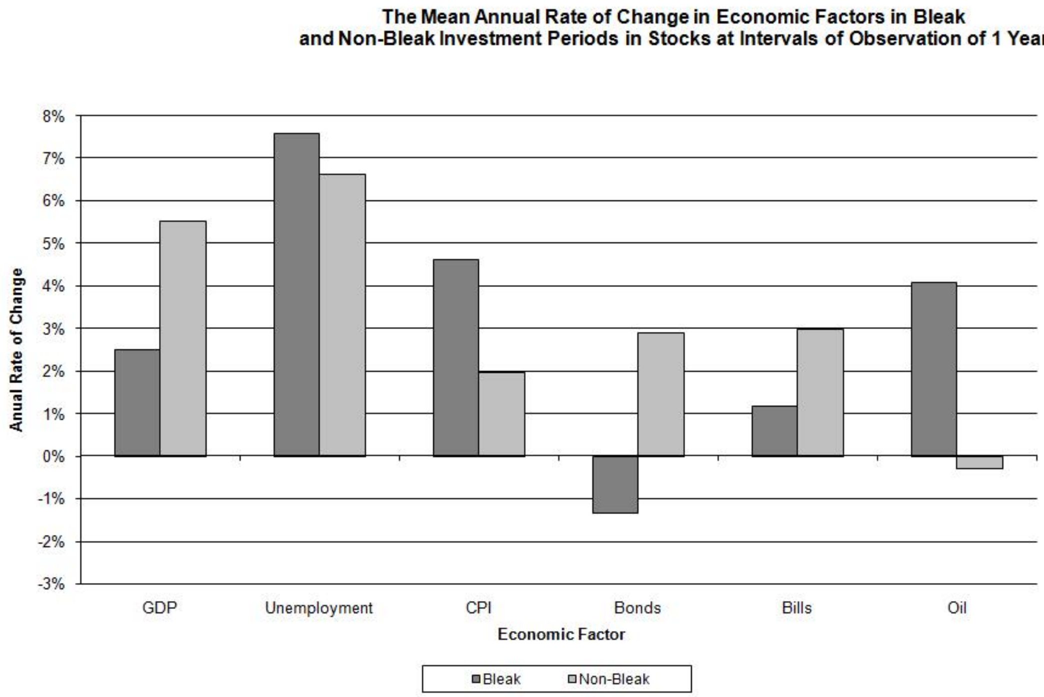


Figure 4.7 The Mean Annualised Rate of Change in Economic Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 10 Years

