BANK OF ENGLAND

Quarterly Bulletin

2017 Q2

Topical article

An improved model for understanding equity prices

ISSN 2399-4568

An improved model for understanding equity prices

By Will Dison and Alex Rattan of the Bank's Macro Financial Analysis Division.[1]

- Central bank policymakers monitor equity prices, alongside a range of other asset prices, to support both their monetary and financial stability objectives.
- A Dividend Discount Model (DDM) is a simple type of model that can be used to help understand past moves in equity prices. DDMs are based on the net present value relationship that relates equity prices to expected future shareholder payouts, risk-free interest rates and compensation for risk.
- The Bank has recently improved its DDM. The revised model accounts for share buybacks and variation over time in long-term growth expectations. It also better captures the variation in risk-free interest rates across maturities.

Overview

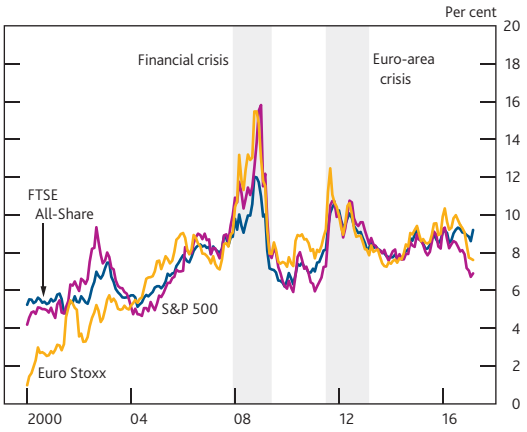
Central bank policymakers monitor equity prices, alongside a range of other asset prices, to support both their monetary and financial stability objectives. Equity prices contain information about the current state of the economy and the economic outlook. They are also one channel through which monetary policy operates. And equity price moves can provide signals about financial stability risks, as well as being a source of risk in their own right.

Dividend Discount Models (DDMs) are a simple type of model that can be used to help understand past moves in equity prices. DDMs are based on the net present value relationship that relates equity prices to expected future shareholder payouts, risk-free interest rates and compensation for risk. DDMs can be used to estimate the equity risk premium (ERP), a key variable that captures the additional return that investors expect to receive from equities relative to risk-free assets, to compensate them for the market risk associated with holding equities (**summary chart**). DDMs can also decompose past moves in equity prices into the contributions of changes in growth expectations, risk-free interest rates and the ERP.

The Bank has recently improved the specification of its DDM in a number of ways. First, the modelling of dividend expectations has been made more sophisticated so as to capture changes over time in the rate at which dividends are expected to grow in the long run. Second, the model now incorporates share buybacks, an alternative channel through which firms can return cash to shareholders, alongside dividend payments. And third, the new model better captures the variation in risk-free interest rates across maturities. These changes to the Bank's DDM should improve the accuracy of the model's decompositions and ERP estimates, aiding the Bank's monitoring of equity price moves in support of its policy objectives.

Summary chart The risk compensation associated with equities rose sharply during the financial and euro-area crises

DDM estimates of equity risk premia for international equity indices(a)



Sources: Bloomberg, IMF *World Economic Outlook*, Thomson Reuters Datastream and Bank calculations.

(a) Monthly averages.

(1) The authors would like to thank Ryan Murphy for his help in producing this article.

Introduction

Central banks monitor equity prices, alongside a range of other asset prices, to support both their monetary and financial stability objectives. This article describes a simple type of model, called a Dividend Discount Model (DDM), that can be used to help understand moves in equity prices. As well as describing improvements the Bank has recently made to its DDM, the article illustrates how the model can be applied to shed light on the moves in equity prices since the early 2000s.

The article is structured as follows. The first section discusses why central bank policymakers monitor equity prices. The second section establishes a framework — the net present value relationship — for analysing moves in equity prices and discusses how DDMs utilise this relationship. It also discusses how DDMs are used by policymakers. The third section sets out in more detail the specification of the Bank's DDM and the improvements that have recently been made to this. The fourth section of the article discusses the uncertainty around the model's estimates of the ERP. Finally, the fifth section illustrates an application of the model to help understand equity price moves since the early 2000s. A box discusses the economic theory underlying the expected return on equities and the factors that drive the variation in this expected return over time.

Why are policymakers interested in equity price moves?

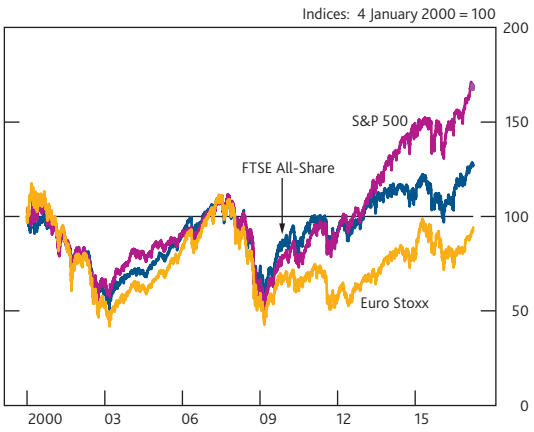
Central bank policymakers monitor equity prices for a range of reasons. One reason is that equity prices contain information about the economic outlook. An equity claim entitles an investor to a share of a firm's future profits. If investors revise up their expectations for future macroeconomic growth, and hence firms' profits, they will value equities more highly, driving up equity prices. The information from equity prices may also be timelier than that from other sources, which are often available only with a lag.

Equity prices can also convey information about the degree of uncertainty around the outlook. Investors dislike uncertainty, so equity prices tend to be lower when there is wider uncertainty about how the economy will evolve. **Chart 1** shows that international equity indices fell sharply during 2007–09 and during 2011. These episodes coincided with the onset of the financial crisis and the euro-area crisis respectively, periods of elevated macroeconomic uncertainty. This rise in uncertainty will have pushed down on equity prices, alongside the weakening in the growth outlook.

Another reason central banks pay close attention to equity prices is that they are one channel through which monetary policy operates.(1) All else equal, a looser monetary policy stance will tend to raise equity prices. Higher equity prices increase households' financial wealth, so boosting consumer spending. Higher equity prices also reduce firms' cost of equity finance, which will influence their investment decisions. In turn, higher aggregate demand should feed through into higher inflation.

Chart 1 Equity prices fell sharply during the financial and euro-area crises

International equity indices(a)



Sources: Bloomberg and Bank calculations.

(a) Local currency terms.

Monitoring equity prices is also key to supporting the Bank's financial stability objectives. If equity prices are high relative to macroeconomic fundamentals they may be more vulnerable to sharp falls. In turn, that could induce equity holders to sell other assets, generating spillovers to other markets. The Bank's stress tests assess the resilience of UK banks to a range of risks, including sharp falls in equity prices. In practice, assessing the appropriate level of equity valuations is challenging and policymakers base their judgement on a range of valuation metrics.

