

1. Introduction to the Financial Markets

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1.1 The Financial Markets

Some indication of an improving global economic environment and stronger stock market pushed government bonds lower this week. (*Financial Times*, 25/26 August 2001)

The yield curve steepened sharply this week as more gloom descended on the economy and investors bet that the US Federal Reserve might cut interest rates by as much as 50 basis points in November (*Financial Times*, 27/28 October 2001)

How can the economic environment influence the values of various assets such as stocks and bonds? More specifically, how can we use such influences to get a better view of how some asset values will change? Even more preliminarily, what do these quantities such as “yield curve” and “basis points” mean for investors and those, like ourselves, who are trying to project the values of certain financial assets? If we can get a better view of asset values in the near future then we may sell those we expect to fall in price while holding on to those we expect to increase in value or even increase our holding of them. But how long is “the future”? How long ahead can we expect to get a worthwhile view that can be used in this way to make money?

Such a process of buying and selling financial assets is risky. This is particularly so in view of the fall in technology shares during 2001, from when they were heavily overpriced to the present, when a number of dotcom firms have gone bankrupt and even large companies are in financial difficulties, with reduced profitability. Even more risk has been added to the economic environment with the attack on the World Trade Center in New York on 11 September 2001. The subsequent reduction in air travel caused a fall of up to 50% in the share values of some airline companies. Numerous bailouts by governments of their local airlines, such as SwissAir, then occurred. Considerable amounts of personal and corporate investment were wiped out in the process. Clearly, predicting the future is made very much more difficult in the presence of such events, with the possibility of more to come. With increased risk must also come better risk assessment and control as an increasingly important part of financial asset management.

But how did we get here from the earlier days? How did the enormous financial services industry, with its decidedly global features straddling international frontiers, develop from the small beginnings of the local financial asset groups of the 18th and 19th centuries?

Various “quant” groups (a term denoting strong dependence on quantitative analysis), especially our own *NewQuant* team, have developed a number of techniques for prediction in the financial markets. To explain these processes to a wider audience, particularly those coming from Artificial Intelligence, we need to start by giving a brief description of the markets and how they function. We will then proceed to answer the questions raised above and related ones as we move through the book.

We start with money, the root of it all. The power of money grew commensurately with the Industrial Revolution. As this took off, increasingly large sums of money were needed to finance the building of factories, enabling goods to be produced for workers. As part of the growth of wealth new methods had to be introduced to support such financing, with new methods of raising money by temporary borrowing from the wealth-owning classes. Thus shares were issued in companies, which promised to pay to the holder a proportion of the profits of the issuing company as well as ultimate return of the capital. Some of these companies did not survive, but in the creative atmosphere of the Industrial Revolution enough became profitable for a flourishing market of such stocks to be created. These stocks had value in themselves, in terms of future share dividends and the level of company profits, and so began to be traded in their own right. Thus began the Stock Market. Assessments of the risk of stocks was important, and such measures as the price-to-earnings ratio are used in the process. Aggregates of stock prices were assembled, such as we now have in the FTSE 100 or FTSE 250 indices in the UK or the S&P 500 index in the USA, so as to give a measure to the overall rises or falls in the most successful and larger companies.

At the same time, governments were called on to provide an increasing range of benefits for their populaces. Each government had to achieve this by either taxing or borrowing. Thus arose the issuance of government bonds, which promised both a dividend at a certain rate of interest as well as repayment of the capital after a certain number of years (the time to maturity). These bonds were more secure than company stocks, since it was much less likely that a government would go bankrupt than would a company (although the value of a government bond could fall drastically if there was high inflation in the country). Banks, which had been developed as a repository of money and provided mechanisms for safe deposits of money over short periods, also issued their own stocks.

As the financial markets grew in size more complex instruments were also created. In order to reduce the risk of future loss of value, future contracts were devised. These were originally for pork bellies, say to be sold at a guaranteed price six months hence. Buyers of these contracts came forward, seeing an opportunity to make a profit, so allowing the formation of futures markets (first in Chicago), so as to allow “hands off” trading to occur, with the market acting as an unbiased intermediary (but also taking its cut of the proceeds) holding to account the buyer and seller of the contracts. Futures contracts were created in other commodities, and became increasingly important, so leading to a spread of futures markets. Further artificial assets were created to allow for leverage, the process in which an investor does not need to pay for the total cost of a futures contract but must only pay a fraction of that ahead of a final day of reckoning. Thus were created options, in which an option could be taken out on a certain asset, with the option allowing the holder to buy a certain asset at a certain price (related to its present price and expectations of

the possibility of it changing) at a certain future point. The option need not be exercised if the asset price fell so that the asset was not valuable enough to the prospective buyer; it would be exercised if the price rose enough above its present price at which the option was purchased. Thus the option buyer was only liable for the option price itself, only a small proportion of the actual asset price. In this way leverage could be obtained, and a smaller amount of outlay could lead to a much larger profit. Option pricing has since become a very important part of financial analysis, and has led to much mathematical development involved with stochastic time series.

