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Precisely Wrong or Roughly Right?
An Evaluation of Development Viability

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Abstract

This paper investigates the effect of choices of model structure and scale in development viability appraisal. The paper addresses two questions concerning the application of development appraisal techniques to viability modelling within the UK planning system. The first relates to the extent to which, given intrinsic input uncertainty, the choice of model structure significantly affects model outputs. The second concerns the extent to which, given intrinsic input uncertainty, the level of model complexity significantly affects model outputs. Monte Carlo simulation procedures are applied to a hypothetical development scheme in order to measure the effects of model aggregation and structure on model output variance. It is concluded that, given the particular scheme modelled and unavoidably subjective assumptions of input variance, that simple and simplistic models may produce similar outputs to more robust and disaggregated models.

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1. Introduction

Until relatively recently, the discipline of development appraisal has remained the provenance of surveyors and developers. It largely been ignored by other participants in the development process, particularly planners, architects and construction specialists. This is now changing. Close attention is now paid to the viability (and profitability) of development proposals as the UK government seeks to extract developer and/or landowner contributions to affordable housing, public services and infrastructure. Consequently the theory, application and outputs from development appraisal are under intense scrutiny from a wide range of users. Since Circular 05/05 proposed the submission of 'financial information' to provide a basis for negotiations between developers and local planning authorities about viable levels of affordable housing, tests of the financial viability of development projects have become an integral part of the planning process, both at the forward planning and development control stages. At the, macro-level large-scale Strategic Housing Land Availability Assessments require proposed plans to be achievable. However, the time frame for development can be decades rather than years and, as a result, generating detailed and reliable cost and revenue projections can be impractical. At the other end of the scale, viability appraisals are carried out to inform negotiations about affordable housing levels for a scheme about which there may be a high level of information on permitted development and expected costs over a relatively short timeframe.

In terms of critical evaluation from the real estate academic community, development appraisal has remained something of a backwater. In contrast, often linked to market traumas, over the last four decades methods of appraising standing investment properties have been the subject of widespread academic and professional debate. Whilst the RICS monitors variance and accuracy of investment valuations, there is no comparative institutional evaluation of the performance of development appraisals. Nevertheless, conventional development viability models have been subject to some criticism, particularly their simplified composition, failure to mirror reality and theoretical weaknesses.

This paper investigates the extent to which these limitations and weaknesses of development viability models matter. We examine whether model choice and composition (in terms of complexity of information content) has a significant effect on model outputs. The paper attempts to address two questions concerning the application of development appraisal techniques to viability assessment within the planning system. The first relates to the extent to which, given intrinsic input uncertainty, the choice of model structure significantly affects model outputs. The second concerns the extent to which, given intrinsic input uncertainty, the level of model complexity significantly affects model outputs.

The remainder of the paper is organised as follows. In Section 2 viability models are briefly discussed in the wider context of model formation. After summarising the mathematical structure of conventional development viability appraisal models in Section 3, drawing upon a review of the literature, the composition of viability models is critically evaluated and previous research in this area is reviewed in Section 4. In the empirical section of the paper, simulation techniques are applied to a range of viability models in order to assess the extent to which choice of model affects the output or decision. Finally, conclusions are drawn.

2. Viability Modelling in Context

Many of the issues currently generating concern about development viability modelling are far from unique to this type of modelling. Indeed, they are echoed in the literature on good practice in model construction and evaluation. Although they were discussing environmental models, the warning and guidance of Jakeman, Letcher and Norton (2006, quoted at length below) echoes many of the concerns often expressed (albeit anecdotally) about the application of financial models to assess development viability. It is difficult to improve on their articulation that

> "The uses of modellers by managers and interest groups, as well as modellers, bring dangers. It is easy for a poorly informed non-modeller to remain unaware of limitations, uncertainties, omissions and subjective choices in models. The risk is then that too much is read into the outputs and/or predictions of the model. There is also a danger that the model is used for purposes different from those intended, making invalid conclusions very likely. The only way to mitigate these risks is to generate wider awareness of what the whole modelling process entails, what choices are made, what constitutes good practice for testing and applying models, how the results of using models should be viewed, and what sorts of questions users should be asking of modellers. This amounts to specifying good model practice in terms of development, reporting and critical review of methods" (Jakeman, Letcher and Norton, 2006, 603).