Policymakers typically monitor equity prices at an aggregate level. For example, movements in broad equity indices may convey information about the economic outlook for a country or economic area. But the Bank also looks at equity prices at more granular levels. For example, variation in equity prices across sectors can shed light on the composition of economic growth and on how shocks are propagating through the economy. And moves in the equity prices of individual regulated firms, including banks and insurance companies, could indicate changes in investors' assessment of firms' prospects, and hence can act as a useful indicator to supervisors.

It is important to understand the drivers of moves in equity prices, as these could have different implications for policy. For example, a fall in equity prices could reflect a weakening in the growth outlook or a rise in macroeconomic uncertainty. The next section sets out a simple framework for analysing equity price moves.

(1) The monetary policy transmission mechanism is discussed in more detail in Bank of England (1999). Joyce, Tong and Woods (2011) discuss the channels through which quantitative easing affects the economy.

A framework for analysing equity prices

Expected returns

On average, the return on equities tends to be higher than the return on less risky assets, to compensate investors for the greater degree of uncertainty associated with equity returns. A bond issued by a creditworthy sovereign is close to being risk free, as the return on holding the bond to maturity is known at the outset. By contrast, the return on an equity investment is more uncertain, as it will depend on a firm's future profits, which in turn depend on the wider macroeconomic environment. And since equity liabilities rank below debt liabilities in a firm's capital structure, if a firm becomes bankrupt and is wound up, equity holders will only receive any value that remains once all creditors have been repaid.

In order to induce investors to hold equities despite their greater riskiness, investors must expect to receive a higher return on equities than on risk-free assets such as government bonds. This expected excess return is called the equity risk premium (ERP). In symbols,

$$\textit{Expected equity return} = R^f + ERP \tag{1}$$

where R^f is the risk-free rate, the hypothetical return on an asset whose return is known with certainty. The box on page 93 discusses in more detail the economic determinants of the ERP.

It is possible to derive a simple formula connecting equity prices to dividend expectations and the ERP. If an investor buys an equity today with the intention of selling it in one year's time, the return they expect to make on that investment is given by

$$\textit{Expected equity return} = \frac{\mathrm{E}_t(P_{t+1}) + \mathrm{E}_t(D_{t+1})}{P_t} \tag{2}$$

where $\mathrm{E}_t(P_{t+1})$ is the investor's expectation today for the price of the equity in one year's time, $\mathrm{E}_t(D_{t+1})$ is the investor's expectation today for the dividend payments they will receive over the year and P_t is the current price of the equity. Combining the two previous equations gives

$$P_t = \frac{\mathrm{E}_t(P_{t+1}) + \mathrm{E}_t(D_{t+1})}{R^f + ERP} \tag{3}$$

This formula shows how equity prices contain information about the economic outlook. Equity prices today (P_t) will be higher if investors expect macroeconomic growth to be stronger and hence future dividend payments (D_{t+1}) to be higher. And when investors are more uncertain about the future, the expected excess return on equities needs to be higher to induce them to hold equities instead of bonds. That is reflected in a higher ERP and lower equity prices.

The net present value framework

The previous formula relates equity prices to expectations for dividend payments over the coming year. But equity prices will also depend on investors' expectations for the level of dividends that will be paid by firms in future years. Applying a similar argument to that used above it can be shown that

$$P_t = \sum_{k=1}^{\infty} \frac{\mathrm{E}_t(D_{t+k})}{(R_k^f + ERP)^k} \tag{4}$$

Here $\mathrm{E}_t(D_{t+k})$ denotes investors' expectations today for the level of dividends that will be paid out in k years' time, R_k^f denotes the annual return on a risk-free investment that is made today and pays off in k years' time, and the summation operator $\sum$ indicates that discounted expected dividends are summed over every future year. This formula — the net present value relationship — states that equity prices equal the expected level of future dividends, discounted by risk-free interest rates plus an additional expected return to compensate investors for exposure to the risk associated with holding equities. This relationship is at the heart of a class of models called Dividend Discount Models (DDMs) that can be used to help understand moves in equity prices.

Dividend Discount Models

DDMs have two key uses. First, they can be used to estimate the ERP, an important variable for policymakers. For example, changes in the ERP will affect firms' cost of capital, which may in turn influence their plans for investment, including in machinery, skills and research. For this reason, an estimate of the ERP from the Bank's DDM feeds into models that influence the Monetary Policy Committee's investment forecast and hence its forecast for wider economic growth. The ERP can also provide a signal about uncertainty. For example, a high ERP could indicate that uncertainty about the macroeconomic outlook is high. That may have implications for households' spending decisions and firms' investment choices (Haddow *et al* (2013)). From a financial stability perspective, a low ERP could indicate that equity valuations are stretched relative to macroeconomic fundamentals, potentially increasing the risk of sharp price falls. Estimates of the ERP from the Bank's DDM are therefore one of a range of indicators that the Bank monitors to assess equity valuations.

The ERP cannot be observed directly, however, so a model is needed to estimate it. DDMs estimate the ERP using the net present value relationship set out above. With the exception of the ERP, all of the terms in this relationship can either be observed or approximated. The prices at which equities are traded in the market can be observed. No asset is completely risk free, but risk-free rates can be approximated by the yield on bonds issued by creditworthy sovereigns. And the level of future dividends can be forecast, for example using models based on firms' recent dividend payments and macroeconomic projections. Alternatively, dividend expectations can be

inferred from survey data. An estimate of the ERP is then given by the value that makes the net present value relationship hold.

The second key use of DDMs is to decompose equity price moves into the contributions of changes in risk-free rates, the ERP and growth expectations. Such a decomposition is obtained by successively varying, one at a time, each of the three terms on the right-hand side of the net present value formula and determining the associated change in equity prices according to that relationship.

Care is needed when interpreting DDM decompositions, as the components of such a decomposition do not represent structural drivers of equity price moves, but mixes of more fundamental factors. For example, a strengthening in the demand outlook is likely to be associated with a rise in equity prices, reflecting expectations of higher firm profits and greater payouts to shareholders. But this scenario is also likely to be associated with an increase in market interest rates, reflecting expectations that monetary policy will be tightened to offset the associated rise in inflationary pressure. A DDM decomposition will therefore show a positive contribution from higher payout expectations and a negative contribution from higher risk-free interest rates.

Nevertheless, DDM decompositions are still a useful tool to aid policymakers in understanding equity price moves. For example, a fall in equity prices could reflect a deterioration in investors' expectations for firms' earnings and dividends, or a rise in the ERP. The first of these drivers might be associated with a weakening in the central case outlook for economic growth, while the second might instead point to a rise in the uncertainty around that central case. These scenarios could have different policy implications.

Since any model is subject to uncertainty, the Bank also employs a range of other models, alongside the DDM, to aid its monitoring of equity prices. These include alternative models to estimate the ERP, such as an approach that forecasts future equity returns based on a panel of predictor variables (Chin and Polk (2015)). Other models relate equity prices to macroeconomic variables, or seek to estimate the structural drivers of equity price moves.