1.2 Economics and the Markets

What drives the markets? We have already had some indication of factors achieving this in the quotations at the beginning of the chapter. Thus we have cited the general economic environment, the stock market, and interest rates on government and bank short-term lending. These are important, but there are also other factors that should not be neglected. Thus there will be actual costs of manufacturing commodities, such as cars, washing machines and refrigerators, or of manufacturing tools. These commodity prices will themselves be determined by the prices of the raw material, such as precious metals, used in the commodity manufacturing process. Such metals prices will therefore also be important in determining market profitability and hence stock values. Related raw materials for other goods, such as for chip manufacturing, also need to be considered.

Can we recognise, on economic grounds, the economic key players who can be said to drive the markets? The difficulty in so doing is that we need to take account of effects that are lagged by several months, even up to a year or more. Thus a writer in *The Economist* noted recently:

There is always a lag of 6–12 months before monetary policy has its main impact, but it traditionally works through lower long term bond yields, higher share prices and a weaker dollar. (“Get a Parachute”, *The Economist*, 25 August 2001)

If we take account of such longish lag times then we can expect, from this and many other analyses, that monetary policy (levels of interest rates set by central governments, amounts of money supplied, amounts of bonds issued) will play an important role in stock and bond prices month-on-month. This may not be so evident at a higher frequency, such as day-by-day, since the money transmission mechanisms present in the complex economy impact relatively slowly. This goes through the line of changes that have to be taken up by interest-paying company borrowings, which themselves affect factory prices which then impact on consumers and thence profits. This changes demand and confidence in a stock or in the stock market as a whole, and thereby also causes changes in demand in bonds (usually regarded as a safe haven compared to riskier stocks). As noted in the quotation, these effects are delayed. More rapid response can occur day-on-day owing to monetary decisions, but these have a tendency to be smeared out by the numerous effects of local and global disturbances that appear more as the noise seen in the returns, such as shown in the US bond returns of Fig. 1.1.

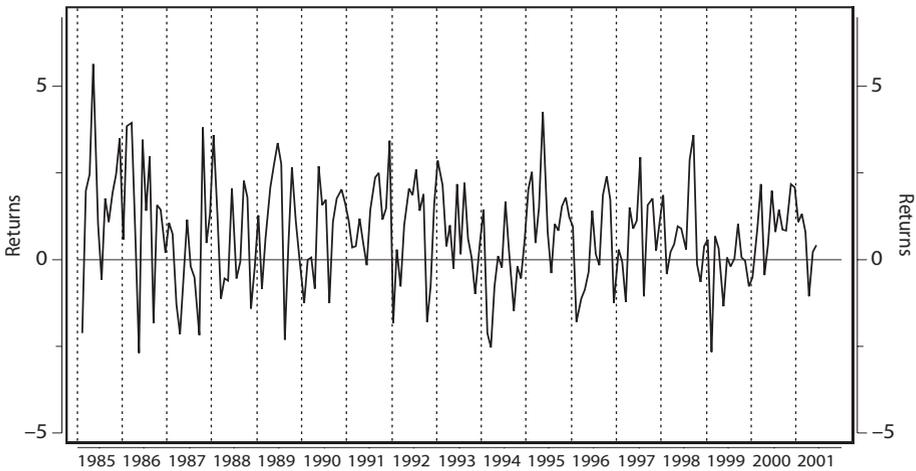


Fig. 1.1 US bond returns.

Thus while we can recognise key players it appears difficult to use them to build *ab initio* models of their effects on market prices. This is to be compounded with market psychology. For investors are strongly swayed by general market sentiment. Thus the rumour “sell – sell – sell” can sweep the markets, driving prices down ever lower; alternatively, and as occurred during the late 1990s, prices can rocket by means of the phenomenon of “irrational exuberance”, leading to the “buy – buy – buy” signal swirling around. Both of these effects involve positive feedback – if a lot of traders sell a stock the price will drop, encouraging more to sell. Thus to take account of these psychological effects we must turn to models which include some aspects of these crowd-following features. We will close the book with a brief description of the most recent exciting approach of multi-agent modelling to begin to take some account of these interesting aspects.

1.3 Financial Markets and Economic Data

The data we have available is of two sorts. One is of time series of economic data: for each major country the GDP, money supplies (M1, M2, ...), interest rates, unemployment level, and so on. This data is only collated monthly, if not quarterly. It cannot be obtained with higher frequency since it is difficult to collect and also may not change enormously over the period of a month. It is possible to interpolate between data points so as to produce values every week or even every day. However, the basic problem here is as to what interpolation method is to be used. If we take only the information provided then no new data occurs, and only a constant interpolation is justifiable. Other methods could be employed, such as using a piecewise linear fit, or fitting with a polynomial. But there is no justification for any of these, as we have already noted. Thus if we wish to employ economic data for which we have information, then only a monthly approach can be used.