Broadly in line with other definitions, Helms (1998, 234) describes a model as an "abstract representation of objects and events from the real world for the purpose of simulating a process, predicting an outcome, or characterising a phenomenon". Prisley and Mortimer (2004, 90) summarise the roles of models as essentially "describing, predicting and estimating". Models can be produced for a range of reasons including; to improve understanding of processes, to explore alternative scenarios, to predict or forecast or, as in the case of development viability modelling, to provide a basis for guidance or decision-making.

Model evaluation tends to focus on two aspects: composition and performance (Prisley and Mortimer, 2004). Whilst composition is essentially concerned with the internal coherence of models in terms of their theoretical basis, assumptions and suitability for designated function, performance evaluation focuses on external measures. For instance, statistical comparison of model predictions with field observations is a standard approach. An implicit, but central element, of this study is evaluation of different development viability models.

A development viability appraisal can be characterised as a simple rule-based, data model that attempts to provide a well-defined representation of the expected input-output behaviour of a system. In the context of the current planning regime, the 'rule' is that a scheme is viable if a potential development remains sufficiently profitable at given levels of affordable housing and/or other planning-related payments. Ideally, development viability models will identify and describe the revenues and costs from a proposed real estate development, predict the level and timing of all financial inflows and outflows and predict accurately the profitability or land value. As such, development viability models need to accurately simulate both the timing and amount of actual monetary receipts and expenditures.

In development appraisal models, the early stages of the model formation process are well-established. Although there is some disagreement about certain details of the optimal model structure, the process of financial flows in development projects is fairly well understood. In addition, given the disagreement about certain details, the mathematical model for solving the problem is generally accepted. However, it is aspects such as the level of aggregation, quantification of uncertainty, model confirmation and/or testing stages that are less well-established.

A key decision in model formation is what resolution or granularity it should be, both in terms of specification of amounts and their timing. As stated above, an important issue for this paper is the extent to which model structure and scaling can affect model outcomes. In development appraisal, as in many fields, the low cost of computing has resulted in increased sophistication of modelling as numbers of variables has increased and interactions between variables has been specified. However, in the same way that an overly detailed map can be unusable, models that attempt to include all the detail about a system become intractable (Haggith and Prabhu, 2003). Conventionally, over-parametisation is discouraged and parsimony favoured.

An important issue in scaling is its relationship with error propagation and the ways in which uncertainty (variance) in stochastic variables becomes combined and manifested in model outputs. Essentially, in this context the main concern is the extent to which disaggregation reduces or increases output uncertainty. For viability modelling in practice, it is possible to observe a blend of both simple, highly aggregated and relatively more complex, partially disaggregated viability models. The disaggregation of detailed residential development appraisal models in particular can be unbalanced in that very high levels of resolution are applied to social housing variables whilst very little detail is requested on potentially important variables such as abnormal development costs, construction costs etc.

Model uncertainty largely explains George Box's renowned observation that "[a]ll models are wrong, but some are useful" (Box and Draper, 1987, 424). Two of the most important sources of output uncertainty stem from model structure uncertainty and input uncertainty. Model structure uncertainty is caused by the processes of simplification and formulation inherent to modelling (Li and Wu, 2006). Input uncertainty can be classified as either aleatory (stochastic, irreducible) or epistemic (reducible, subjective). The former is variable or parameter uncertainty that can be characterised and measured. Typically, it can be handled in Monte Carlo simulation given some knowledge of variability and probability distributions. The latter results from incomplete knowledge and involves variable or parameter uncertainty that cannot be characterised and measured. Often it is difficult to distinguish between the two.