This section has set out the general features of DDMs. In practice, however, DDMs vary widely in their exact specifications. Different approaches can be used to forecast future dividends, and different measures of risk-free rates may be used. The Bank has recently improved the specification of its DDM, which is set out in the next section.

The Bank's Dividend Discount Model

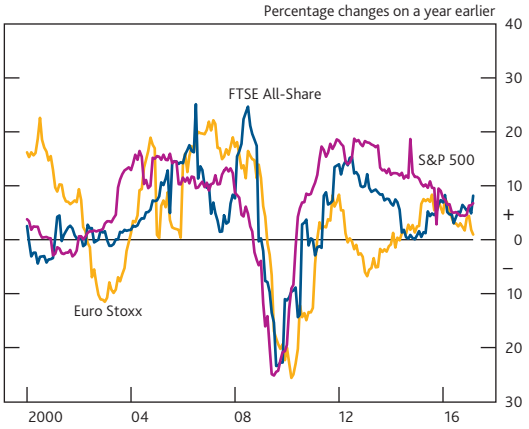
The previous version of the Bank's DDM was described in Inkinen, Stringa and Voutsinou (2010). The new model improves on this specification in three ways. First, the modelling of dividend expectations has been made more sophisticated so as to capture changes over time in the rate at which dividends are expected to grow in the long run. Second, the model now incorporates share buybacks, an alternative channel through which firms can return cash to shareholders, alongside dividend payments. And third, the new model better captures the variation in risk-free interest rates across maturities.

Modelling dividend growth

A key input to a DDM is an estimate of the expected level of future dividends. DDMs vary in how they estimate this quantity. A simple approach is to assume that dividends are expected to grow in line with past average growth rates.(1) But in reality dividend growth rates tend to vary over time, with dividends rising faster during booms when firms' profits are growing strongly, and rising more slowly, or even falling, during recessions (**Chart 2**). That suggests that expected future dividend growth rates are also likely to vary over time.

Chart 2 Dividend growth varies over time

Dividends paid by listed firms(a)



Sources: Thomson Reuters Datastream and Bank calculations.

(a) Refers to dividends paid over a twelve-month period. Dividends are calculated as the product of the dividend-price ratio and the equity index price level. For the Euro Stoxx, the dividend-price ratio for the Datastream euro-area total market index is used.

A variety of approaches can be used to capture the time variation in expected dividend growth. Bottom-up approaches use equity analysts' forecasts for individual firms' future dividends, based on firms' profits, investment and business plans, and prospects in the sector in which the firm operates. These firm-level dividend forecasts are then aggregated to produce forecasts for the combined dividends paid out by all the firms in an equity index. By contrast, top-down approaches are based on projections for future GDP growth, for example from macroeconomic models. The past relationship between GDP growth and dividend growth is used to transform the GDP projections into projections for the aggregate level of dividend payments. In practice, the Bank's

(1) This assumption gives rise to a simple type of DDM called the Gordon growth model (Gordon (1962)).

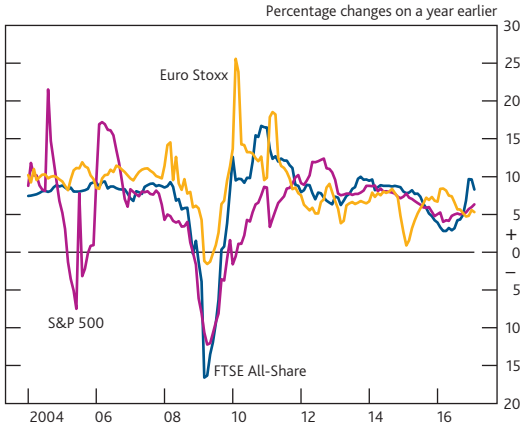
DDM uses a bottom-up approach to model short-horizon dividend expectations and a top-down approach to model longer-horizon dividend expectations.

Short-term growth expectations

The Bank's DDM measures short-horizon dividend expectations using survey data from equity analysts. Equity analysts monitor individual companies and provide forecasts for a range of each firm's accounting variables. The Institutional Brokers' Estimate System (IBES) aggregate firm-level forecasts covering around 20,000 companies to produce aggregate forecasts for dividends at an equity-index level. **Chart 3** shows that the IBES dividend growth forecasts vary with the economic cycle, for example falling during 2008 and early 2009, around the time of the financial crisis.

Chart 3 Expected future dividend growth varies over time

IBES twelve-month ahead dividend growth forecasts[a]



Source: Thomson Reuters Datastream.

(a) Forecasts for dividends over the coming twelve months.

IBES produce forecasts at a range of horizons. At the aggregate level, annual dividend growth forecasts are available at the one, two and three-year horizons. IBES also produce a longer-term dividend growth forecast. In the Bank's DDM the longer-term forecasts are used to model dividend expectations at the four and five-year horizons. **Chart 4** shows that the IBES dividend growth forecasts typically vary across horizons, another feature of the data that would not be captured by the simple assumption that future dividends were expected to grow in line with past averages.

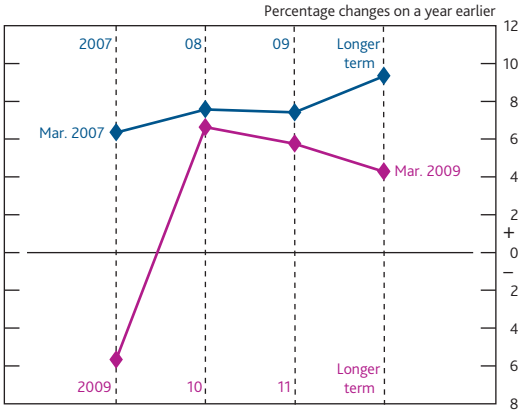
As discussed in the next section, the accuracy of the IBES forecasts is a key source of potential error in the DDM. The IBES forecasts may be imperfect measures of actual expectations, for example if they lag changes in actual expectations or if they are overly optimistic about firms' prospects. The aggregation of forecasts across firms should mitigate any idiosyncratic firm-specific errors in the forecasts, but would not remove any such systematic bias.

Long-term growth expectations

A simple approach to modelling longer-term dividend growth expectations is to assume that these are constant over time.

Chart 4 Expected dividend growth rates vary across horizons

IBES dividend growth forecasts for the FTSE All-Share



Source: Thomson Reuters Datastream.