We meet a discrepancy when we turn to financial data, for that is available at a much higher frequency, often tick-by-tick, but at least daily. We can attempt to correlate market returns with overall changes in the economy. Since some data is available between end of month times, it is more natural, at the higher frequency end, to consider particular stock values as being driven in a more sectorial manner and tied into other higher frequency data relevant to that sector. Thus the price of oil and of relevant commodities may be expected to have the most important effects on the day-to-day values of a particular stock. However, stock indices, which combine a range of stocks across all sectors, cannot expect to be driven only, or even in the main, by such factors. These indices will be responding also to market sentiment (crowd-driven, by rumour and new information mixed together) over the short term. Over the long term we can expect to see the influence of economic variables playing their lagged role. Yet again we cannot expect to be able to deduce specific models of this dependence.

Bond prices are also available at a much higher frequency compared to economic data. What has been said above for stocks can apply to them *mutatis mutandis*.

Finally we must consider exchange rates; they have the highest frequency of all. In the longer term they are clearly affected by economic factors. For example, research at Dresdner Kleinwort Wasserstein has shown that in the last decade movements of the exchange rate of the euro (before 1999 by its constituent currencies) against the dollar have closely reflected the difference between productivity growth in the euro area and the US. This is consistent with our earlier discussion of economic monetary values driving other assets. However, this will not be true in the short term, where dealer psychology is to be expected to play a much stronger, if not totally overwhelming, role.

Behind all this is the question: are the markets predictable at all? This is related to the Efficient Markets Hypothesis: that it is not possible to forecast the return on an asset and that all relevant market information has already been incorporated in its price. This will be discussed more fully in Chapter 3, but suffice it to say here, supported by the quotes on impacts of monetary decisions on bond and asset prices, that the markets do have some degree of predictability. There is still information that has not been incorporated in the price of some assets, and careful search for such fundamentals can lead to valuable forecasts.

We will consider various modelling technologies throughout the book, and in the process indicate that markets are not completely efficient. Increasing uses of forecasting models in the future will undoubtedly tend to make for higher market efficiency. Complete efficiency has not yet arrived, however.

1.4 What Are We Predicting?

Let us summarise the points of the preceding sections

- Economic effects make their evident mark on financial assets over the longer rather than the shorter term (over months rather than days).
- The drivers of changes in financial assets in the shorter term (over days) are difficult to assess, but undoubtedly include changes in market sentiment as well as shorter-term “shocks”.

- The most secure financial assets are government bonds rather than company stocks, while among stocks it is preferable to consider stock indices rather than individual stock values themselves.

Contrasting these features leads us to consider as our basic financial assets a portfolio of Government bonds and equity indices. Moreover, we will consider the G7 countries rather than developing countries. This is due to the higher risk of these latter assets.

Taking note of the summary above, if we also wish to use economic fundamentals to help improve our prediction efficiency then we must restrict ourselves to monthly data. Thus our candidate series for prediction (as used in examples in this book) are:

- **Bonds:** US, UK, Germany and France (now becoming the European bond in 2002), Japan, Canada and Australia (instead of Italy).
- **Equity indices:** MSCI (Europe), DAX, TOPIX, S&P500, FTSE100.
- **Fundamentals** used as model inputs: a large range is available, but we use financial advice to reduce them to about 40–80 overall time series. From these we have to search for suitable lagged variables, examining lags of up to 24 months, to pick out from 10 to 50 variable which can encompass the driving force on the target time series.

That is our prediction task. It involves searching through up to 1200 lagged variables to determine suitable fundamentals for our target series, as well as constructing suitable prediction models, combining them for a given market and then designing a portfolio.

We turn to describing more specifically the overall components of this process in the following section.

1.5 The Overall Process

The overall process used by the *NewQuant* team contains components needed in any attack on forecasting of assets. This follows from the nature of the time series being forecast and of the information available from fundamentals, as discussed earlier in this chapter. Thus the following stages have been developed to obtain a final proposal of allocations of assets in a portfolio investing either solely in G7 bonds (and cash) or in both G7 bonds and equity indices:

- **Data analysis**, in which the candidate input series to act as fundamentals are analysed statistically to ensure they possess suitable characteristics to be able to serve the purpose. Those input time series which are unsatisfactory are rejected (usually about a few per cent).
- **Data selection**, where analysis is developed to search through the remaining time series for the most deserving candidates to act as fundamentals in models then to be built.

- **Model building**, where a number of models are constructed on the basis of the previously selected candidate fundamental series, these models being tested to ensure they reach certain levels of forecasting effectiveness.
- **Prediction combining**, in which the various predictions of a given asset made by different model technologies are combined to give a single asset prediction, with a weighting that takes into account the historical success levels of the various model technologies.
- **Portfolio allocation**, involving the allocation of the various assets on the basis of the combined predictions just made for the following month, possibly also taking account of prediction uncertainty (or spread).
- **Advice** sent to clients to act accordingly, with an account of the nature of the results.

This overall process involves a number of stages, each of which is somewhat complex. Thus work has been ongoing on all the stages to continually improve them in the light of new ideas and technology arising from Artificial Intelligence as especially applied to financial forecasting. It is these stages, and related topics, which will be developed throughout the book. It will thus cast light across a number of areas, each of which has been developed to a level of expertise which appears appropriate to attempt to describe in a connected form.