EValue

Insight Asset Model

EValue asset model overview

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Overview

The aim of the EValue asset model is to provide its users with the best possible understanding of their investment options.

The typical ultimate consumer of our model is a private investor making decisions about long term investments most likely through collective investment schemes. More specialised uses include analysis of structured products, allocation of assets for investors in our typical user's situation and projections expressed in real and income terms as opposed to simply capital growth in face value terms.

What we hope to be able to show our users is first what investment outcomes they need to be prepared for and secondly a sound basis for making sensible decisions about the investment opportunities available to them. For example the model should be able to provide sensible asset allocations for long term investments.

To that end the model must

- adapt to changing economic circumstances,
- reflect the likely term of investment,
- illustrate the impact of inflation,
- make income projections compatible with capital growth projections.

Many users will see the results of our model via our illustration tools and it therefore needs to deliver data in the form those tools use and covering all of the more than 60 assets and economic indicators those tools cover.

The investors need an understanding of what investments might achieve and what risks they might face en route. That means taking account of

- current circumstances,
- the likely term of investment,
- inflation,
- income and capital growth.

Doing so will impose various burdens on the model.

We also want the model to be realistic in terms of individual investment paths, not merely in aggregate. In addition to being a useful discipline, achieving this aim will make for a model that is broadly and easily applicable.

2. Philosophy

This section is to provide insight into how we intend to achieve the aims described above.

Our ideal is a totally objective model. In practice that ideal is unattainable but we must still try to get as close as possible. There are several steps we can take towards this ideal.

2.1 Empirical foundations

There is not enough data to make the model entirely empirical but we can do the best with what we have. In particular we will work hard to keep our models as simple as possible to allow empirical calibration processes and to make sure that our estimates are compatible with the history of events that we are assuming were governed by the modelled process.

Models to be calibrated with limited amounts of historical data must be specified very efficiently. That is the model must achieve the required flexibility with as few variable parameters as possible and we have gone to great lengths to achieve that.

We must also make sure that historical events are feasible in terms of the model that is based upon them. We want to take care to avoid accidentally assuming that the future will be much less extreme than the past.

2.2 Systematic Update Process

We do not want to rethink the model at each update and want to avoid updates aimed at reflecting current received wisdom. To this end we will follow a systematic and quantitative update process that minimises the discretion we exercise during updates.

2.3 Fix at source

Achieving a completely automatic update process is extremely ambitious and there will undoubtedly be situations that produce awkward or even clearly inappropriate results. An important principle in dealing with such situations is to fix problems as close to the source as possible. If the results of the simulation create a problem we should work out why the model produced those results and fix that. We should never just change the numbers.

2.4 THE MODEL IS NORMATIVE

We mean that the model should have something to say about the adequacy of returns for its users rather than simply assuming that the market is straightforwardly correct from the point of view of our users. That means allowing relative returns to change and accepting asset allocations that are not market weighted.

2.5 Controlled risk premia

While we will allow relative returns and risk premia to vary we must not lose control of them and inadvertently allow extreme risk premia. We can do so by for example choosing models that are arbitrage free and making the expression of the risk premium as explicit as possible.

The normative role of the model frees it from some restrictions on asset returns but the requirement that risk premia be controlled provides an alternative restraint.

2.6 Continuing development

Changing economic circumstances, availability of data, technical developments, practical problems and improvements in computational efficiency or power will demand, allow or suggest developments of the model and where appropriate we should incorporate such developments. However we recognise continuity as a valuable goal so such changes should be implemented carefully to minimise and control their impact.

2.7 Transparency

We should be as open as possible about the model compatible with preserving our intellectual property and allowing the model freedom to develop. The model represents a substantial investment on our part and we do not want to help competitors to catch up. Similarly we do not want users to rely on features of the model we are not committed to, potentially making it difficult to implement otherwise desirable developments.

One practical measure we are able to take in this direction is interim reporting. We can report on interim developments in the model allowing those managing services based upon our model to understand likely developments well in advance of their implementation.

3. Concepts

3.1 Simulated Scenarios

The model will specify the relative probability of different future paths for the whole economy. To perform calculations on this model we will sample a set of paths or scenarios according to this probability. Each scenario is a potential future history for the economy showing returns for each asset class for each year of the simulations. We can then see what happens to an investment plan in each scenario. With that information we can find averages, standard deviations, worst cases, quantiles and so on.