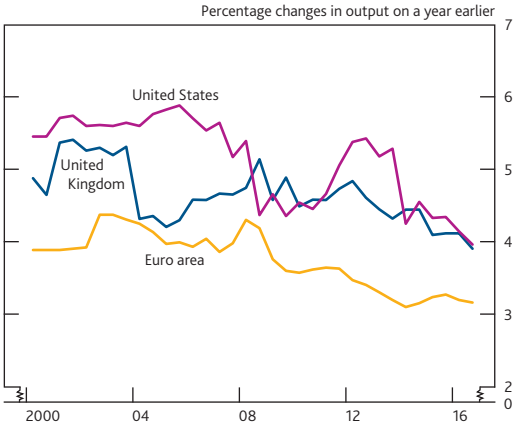
This might be more reasonable than assuming that short-term growth expectations are constant. Long-term growth expectations are likely to be more stable than short-term growth expectations, as their horizon is longer than the typical length of business cycles. The Bank's previous DDM, in common with many other DDMs used elsewhere, took this approach. It assumed that, beyond the five-year horizon, dividends were expected to grow in line with average historic GDP growth rates.

In reality, however, expected long-term dividend growth rates are likely to vary over time. For example, expected long-term GDP growth might have fallen since the financial crisis.

The Bank's revised DDM captures time-variation in long-horizon dividend growth expectations by tying these to long-term GDP projections. Specifically, the model assumes that beyond the five-year horizon, dividends are expected to grow in line with five-year ahead GDP forecasts produced by the International Monetary Fund (IMF). These forecasts have indeed trended down somewhat since the financial crisis (**Chart 5**).

Chart 5 Long-term growth forecasts have declined since the financial crisis

IMF five-year ahead nominal GDP forecasts



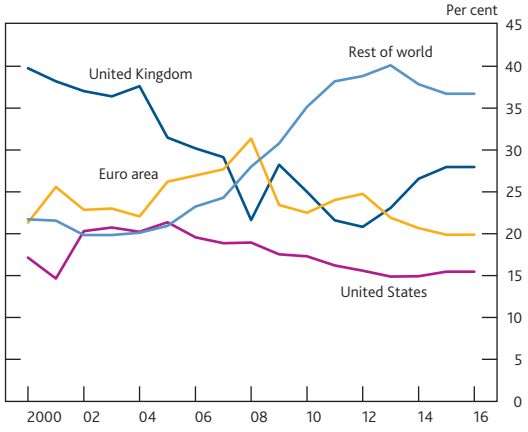
Sources: IMF *World Economic Outlook* and Bank calculations.

Regional exposures

The FTSE All-Share has a high degree of international exposure. Firms in the index generate around 70% of their revenues outside of the United Kingdom (Liu (2016)) (**Chart 6**). And the overseas exposure of the index has grown since 2000, particularly its exposure to regions outside of the United States and euro area. The S&P 500 and Euro Stoxx are also internationally exposed, although to a lesser degree.

Chart 6 The FTSE All-Share has a high degree of international exposure

Estimated proportion of FTSE All-Share firms' revenues generated in each region



Sources: Thomson Reuters Datastream and Bank calculations.

Firms' international exposure means that their profits, and hence dividends, will be influenced by overseas as well as domestic economic developments. That may mean that it is inappropriate to model the long-term expected dividend growth of an equity index as being a function of the outlook for the domestic economy alone.

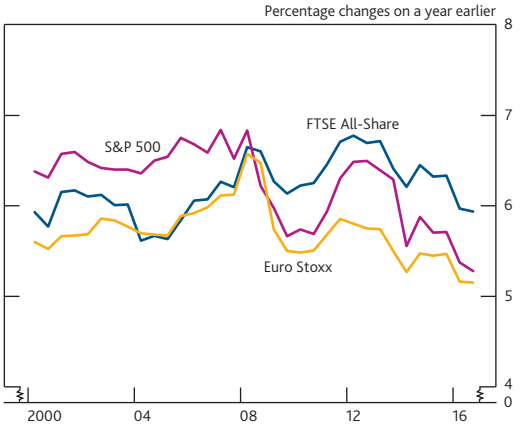
The Bank's new DDM attempts to capture the influence of the overseas growth outlook on the prospects for an equity index's dividend growth. The model assumes that at long horizons dividends are expected to grow in line with a weighted average of the long-term GDP forecasts for different regions. The weight on each region is chosen to match the share of revenues that firms in the equity index derive from that region. The weights vary over time, reflecting the changing geographic exposures of each index. **Chart 7** shows the resulting long-term dividend growth forecasts. In recent years, these forecasts have pointed towards the outlook for long-term dividend growth being stronger for the FTSE All-Share than for the S&P 500 and Euro Stoxx. That reflects the stronger growth outlook in emerging markets relative to advanced economies, and the greater exposure of FTSE All-Share companies to those regions.

Share buybacks

Share buybacks are an alternative channel through which firms can distribute cash to shareholders, alongside dividend payments. In a share buyback operation, a firm purchases its own shares for cash, reducing the number of shares outstanding.

Chart 7 The long-term dividend growth outlook is stronger for the FTSE All-Share than for the S&P 500 and Euro Stoxx

Long-term dividend growth forecasts

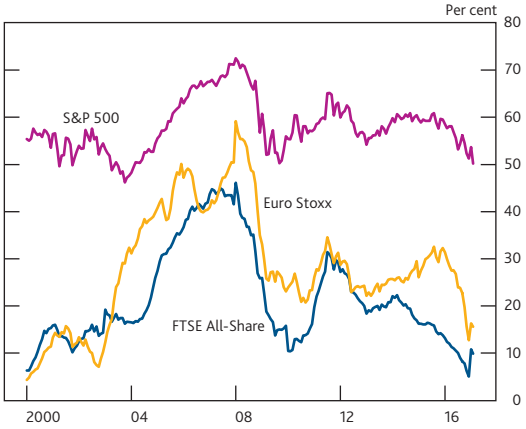


Sources: IMF *World Economic Outlook*, Thomson Reuters Datastream and Bank calculations.

The prevalence of share buybacks varies across countries and over time. Share buybacks are particularly important in the United States, where they typically account for over half of all cash distributed to S&P 500 shareholders (**Chart 8**). In recent years buybacks have declined in importance for FTSE All-Share firms, and now represent only around 10% of the index's shareholder remuneration. Buybacks tend to be more volatile than dividends, growing strongly during booms and falling back sharply when economic growth slows. This pattern may reflect firms' preference for maintaining the level of dividend payments over time and using buybacks as the marginal tool for varying shareholder remuneration.

Chart 8 Share buybacks are a significant component of shareholder remuneration in the United States

Share buybacks as a proportion of total shareholder remuneration



Sources: Bloomberg, Thomson Reuters Datastream and Bank calculations.

In common with many DDMs used elsewhere, the Bank's previous DDM did not account for share buybacks. That may have been associated with a downward bias in the model's estimates of the ERP. That bias is likely to have been greatest

for the S&P 500, given the importance of share buybacks for firms in that index. Accounting for buybacks raises the expected level of future shareholder payouts assumed in the model. All else equal, that pushes up on the level of expected future equity returns implied by the model, so raising the estimated ERP.

The omission of buybacks may also have distorted the time profile of the model's ERP estimates. For example, the declining importance of buybacks for FTSE All-Share firms over recent years would have been associated with a reduction in the degree of the downwards bias. That may have been reflected in the model-implied ERP rising more sharply than would otherwise have been the case.