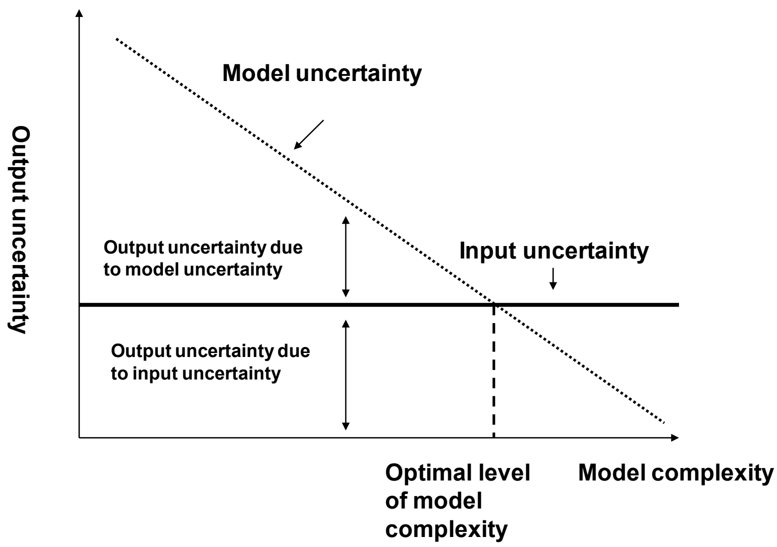
For linear models, while it is possible to calculate model output uncertainty as a function of the variances of inputs and their co-variances, the accuracy of the calculation depends upon knowing the functional form and basic statistics of the input variables. In this paper, we use a more flexible Monte Carlo simulation approach to estimate the effect of choices of model structure and scale on model output. However, it is important to acknowledge that, since information on variances and distributions is difficult to obtain, the model outputs are based upon inferred and therefore but largely subjective estimates. The extent to which we find that disaggregation adds or decreases uncertainty will depend on *our* assumptions about the variance and distribution of the variables.

In areas as diverse as economic forecasting, hydrology and meteorology, it has been found that simple models can outperform complex models with many more variables and parameters (see, Beven and Freer, 2001; Hendry and Clements, 2003; Richardson and Hollinger, 1985). Given that producers of viability appraisals have a great deal of discretion in terms of the level of detail that is modelled, one important issue concerns the identification of optimal model complexity. It is possible that simple development appraisal models and complex development appraisal models may display equifinality - a situation where different parameter sets may yield equivalent model outputs. In the environmental and ecological literature *inter alia*, this is often characterised in terms of whether there are significant performance differences between small, simple and highly aggregated models relative to large, complex and highly detailed models. The former type of model tends to be more parsimonious using *portmanteau* variables and parameters in order to circumvent the additional costs and complexity of populating complex models.

Nearly three decades ago, McLaughlin (1983) pointed out that, in the modelling of ecosystems, increases in model size and complexity did not necessarily provide the expected improvement in model performance. This was due to the fact that large, complex models are more difficult to use and a realisation that the key barrier to improving model performance was not lack of detail but a lack of accuracy in model inputs. A key variable is the signal to noise ratio in the data. The higher this ratio, the more likely it is that large complex models will be more efficient. Where it is low, it has been argued that there is little reason to expect that a large, complex model encompassing numerous noisy estimates will perform any better than a model with fewer estimates (see Jakeman *et al*, 2006).

In trying to understand the persistence of simple models in practice, a rationale may lie in the level of input uncertainty in the models. This may be so high that there are no benefits in terms of reduced output uncertainty from improving the model structure or the level of complexity. Given substantial input uncertainty, there may be little motive or incentives for modellers to improve the quality of their model structures or to add additional detail. In the diagram below, the trade-off between the accuracy of the inputs and the reliability of the model structure is illustrated. The key point is that total output uncertainty can be a function of both the intrinsic uncertainty in the assumptions made about future inputs and uncertainty due to model structure. As the coherence of the model and assumptions improve, output uncertainty tends to reduce. However, at a given point, no additional reduction in uncertainty is gained by improving the structure because of the fixed level of input uncertainty.

Figure 1: The Limits of Model Complexity



3. Conventional Approaches to Modelling Development Viability

Determining whether a proposed development is viable or not, is, at first sight, a straightforward process. The key issue is whether the estimated value of a scheme yields sufficient return to the developer and landowner to warrant the cost involved in bringing it to fruition?

Consequently, the output from a development viability appraisal is usually either an estimation of land value or an estimation of profit together with the following decision criteria:

- Is the land value sufficient to entice the owner to sell?
- Is the land value sufficient to outbid all other offers in relation to alternative uses for the site?
- Is the profit sufficient to incentivise the developer to proceed with the development given its risk profile?