3.2 Risk Premia

Many prices or asset values are assumed to have some link to expected future cash flows. However the link may not be the simple average of future cash flows. Instead more importance will be given to some outcomes than others which will shift the average. In general more weight is given to possible negative outcomes than positive outcomes and the wider the range of outcomes the larger the impact this will have.

In such cases the average return will be higher than implied by treating the price as a straightforward average. This expected extra return is usually called the risk premium. In simple models the risk premium can sometimes be described by a single number. In general however it might depend upon the investment term and the benchmark. It can also vary from asset to asset in ways that are more complicated than might be expected simply by comparing the dispersion of their returns.

3.3 Model Updates

The commitment to keep the model up to date means reflecting changing economic circumstances in the model. We do this by rerunning the simulation with assumptions changed to reflect new economic circumstances. In principle that could mean changing any feature of the model including the specification. However in our model we make use of a state space approach. The model determines the probability of transition from one state to another, for instance the chance of next year's interest rate being 6% is different depending on whether the current interest rate is in the 5% state or the 4% state.

The content of most updates is a reassessment of the starting state. Indeed our model is as far as possible time homogeneous which means that when the model considers a future state of the economy it does so in the same way it would if that were the current state. This is analogous to saying that the laws of physics are the same everywhere. Time homogeneity keeps things conceptually and practically simple yet it is not something that is achieved by, for example, simple Brownian motion models of fixed income returns.

3.4 MODEL CALIBRATION

The state of the model is only one part of the whole. The other parts are the specification and the parameters of the model. The specification is the structure of the model while the parameters are the specific values of quantities in the structure. For instance the structure might specify that one quantity is proportional to another and a parameter will specify the ratio between them. We refer to the process of setting the parameters as calibration.

It is something that we have put a lot of work into and do not expect to change much but as new information becomes available we want to take it into account and we do not want to wait until it becomes glaringly obvious that we need to update the parameters to do so. We will therefore perform calibrations on a regular basis but less frequently than we update the starting state of the model.

4. Structure

Modelling interest rates is of fundamental importance when modelling return and risk over the long term. When rates increase, future return expectations for cash and bond returns rise. Moreover, to estimate the risk of bonds over different investment horizons, it is essential to consider how the negative price impact of interest rate rises is offset by improved reinvestment returns over the time horizon of interest. For these reasons, the EValue asset model starts by modelling interest rates.

Returns for cash and fixed income assets are directly determined by the evolution of interest rates. All other asset classes have some dependency on interest rates. We expect growth rates to be higher when interest rates are high, so equity dividend growth rates and property rent growth rates are linked to interest rates. Property rental yields are expected to depend on the cost of finance, so they are linked to interest rates. Interest rates also determine market expectations of future exchange rates, so currency strengths are linked to interest rates.