The Bank's DDM now incorporates share buybacks. Since buybacks are economically similar to dividend payments, when valuing equities investors should account for the cash they expect to receive through both channels. The net present value relationship thus becomes

$$P_t = \sum_{k=1}^{\infty} \frac{E_t(D_{t+k} + B_{t+k})}{(R_k^f + ERP)^k} \quad (5)$$

where $E_t(B_{t+k})$ denotes investors' expectations today for the level of cash they expect to receive through share buybacks in k years' time.

One challenge in accounting for share buybacks in a DDM is the measurement of expectations about future buybacks. Equity analyst forecasts for future buybacks are not readily available. In practice, the Bank's DDM therefore assumes that buybacks are expected to grow at the same rate as dividends. Although both components of shareholder remuneration are assumed to be expected to grow at the same rate, accounting for buybacks raises the starting level of payouts, and so increases the expected future level of payouts as well.

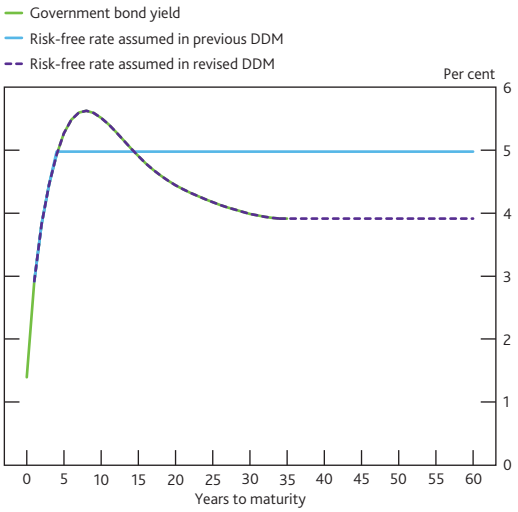
Risk-free rates

The Bank's DDM approximates risk-free interest rates by the yields on government bonds. For the FTSE All-Share and S&P 500, the model uses the yields on UK and US government bonds respectively. For the Euro Stoxx, the model uses yields derived from a combination of French and German government bonds. No government bond is truly risk free as it will always be subject to some risk of default, even if this is small. But as highly creditworthy sovereigns, the bonds issued by these countries are likely to be close to risk free for practical purposes. The yields are taken from the Bank's fitted yield curves.(1)

A key part of the specification of a DDM is a choice of how to model the variation in yields across maturities. Since equities have no fixed redemption date, a DDM requires measures of risk-free rates at very long maturities. Yields from fitted yield curves will only be available out to some maximum maturity, however.(2) This limitation means that the level of long-maturity yields must be extrapolated from the yields at available maturities. The previous version of the Bank's DDM assumed that forward risk-free rates were constant across maturities beyond five years. The new DDM accounts for the full profile of yields across maturities, out to the longest maturity available from the Bank's fitted yield curves. Beyond that point it assumes that forward risk-free rates are constant across maturities at the longest available forward yield. **Chart 9** shows a stylised illustration of these assumptions. In practice, this improvement to the specification of the DDM has only a small impact on the estimates of the ERP.

Chart 9 The Bank's revised DDM accounts for the full profile of yields across maturities

Stylised illustration of the yield curve assumptions in the Bank's previous and revised DDMs(a)



Sources: Bloomberg and Bank calculations.

(a) Instantaneous forward yields.

How accurate are the ERP estimates from the Bank's revised DDM?

As the ERP cannot be observed, any estimate of it is necessarily subject to uncertainty. Part of the uncertainty associated with model-based estimates of the ERP reflects uncertainty about the measurement of the model's inputs. For example, investors' true dividend expectations cannot be observed, so any proxy for these used in a DDM, whether derived from analyst surveys or GDP forecasts, is necessarily only an approximation. The inherent uncertainty about the true value of the ERP is reflected in the wide dispersion of ERP estimates in the literature.(3) Given the uncertainty associated

(1) See www.bankofengland.co.uk/statistics/pages/yieldcurve/default.aspx.
(2) Yield curves represent the relationship between yields and maturities. A model is typically used to interpolate yields at maturities where no instrument is traded in the market.
(3) For example, Duarte and Rosa (2015) compare the ERP estimates from 20 different models widely used by industry practitioners and in the academic literature. They find that the ERP estimates vary widely across models, with the 1960–2013 average level of the S&P 500 ERP varying between –1% and 14.5%.

What factors influence the ERP?

The ERP varies over time. In common with the risk premia associated with other risky assets, the ERP tends to vary countercyclically, being higher when growth is weaker and unemployment more elevated. This box discusses some of the economics underlying the ERP and the factors that drive its variation over time.

In simple models, the ERP depends on the level of uncertainty about future equity returns and the degree of investors' dislike towards that uncertainty (Cochrane (2009)). Investors are typically risk averse — given a choice between investments with the same expected return, they will prefer an investment with a certain return to an investment with an uncertain return. When macroeconomic uncertainty, and hence the uncertainty about future equity returns, is elevated, the expected return on equities needs to be higher in order to induce investors to hold these assets. In this situation, the ERP will be higher and equity prices lower.

As discussed in the next section, elevated macroeconomic uncertainty is likely to have been one factor behind the rise in the ERP during the financial and euro-area crises. Another factor may have been that investors were more risk averse, disliking a given level of uncertainty more strongly. In practice, it is often hard to separate the roles of risk aversion and uncertainty. The VIX index of implied volatility on the S&P 500 is often used as a measure of either quantity. **Chart A** shows that the S&P 500 ERP and the VIX do indeed tend to move together.

In more sophisticated models, the ERP will depend not only on the uncertainty associated with equity returns, but also on the states of the world in which equities are likely to do well and the states of the world in which they are likely to do badly. These models assume that investors value a given return more highly when they are poorer and less highly when they are richer. The ERP will therefore depend on the covariance of equity returns with the business cycle.

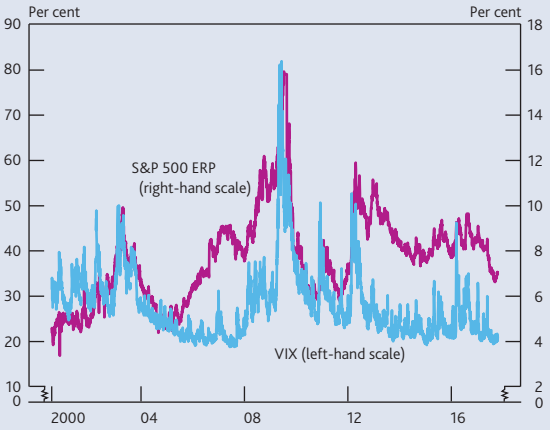
A simple example of an insurance contract can make this intuition clearer. Consider a fire insurance contract that pays out if the contract holder's house burns down. This is an example of an investment that pays out in bad states of the world when the investor is likely to be poor and will value the payout more highly. The investor will therefore be willing to make an expected loss on the contract, on average paying out more in insurance premiums than they expect to receive in payouts.