Because the range of development constraints and possibilities vary between individual sites, appraisal techniques relying upon 'the law of one price' can be problematic. Sole reliance on prices achieved on what might be regarded as similar, neighbouring sites can often be, at best, a useful backup. Instead, variations of a project-based modelling approach, known as the residual method of appraisal, are often used. The residual method is based on the assumption that an element of latent or residual value is released after development has taken place. The value of the site in its proposed state is estimated, as are all of the costs involved in the development, including a suitable level of return to the developer. If the value of the completed development is greater than its cost to build, the difference, or residual value, is the value of site. The conventional (no forecasting) residual valuation of a development site is

$$LV_0 = (1+i)^{-T}\left[\frac{R_0/y_0}{(1+p)} - DC_0 - I_{DC}\right] \qquad [1]$$

Where LV_0 = present net land value

i = cost of finance (annual interest rate)

T = development period; lead-in period + construction period + void period (T_{lp} + T_{cp} + T_{cp})

R_0 / y_0 = current estimate of rent, R, divided by current estimate of yield, y (i.e. development value (DV)

p = profit as a percentage of DV

DC_0 = current estimate of total development costs (DC)

I_{DC} = interest charges on DC, calculated as follows:

$$I_{DC} = (1+i)^{-T_{lp}}\left[\left(DC/2\left(((1+i)^{T_{cp}})-1\right)\right) + (DC((1+i)^{T_{vp}})-1)\right]$$

With forecasting of rental growth, yield movement and construction costs, the residual model is as follows:

$$LV_0 = (1+i)^{-T}\left[\frac{R_0(1+r)^T/y_T}{(1+p)} - DC_0(1+c)^T - I_{DC}\right] \qquad [2]$$

Where r = forecast of annual rental growth rate

y_T = forecast of initial yield at time T

c = forecast of annul construction cost inflation

The variables can be transposed so that developer's profit becomes the dependent variable. In the traditional residual model, the number of cost and revenue categories is usually quite small. However, in practice, the granularity of the cost and revenue variables is selected arbitrarily. For a large scheme, the number of sub-categories could theoretically run into hundreds if not thousands. However, the most commonly cited limitation of this simple residual model has not focussed on the typically high level of aggregation but on the assumptions about the timing of costs and revenues. In this type of model, it is assumed that costs are spread equally over the development period and that all revenues are received at the end of the period.

Cash flow approaches emerged in the late 1970s that could more accurately reflect (mathematically at least) the timing of revenue and expenditure over the development period. Projecting a cash flow is particularly useful for developments where the initial land acquisition or disposal of the completed development is phased. The basic approach of the discounted cash flow approach is that the net present value (NPV) of the development scheme is estimated where

$$LV_0 = R_0 + \sum_{i=1}^{n-1} \frac{R_i - p}{(1+r)^i} + \frac{DV_n}{(1+r)^n} \qquad [3]$$

Where: R = recurring periodic net revenue received at the end of each period
r = cost of finance
n = number of periods
and other variables are as defined above

In a standard cash flow development appraisal, r is taken as the cost of finance and profit is included as a cash outgoing that may be taken out as revenue is received or at the end of the development period. Although we have expressed profit as a proportion of revenue, it can also be expressed as a proportion of development cost. The NPV (assuming that it is positive) is then the surplus that is available for land after all costs (including profit) have been deducted.

4. A critical review of conventional development viability appraisal models

4.1 Model Structure Uncertainty in Development Viability Modelling

A number of the practices and assumptions used in viability model structures are considered to lack rigour in mainstream capital budgeting theory. The fundamental issue is that, rather than draw upon conventional project appraisal models, cash flow models tend to be based on the same assumptions as the simple residual model and essentially add a cash flow framework. Consequently, the only significant improvement in terms of model composition of using cash flow approaches has been that the effects of timing of development cash flows are now appraised more rigorously. Real estate academics from a corporate finance background who have ‘stumbled upon’ development appraisal have made a number of criticisms regarding the robustness of the underlying development viability model as it is specified and the way that it is applied (see for example Brown and Matysiak, 2000; Geltner and Miller, 2000). Some common limitations are: failure to inflate future costs and forecast revenues, simplistic incorporation of return requirements and inclusion of financing as a cost.

In conventional approaches to modelling development viability, it is common (although not universal) practice[1] to input current values and current costs. This avoids incorporating assumptions about inflation in costs and values. In practice, anecdotal evidence suggests that some developers do adjust cost and values to reflect expected inflation. This is also illustrated in some development appraisal textbooks, and specialist development appraisal software allows for inflation assumptions to be incorporated. It is also standard practice in the appraisal of standing property investments.

It is usual practice to assume required profit in terms of a cash sum and to include it in the cash flow. In contrast, in mainstream project appraisal, required profit is expressed in terms of required return. The expected cash flow is discounted at the required return in order to assess viability or to assess the surplus available to purchase the land. A number of commentators have pointed to a common error in project evaluation - the potential confusion between the use of cost of debt and the opportunity cost of capital in the cash flow appraisal. This confusion is entrenched in standard development appraisal.