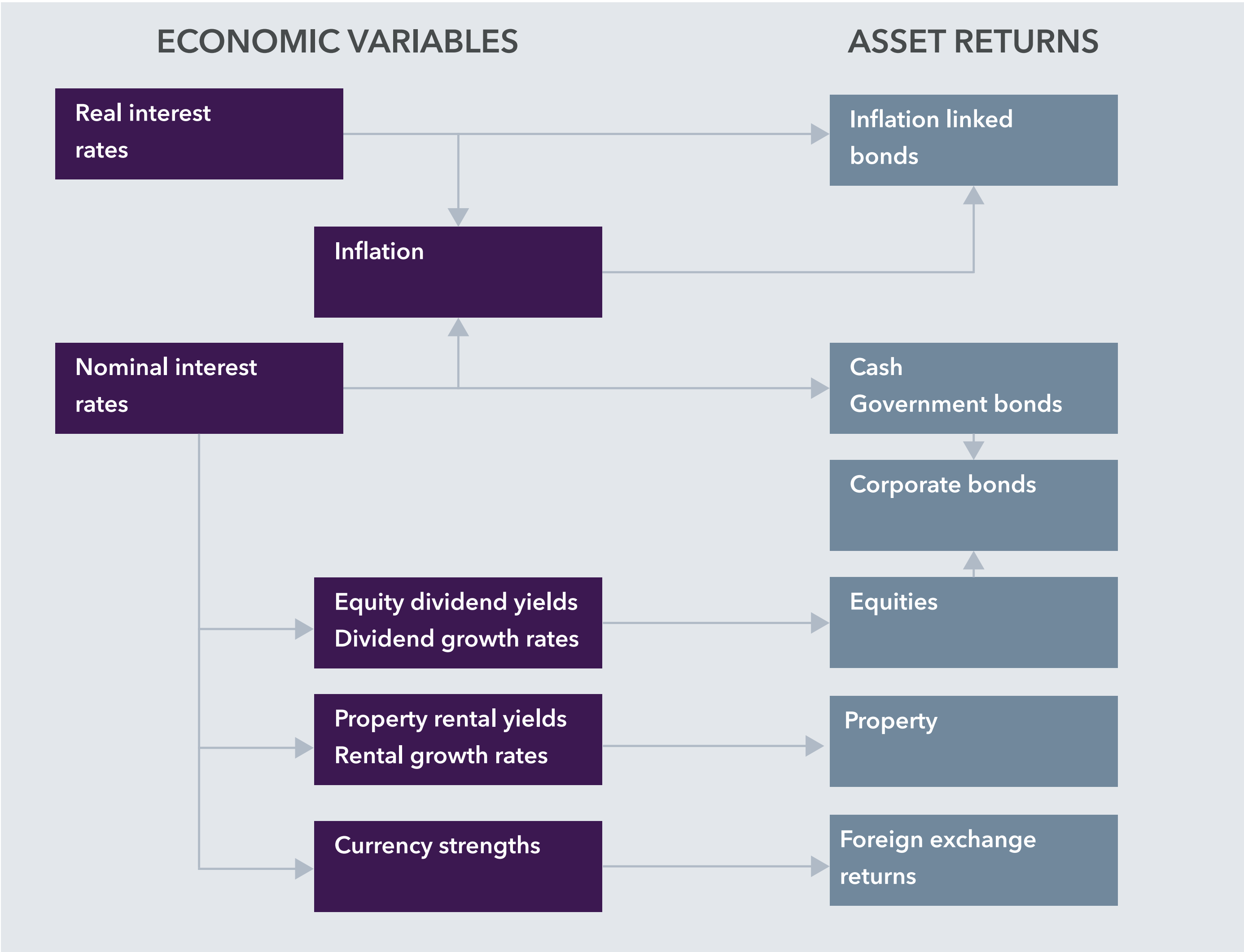

Figure 1: Structure of the EValue Asset Model, Insight.

The diagram in Figure 1 shows the structure of the model in terms of inter-dependencies between economic variables and asset classes. The dependencies between economic variables we outlined are represented by dashed arrows. Solid arrows show which asset return or economic variable outputs can be directly calculated from a set of basic economic variables. Thus equity, property and FX returns are directly determined by economic variables in the model. Real interest rates, together with nominal interest rates, determine inflation and the returns of inflation-linked bonds. Finally, corporate bonds are determined by government bond and equity returns.

The following sections describe the models for each asset class and the links between different asset classes in more detail. The EValue asset model is a fully symmetric international model, and we will also outline the international dependence structures in the model.

5. Fixed income

The EValue interest rate model is a cutting edge model designed to provide the most realistic view of the potential evolution of interest rates over the long terms required for investment return projections. Specifically, our design requirements included the following advantages over other interest rate models:

1. The model accurately reflects current interest rates at the start of projections. This is important because the expected level of fixed income asset returns depends on the current interest rates.

2. The model includes controlled risk premia reflecting real world behaviour, not simply pricing behaviour. Controlled risk premia ensure that the expected level of returns is realistic when compared with the level of risk, and that asset allocations based on the model will not unduly favour any asset.

3. Simulated scenarios are realistic in aggregate, in particular the scenarios of recent history such as the high rates of the 1990s and the persistent low rates post global financial crisis are given reasonable weights. This ensures that simulated asset returns have realistic risk. For example, a wide range of probable interest rate levels in the long term means that, for long investment horizons, cash becomes more risky than government bonds.

4. Simulated scenarios are also individually realistic, in particular nominal interest rates are always positive. A consequence of the last feature is that government bond returns have limited upside when interest rates are low.