An equity investment is the mirror image of an insurance contract. Equities tend to do badly in recessions and periods of weak economic growth, precisely the times when an investor is more likely to be poorer or unemployed and so value a positive return more highly. Equities therefore need to have higher expected returns, and a positive ERP, to induce investors to hold an asset that is likely to do well in 'good times', when they value the return less, and do badly in 'bad times', when they would value the return more highly.

In models with frictions and rigidities, the ERP will depend not only on the risk characteristics of equities, but also on equity supply and demand dynamics. For example, changes in the asset allocations of institutional investors can affect equity prices and hence the ERP.

Chart A Implied volatilities and ERPs tend to move together

The VIX and DDM estimates of the S&P 500 ERP



Sources: Bloomberg, IMF *World Economic Outlook*, Thomson Reuters Datastream and Bank calculations.

with measuring the ERP, the Bank's analysis tends to focus less on the precise level of the ERP and more on changes in the ERP over time or on the level of the ERP relative to historic averages.

The recent changes made to the Bank's DDM should improve the accuracy of the model's ERP estimates. For example, investors' long-term growth expectations are likely to vary over time. Accounting for this time variation should improve the measurement of this model input. These changes do not alter the core specification of the model, however.

On average, the ERP estimates from the Bank's revised DDM are higher than those from the previous version of the model. The majority of this difference is accounted for by the incorporation of share buybacks into the model. As discussed above, the omission of buybacks from the previous version of the model is likely to have biased its estimates of the ERP downwards.

While the revisions made to the Bank's DDM should improve the accuracy of its ERP estimates, these are still necessarily subject to uncertainty. For example, growth expectations at longer horizons may differ from the IMF forecasts used in the

model, which refer to the five-year ahead horizon. And, given the greater volatility of share buybacks than dividends, the assumption in the model that buybacks are expected to grow at the same rate as dividends may not hold in reality. The academic literature also typically finds that equity analysts' earnings forecasts are overly optimistic.(1) If analysts' forecasts for dividends are overly optimistic as well, then, all else equal, that bias would be reflected in an upwards bias in the DDM's estimates of the ERP.

One way to assess the accuracy of the model's ERP estimates is to compare their average level to average historic realised equity returns. Over 1900–2014, realised equity returns, in excess of the yield on short-term government bills, averaged 6.1% in the United Kingdom and 7.5% in the United States.(2) Over the post-war period 1946–2014, the equivalent figures were 8.0% and 7.9%. These are broadly similar to the average level of the ERP estimates from the Bank's revised DDM, which since 2000 have averaged 7.6% for the FTSE All-Share and 7.7% for the S&P 500.

Applying the model: understanding equity price moves since the early 2000s

This section illustrates an application of the Bank's DDM to understanding moves in advanced economy equity prices during four episodes since the early 2000s. Equity prices rose strongly over 2003–07, before falling back sharply over 2007–09 at the onset of the financial crisis. Equity prices began to recover during 2009–10, before the euro-area crisis led to a divergence in equity price moves over 2011–13. These moves could reflect a range of factors — a DDM can help shed light on how the role of different drivers has varied over time.

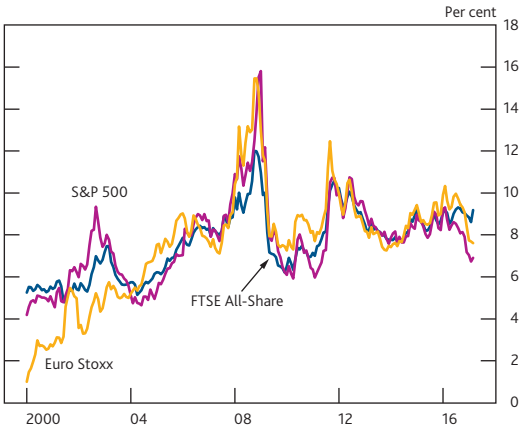
One factor behind the moves has been variation over time in the ERP. **Chart 10** shows ERP estimates from the Bank's revised DDM. The ERP rose sharply during the financial crisis as uncertainty about the macroeconomic outlook, and hence the outlook for firms profits and dividends, rose. The ERP subsequently fell back, before rising again during the euro-area crisis.

2003–07: strong growth in equity prices

Equity prices rose strongly across all three regions during 2003–07 (**Chart 1**). A DDM decomposition attributes much of this rise to an increase in the expected level of future shareholder payouts (**Chart 11**). Dividends grew steadily over this period of economic growth, a trend which equity analysts expected to continue (**Chart 12**). And share buybacks grew even more strongly than dividends, rising from 18% to 45% of FTSE All-Share shareholder remuneration (**Chart 8**). The DDM decomposition suggests that changes in risk-free rates, long-term growth expectations and the ERP contributed relatively little to the rise in equity prices over the period.

Chart 10 Variation in the ERP is one factor behind moves in equity prices

DDM estimates of the ERP for international equity indices(a)

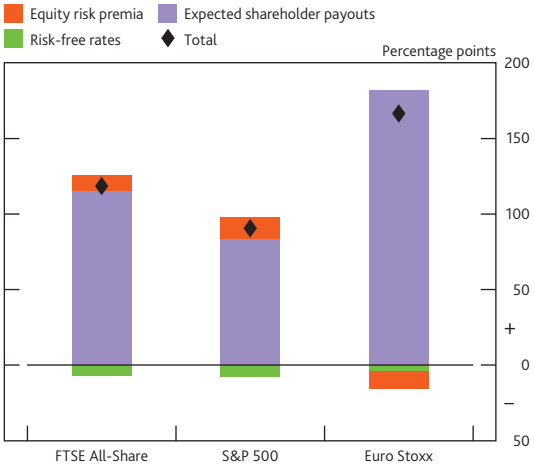


Sources: Bloomberg, IMF *World Economic Outlook*, Thomson Reuters Datastream and Bank calculations.

(a) Monthly averages.

Chart 11 The strong rise in equity prices ahead of the financial crisis was largely accounted for by an increase in expected future shareholder payouts

DDM decomposition of changes in international equity indices between March 2003 and June 2007



Sources: Bloomberg, IMF *World Economic Outlook*, Thomson Reuters Datastream and Bank calculations.