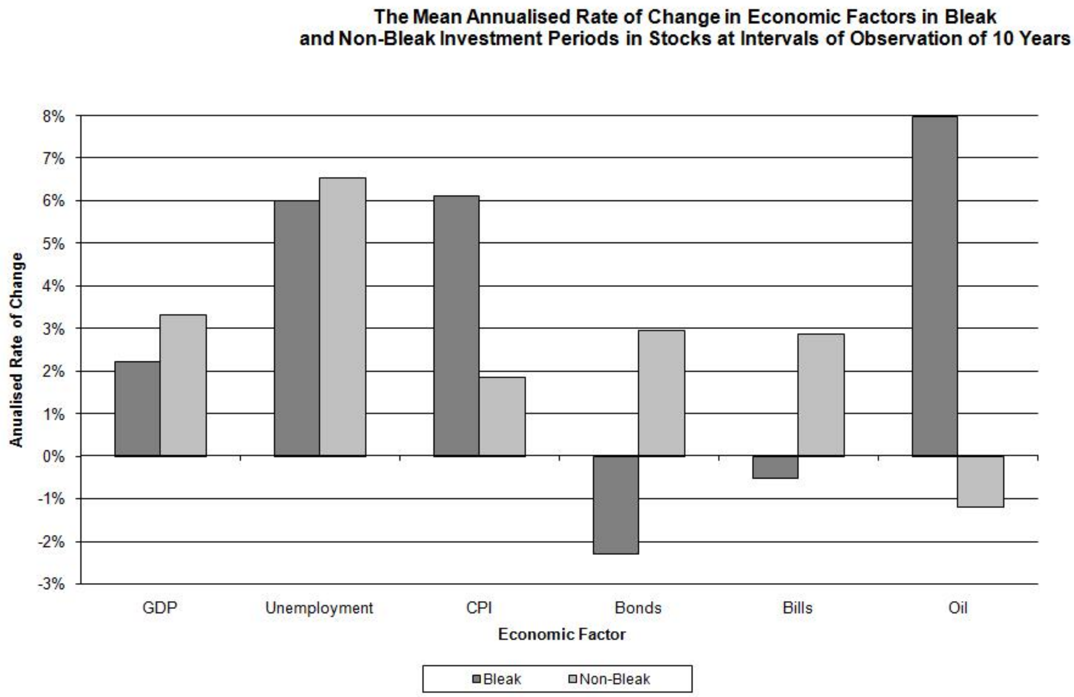


Figure 4.8 The Mean Annualised Rate of Change in Economic Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 20 Years

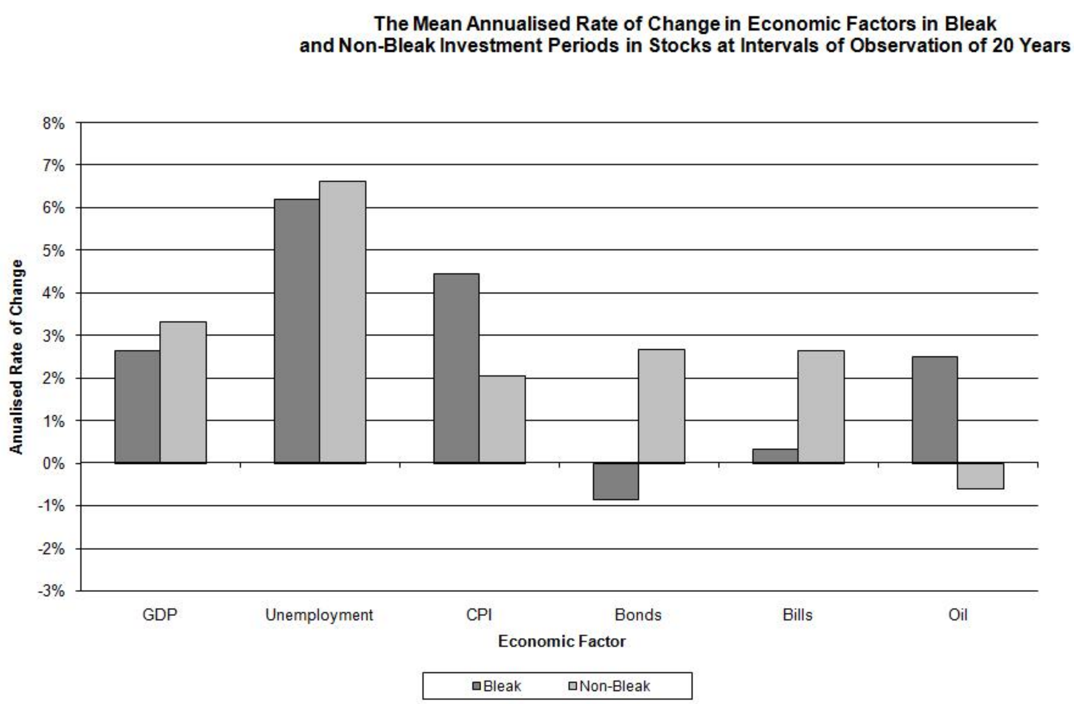


Figure 4.9 The Mean Annual Rate of Change in Metal Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 1 Year