The accurate reflection of current rates of the first advantage goes hand in hand with the controlled risk premia of the second: if risk premia are controlled, so is the extent to which the current yield curve fails to be a forecast of future interest rates. Our model is arbitrage free which is a further source of control of risk premia. The third feature requires using as much data as possible, in general all developments since the end of Bretton Woods. Among other things it is worth noting that our model is calibrated on an empirical basis but is not a simple average.

The final requirement severely limits the range of viable models. Our original intention was to use standard consensus models rather than anything “bleeding edge” but to meet these requirements we were forced to extend an idea of the late Fischer Black to the relatively large and flexible set-up we required to be able to fit actual yield curves. Our efforts in this direction are described in the paper available through the Social Sciences Research Network at this link: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2304372. The resulting interest rate model is a 3-factor Black shadow rate model. The EValue asset model includes models of UK, US, Eurozone and Japanese government yield curves.

Figure 2 illustrates a sample interest rate path simulated in the UK model. This 50-year scenario has very low interest rates over several years in the early part of the history and also some very high interest rates over the second half of the path. Although this range of simulated rates looks very reasonable by any historical comparison, standard consensus interest rate models such as affine term structure models fail to produce such simulations.

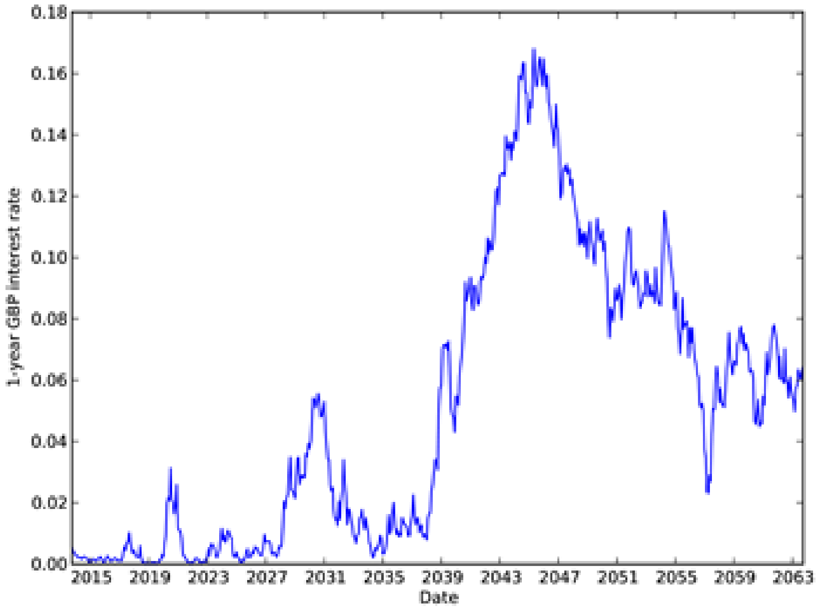

Figure 2: Sample interest rate path with extended periods of low and high rates

In order to provide realistic forecasts of the risk of international government bond portfolios, the asset model must also take into account the international dependence structure of interest rates. This is done by modelling common factors driving the single-economy residuals. Modelling the correlation between the returns of government bonds issued by different sovereigns ensures that the model does not overstate the diversification from investing internationally.

6. Inflation

The EValue asset model includes price inflation, used to calculate real asset returns, as well as returns on inflation-linked bonds. A coherent model of fixed-coupon government bonds, index-linked government bonds and inflation has to take into account long-term expectations of inflation. For this reason, we model the term structure of real interest rates. One important difference between real and nominal interest rates is that real interest rates can be negative, which allows us to meet our requirements with a well-known econometric interest rate model.

Specifically, the EValue asset model uses 2-factor Gaussian affine term structure models of the real yield curve for the UK, US and Eurozone. The difference between the nominal short rate and the real short rate is then our primary measure of price inflation: UK RPI, US CPI and Eurozone HICPxT.

We also model UK CPI, which differs from RPI mainly by its lower level (due to the difference in calculation methodology) and by the lower exposure to housing. In the EValue asset model, we reflect these differences by deriving UK CPI from UK RPI with a negative exposure to property prices, a negative spread and an independent noise process.