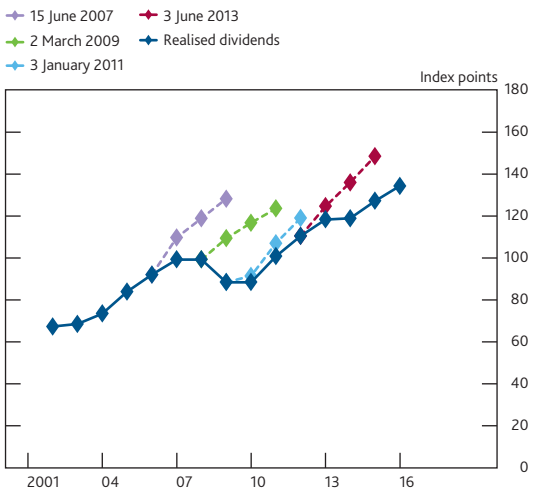
2007–09: the onset of the financial crisis

Equity prices subsequently fell back sharply during the financial crisis, with advanced economy benchmark indices declining by around 50%–60% between June 2007 and March 2009. A DDM decomposition attributes these falls to two factors (**Chart 13**). First, as uncertainty about the economic outlook rose, the ERP increased sharply. And second, as firms' profits fell (**Chart 14**) they reduced their payouts to shareholders. Share buybacks were cut more sharply than dividends, reflecting firms' preference for using buybacks as their marginal tool for varying shareholder

(1) See for example Stickel (1990), Abarbanell (1991), Dreman and Berry (1995), Dugar and Nathan (1995), Chopra (1998), Das, Levine and Sivaramakrishnan (1998), Easterwood and Nutt (1999) and Hong and Kubik (2003).
(2) See Norges Bank Investment Management (2016). Based on the Dimson, Marsh and Staunton Global Investment Returns Database.

Chart 12 Ahead of the financial crisis, analysts expected FTSE All-Share dividends to continue to grow

Realised dividends and IBES dividend forecasts for the FTSE All-Share[(a)]

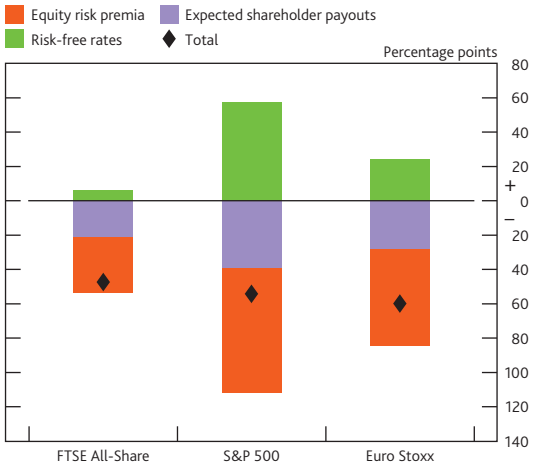


Sources: Thomson Reuters Datastream and Bank calculations.

(a) Realised dividends for each year are calculated as the December average of the product of the FTSE All-Share dividend-price ratio and FTSE All-Share price index.

Chart 13 Lower expected future shareholder payouts and higher equity risk premia contributed to the fall in equity prices during the financial crisis

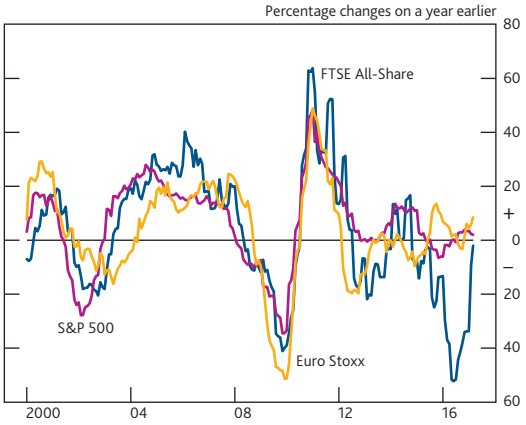
DDM decomposition of changes in international equity indices between June 2007 and March 2009



Sources: Bloomberg, IMF *World Economic Outlook*, Thomson Reuters Datastream and Bank calculations.

Chart 14 Listed firms' profits fell during the financial crisis

Earnings of listed firms[(a)]

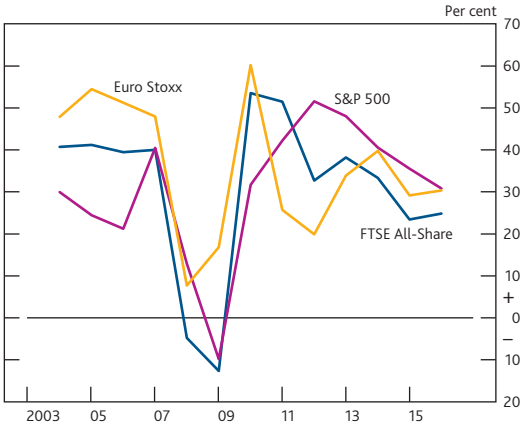


Sources: Thomson Reuters Datastream and Bank calculations.

(a) Refers to earnings over a twelve-month period. Earnings are calculated as the equity index price level divided by the price-earnings ratio. For the Euro Stoxx, the price-earnings ratio for the Datastream euro-area total market index is used.

Chart 15 Dividend growth expectations fell sharply during the financial crisis

IBES cumulative four-year dividend growth forecasts[(a)]



Sources: Thomson Reuters Datastream and Bank calculations.

(a) Based on IBES one, two and three-year ahead dividend growth forecasts and IBES long-term dividend growth forecasts. Observations are taken on the last working day of each year.

remuneration (**Chart 8**). Looking ahead, cumulative dividend growth expectations also fell sharply (**Chart 15**). The lower expected level of future shareholder payouts, reflecting both a lower starting level for payouts and slower anticipated growth, weighed on equity prices over the period.

2009–10: the recovery in equity prices

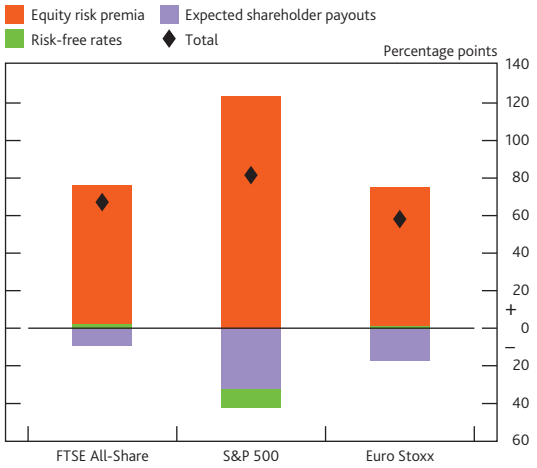
From their trough in early 2009, equity prices recovered strongly over 2009–10 (**Chart 1**). At first sight this might seem puzzling, as firms' profits continued to fall over this period (**Chart 14**). A DDM can help resolve this puzzle. Decompositions from the Bank's model indicate that the key factor behind the recovery in equity prices was support from sharp falls in the ERP (**Chart 16**). In part, these falls may have reflected the actions of central banks, such as the implementation of unconventional monetary policy measures, including asset purchases. Investors may have perceived these actions as having reduced the risk of a prolonged period of very weak economic growth (Joyce, Tong and Woods (2011)). Acting in the other direction, equities were weighed on by a further reduction in expected future payouts to shareholders. Firms' dividends and buybacks continued to fall over this period. And while investors revised up the rate at which they expected dividends to recover, they did not anticipate that all of the gap relative to their previous projections would be made up (**Chart 12**).