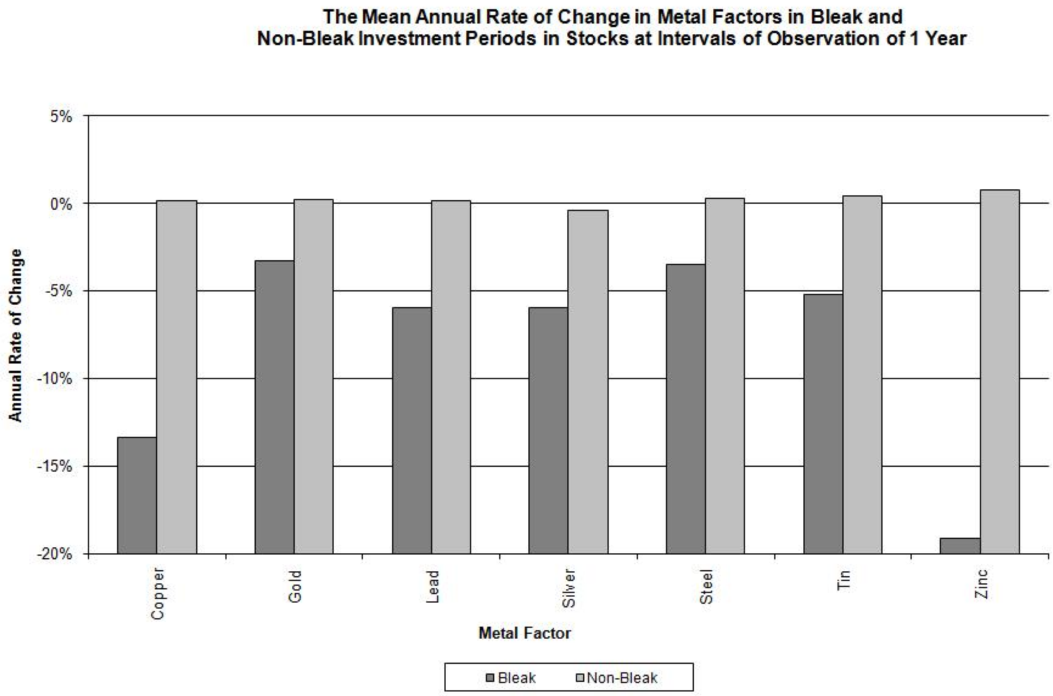


Figure 4.10 The Mean Annualised Rate of Change in Metal Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 10 Years

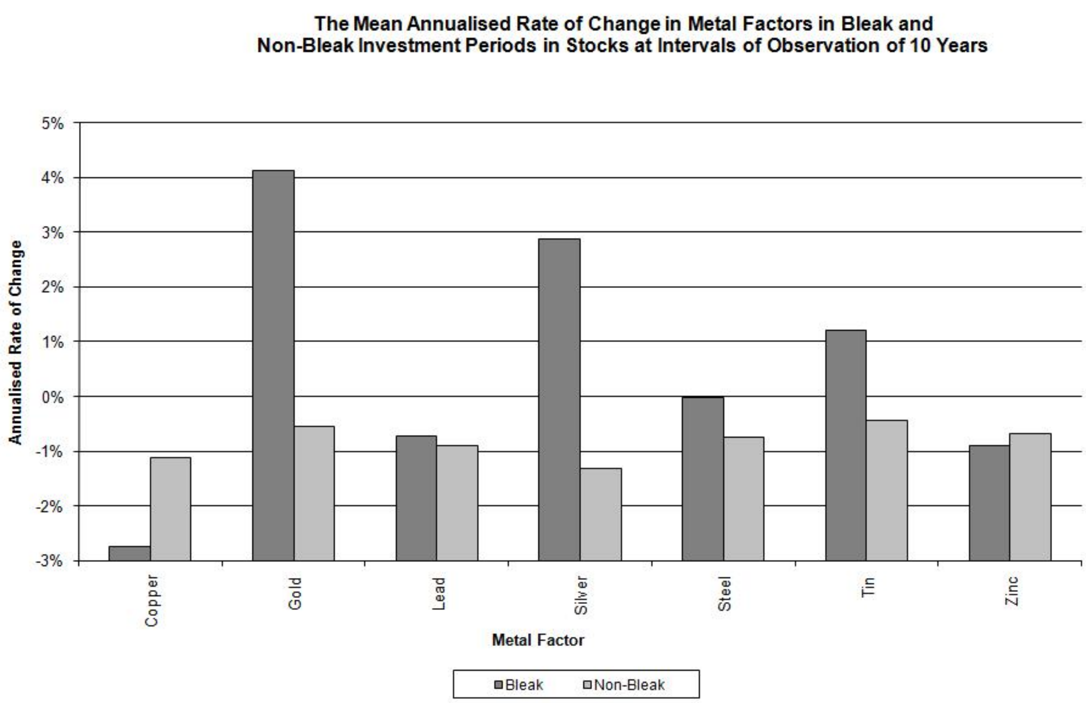


Figure 4.11 The Mean Annualised Rate of Change in Metal Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 20 Years