Similarly, UK and US wage inflation are derived from price inflation in the respective economy by adding an exposure to the real rate and an independent noise process. Historically the difference between wage inflation and price inflation has been strongly linked to the real short term interest rate. This is reflected in our model, resulting in wage inflation which is close to short-term nominal interest rates.

7. Equities

The EValue equity model describes the joint real-world dynamics of the major equity markets, currently covering the UK, US, Eurozone, Japan, Asia-Pacific ex Japan and Emerging Markets. The design requirements for the equity model include the following features:

1. The model projects realistic levels of risk. In particular, it attaches a realistic probability to large shortterm losses, reflecting the heavy-tailed and negatively skewed shape of short-term equity return distributions.
2. The model provides projections of income, capital growth and total return, accurately capturing current levels of income.
3. The model projects realistic levels of future return, considering the impact of changing equity valuations on future expectations. In particular, after a period of rising equity valuations, future expected returns are lower. The model is normative and produces asset allocations which are counter-cyclical with respect to equity “bubbles”. Optimal asset allocations will shift away from equities that become over-valued and towards equities that are under-valued.

The EValue equity model describes the joint dynamics of dividend yields and dividend growth rates in each economy. Total return, capital growth and dividend income can then be calculated from the simulated dividend yields and dividend growth rates. This model is responsive to changing valuations. For example, when equity valuations rise, simulated returns take into account the fact that this implies lower future returns due to the lower level of dividend yield and the lower expected capital growth as valuations slowly revert to their long-run steady state levels.

Because we expect lower growth in a low interest rate environment, mean dividend growth is linked to interest rates.

We use the variance-gamma distribution for monthly equity return shocks. This allows the model to fit skewness and kurtosis estimates obtained from historical return time series, making the probability of large short-term losses much more realistic than in Gaussian models.

The model incorporates an international dependence structure between dividend yields, growth rates and volatility in different economies. This ensures that the reduction in risk due to international diversification is modelled accurately.

Historical time series provide poor estimates of mean equity returns. Instead, the overall level of the equity risk premium, that is, the long-run equity return in excess of cash, is chosen to be consistent with a range of academic and market consensus estimates, including the PricewaterhouseCoopers report commissioned by the Financial Services Authority. The relative risk premia for different equity markets are set using an international Black-Litterman approach, to be consistent with observed market capitalizations. Risk premia are higher for markets which are more risky and / or whose risk is more systematic and therefore harder to diversify, compensating investors for the additional risk.

8. Foreign exchange

Unhedged investments in foreign assets carry significant currency risk. The EValue asset model is designed to provide realistic simulations of currencies, ensuring that the risk of investments denominated in other currencies is not understated. One consequence of foreign exchange risk is investors' preference for allocating a greater weight to domestic assets than would be given by market capitalizations.

The EValue asset model incorporates a symmetric model of currency strengths, which incorporates a dependence structure between different currencies, ensuring that the risk of internationally diversified portfolios can be accurately forecast.

The model obeys uncovered interest rate parity, i.e. deposits in different currencies earn the same average return, once converted to the same numeraire or accounting currency.

9. Other asset classes

Other asset classes in the EValue asset model include corporate bonds, commodities and commercial property.

The EValue corporate bond model is designed to accurately reflect the properties of typical retail collective investments in investment-grade corporate debt. In particular, the maturity and yield are calibrated to match a typical corporate bond fund with a credit rating of "A". Although corporate bonds have low short term volatility, they are strongly correlated to government bonds and to equities, making them more risky in the longer term. The EValue corporate bond model takes these correlations into account by explicitly linking the corporate bond asset class to government bond and equity returns.

The commodity asset class is modelled as an equity-like return (without a dividend yield).

The property model has both equity-like and fixed income elements. It describes the dynamics of the current rental yield and the rent growth. Simulated capital growth and income are then calculated assuming that rents are fixed for the average term of a UK commercial property lease. The model assumes that, for current interest rates, valuations in terms of rental yield will tend to revert to a steady-state level given by the current cost of mortgage finance.

10. Other denominators

Assets can be simulated in any included currency. Due to the symmetric structure of the foreign exchange model (and all other model components), multi-numeraire support is completely natural in the EValue asset model.

In addition, real asset returns can be calculated from nominal asset returns and inflation. The inclusion of a full model of the term structure of real interest rates allows returns of inflation-linked securities to be modelled accurately.

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