2011–13: the euro-area crisis

The period between early-2011 and mid-2013 saw a divergence in equity price moves across regions, with the

Chart 16 Sharp falls in equity risk premia supported the strong recovery in equity prices over 2009–10

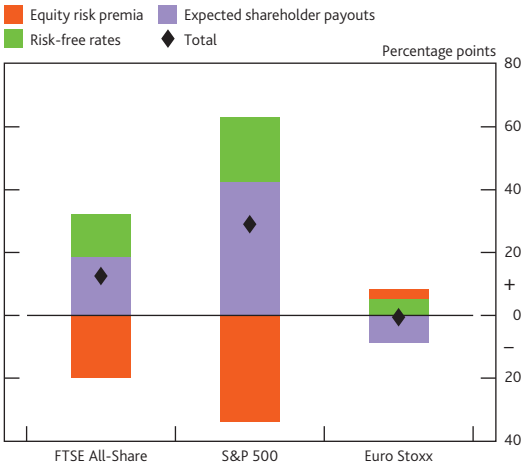
DDM decomposition of changes in international equity indices between March 2009 and January 2011



Sources: Bloomberg, IMF *World Economic Outlook*, Thomson Reuters Datastream and Bank calculations.

Chart 17 A decline in expected shareholder payouts weighed on the Euro Stoxx during the euro-area crisis

DDM decomposition of changes in international equity indices between January 2011 and June 2013



Sources: Bloomberg, *IMF World Economic Outlook*, Thomson Reuters Datastream and Bank calculations.

FTSE All-Share and S&P 500 continuing to rise strongly, while the Euro Stoxx was broadly flat (**Chart 1**). A DDM can shed light on this divergence. The profits of FTSE All-Share and S&P 500 firms rose over the period (**Chart 14**) and they responded by increasing the amount of cash that they paid out to shareholders through dividends and share buybacks (**Charts 2** and **8**). Equity analysts expected dividends to continue to grow over the coming years (**Chart 3**). And long-term growth forecasts for the United Kingdom and United States rose (**Chart 5**). A DDM decomposition suggests that these factors raised the expected level of future shareholder payouts for the FTSE All-Share and S&P 500, supporting these indices (**Chart 17**). The situation in the euro area was very different, however. Against the backdrop of the euro-area sovereign debt crisis, firms' profits and shareholder remuneration stagnated and forecasts for future dividend growth fell (**Chart 2**). A decline in expected future shareholder payouts weighed on the Euro Stoxx.

Conclusion

This article has described the DDM framework for analysing moves in equity prices. The Bank has recently made a number of improvements to the specification of its DDM, which now incorporates share buybacks and time variation in long-term growth expectations. The new model also better captures the variation in risk-free interest rates across maturities. Given the importance of share buybacks as a component of shareholder remuneration, and evidence that long-term growth expectations have declined since the financial crisis, these changes to the Bank's DDM should improve the accuracy of the model's ERP estimates and decompositions of equity price moves. Alongside a range of other models, the Bank's revised DDM will aid its monitoring of asset price moves in support of its monetary and financial stability objectives.

References

Abarbanell, J S (1991), 'Do analysts' earnings forecasts incorporate information in prior stock price changes?', *Journal of Accounting and Economics*, Vol. 14, No. 2, pages 147–65.

Bank of England (1999), 'The transmission mechanism of monetary policy', *Bank of England Quarterly Bulletin*, Vol. 39, No. 2, pages 161–70, available at www.bankofengland.co.uk/archive/Documents/historicpubs/qb/1999/qb9902.pdf.

Chin, M and Polk, C (2015), 'A forecast evaluation of expected equity return measures', *Bank of England Working Paper No. 520*, January, available at www.bankofengland.co.uk/research/Documents/workingpapers/2015/wp520.pdf.

Chopra, V K (1998), 'Why so much error in analysts' earnings forecasts?', *Financial Analysts Journal*, Vol. 54, No. 6, pages 35–42.

Cochrane, J H (2009), *Asset pricing (Revised Edition)*, Princeton University Press.

Das, S, Levine, C B and Sivaramakrishnan, K (1998), 'Earnings predictability and bias in analysts' earnings forecasts', *Accounting Review*, Vol. 73, No. 2, pages 277–94.

Dreman, D N and Berry, M A (1995), 'Analyst forecasting errors and their implications for security analysis', *Financial Analysts Journal*, Vol. 51, No. 3, pages 30–41.

Duarte, F and Rosa, C (2015), 'The equity risk premium: a review of models', *Federal Reserve Bank of New York Staff Report No. 714*, February.

Dugar, A and Nathan, S (1995), 'The effect of investment banking relationships on financial analysts' earnings forecasts and investment recommendations', *Contemporary Accounting Research*, Vol. 12, No. 1, pages 131–60.

Easterwood, J C and Nutt, S R (1999), 'Inefficiency in analysts' earnings forecasts: systematic misreaction or systematic optimism?', *The Journal of Finance*, Vol. 54, No. 5, pages 1,777–797.

Gordon, M J (1962), *The investment, financing, and valuation of the corporation*, R D Irwin.

Haddow, A, Hare, C, Hooley, J and Shakir, T (2013), 'Macroeconomic uncertainty: what is it, how can we measure it and why does it matter?', *Bank of England Quarterly Bulletin*, Vol. 53, No. 2, pages 100–09, available at www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2013/qb130201.pdf.

Hong, H and Kubik, J D (2003), 'Analyzing the analysts: career concerns and biased earnings forecasts', *The Journal of Finance*, Vol. 58, No. 1, pages 313–51.

Inkinen, M, Stringa, M and Voutsinou, K (2010), 'Interpreting equity price movements since the start of the financial crisis', *Bank of England Quarterly Bulletin*, Vol. 50, No. 1, pages 24–33, available at www.bankofengland.co.uk/publications/Documents/quarterlybulletin/qb100101.pdf.

Joyce, M, Tong, M and Woods, R (2011), 'The United Kingdom's quantitative easing policy: design, operation and impact', *Bank of England Quarterly Bulletin,* Vol. 51, No. 3, pages 200–12, available at www.bankofengland.co.uk/publications/Documents/quarterlybulletin/qb110301.pdf.

Liu, L (2016), 'Home is where your cash flows are? UK-focused equities and the international exposure of the FTSE All-Share', available at www.bankunderground.co.uk/2016/11/22/home-is-where-your-cash-flows-are-uk-focused-equities-and-the-international-exposure-of-the-ftse-all-share/.

Norges Bank Investment Management (2016), 'The equity risk premium', Norges Bank Investment Management Discussion Note, October.

Stickel, S E (1990), 'Predicting individual analyst earnings forecasts', *Journal of Accounting Research*, Vol. 28, No. 2, pages 409–17.