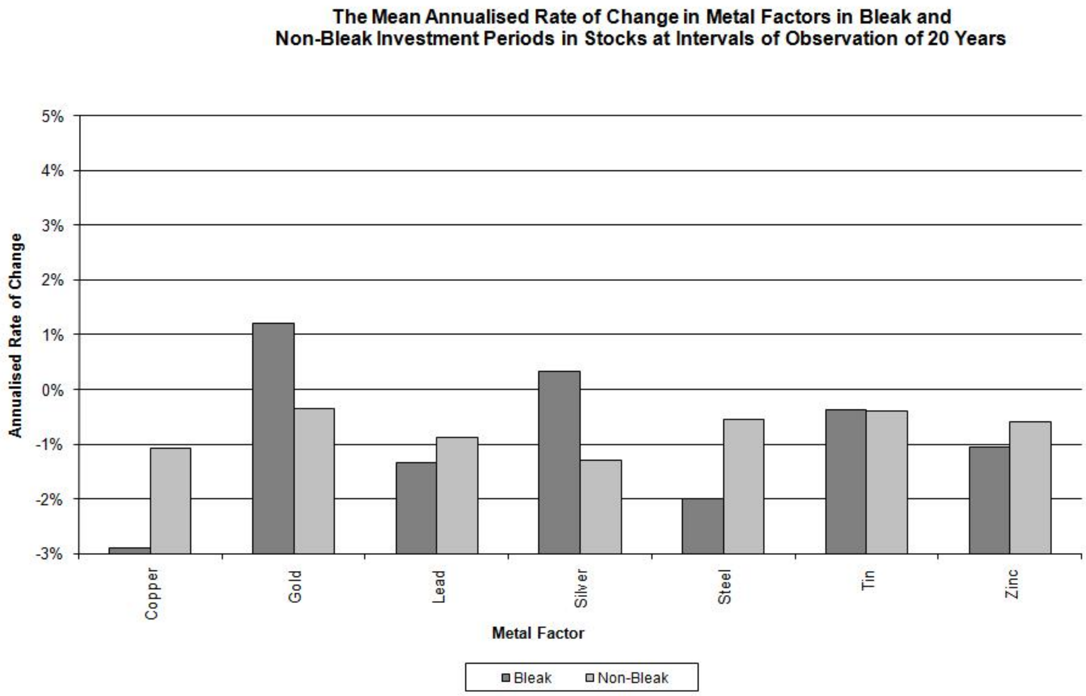


Figure 4.12 The Mean Annual Rate of Change in Agricultural Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 1 Year

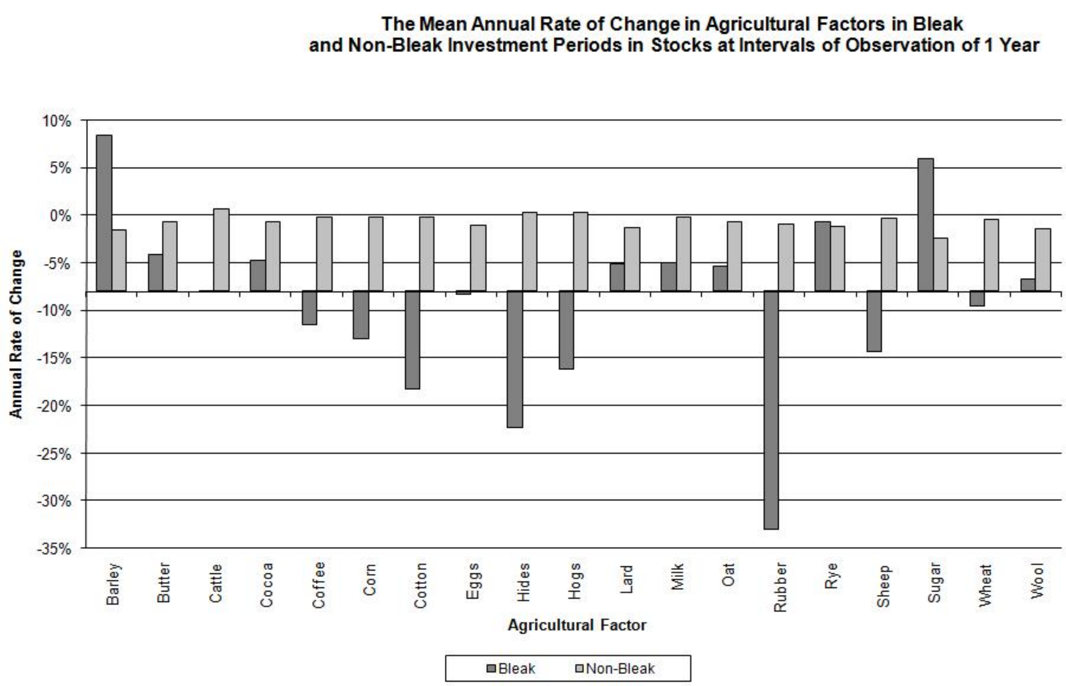


Figure 4.13 The Mean Annualised Rate of Change in Agricultural Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 10 Years

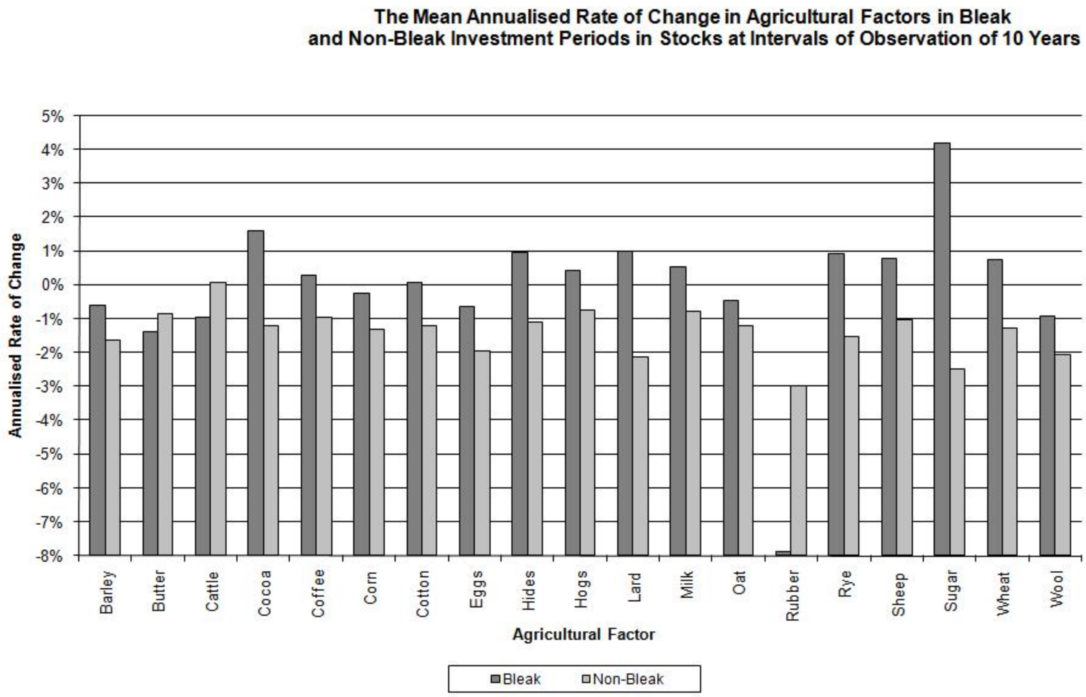


Figure 4.14 The Mean Annualised Rate of Change in Agricultural Factors in Bleak and Non-Bleak Investment Periods in Stocks at Intervals of Observation of 20 Years