It is also common practice to assume all-debt financing. Again, this is in contrast to mainstream project appraisal where the value of the project’s equity and the value added by financing are treated separately

[1] There is little survey evidence of standard practice amongst real estate appraisers. However, practice can be inferred from examination of publically available appraisals, development appraisal software and development appraisal textbooks.

An alternative model is similar to the conventional cash flow model in equation [2] but removes profit as a cash outflow and discounts at a target rate of return rather than the cost of finance.

$$LV_0 = R_0 + \sum_{i=1}^{n-1} \frac{R_i}{(1+i)^i} + \frac{DV_n}{(1+i)^n} \qquad [4]$$

Where *i* = target rate of return
and other variables are as defined above

Whatever their internal robustness, current specialist tools used to perform development viability appraisals add to these weaknesses by oversimplifying the expected cash flow. The Homes and Communities Agency (HCA) recognises the limitations of current assessment tools such as the Greater London Authority's Affordable Housing Development Control Toolkit and the HCA's Economic Assessment Tool when modelling larger, phased developments which might involve deferred planning obligations. The recent HCA guide to economic appraisal states that:

> "The modelling of larger, phased developments [to inform consideration of an approach to the deferment of planning obligations,] will require models which can reflect the future dynamics of housing market recovery, changing values and build costs, demonstrate their sensitivities and their consequent potential impacts on the out-turn scheme position." (HCA, 2009, 13)

Model selection creates some *a priori* expectations of appraisal variance. As noted above, the traditional simple residual model makes a number of simplifying assumptions about the financial flows from development schemes. As well as allowing modellers to incorporate more realistic assumptions about the timing of cash flows, cash flow approaches also permit the incorporation of projections/forecasts of revenues and costs. Traditional simple residual models and traditional cash flow models will reconcile when three conditions hold:

1. All receipts and profits are received at the end of the development period.
2. Costs are spread equally over the development period.
3. Costs and revenues are expressed in current terms.

The extent to which expected cash flows deviate from these simplifying assumptions will determine the extent to which the outputs of traditional simple residual methods and conventional cash flow methods diverge. The extent to which a conventional cash flow approach will produce a different output from a traditional simple residual approach depends upon a combination of the actual distribution of revenues and costs of time relative to simplified assumptions, the operational gearing ratio and the incorporation and level of (positive or negative) forecasts of future costs and revenues are incorporated.

The temporal distribution of costs and revenues.

The degree to which the actual development scheme deviates from the simplifying assumptions that costs are spread equally over the development period and that all revenues are received at the end, will determine the extent to which discounted cash flow models produce a different output to simple residual models.

The difference between forecast revenue inflation and forecast cost inflation.

The amount by which forecast revenue inflation exceeds forecast cost inflation will also affect the difference between the outputs of a traditional simple residual model and conventional cash flow model. All else being equal, positive net inflation i.e. the extent to which revenue exceeds cost inflation will result in higher land values from a conventional cash flow model relative to a traditional simple residual appraisal. In turn, negative net inflation will result in a lower land value.

Operational gearing ratio.

One of the factors determining the relative uncertainty in land value will be the ratio of development revenues to development costs (excluding land costs). The smaller the ratio of development revenues relative to development costs in the simple traditional residual approach, the more sensitive the output will be to a change in development revenues and/or costs. Stated differently, all else being equal, the lower the ratio of development values to development costs, the greater the level of uncertainty in land value in a stochastic environment.

4.2 Input Uncertainty in Development Viability Modelling

The persistence of assumptions that lack theoretical rigour and/or deviate from 'real world' behaviour in the application of development appraisal techniques may seem peculiar. Even within the academic community, existing assumptions have rarely been questioned or evaluated. As noted above, a rationale may lie in the level of input uncertainty in the models. Essentially, substantial uncertainty about projected costs and values may vastly outweigh any reduction in uncertainty that might result from improvements to the cash flow model and therefore there may be little motive or incentive for developers to improve their model structures or increase the level of complexity.

There are two main sources of input uncertainty. First, modellers are uncertain about current levels of costs and revenues. Second, there is forecast uncertainty associated with future cost and price change (inflation). The output from a development viability model is very sensitive to changes in certain, key, inputs; rental and capital value, building costs and development period in particular, but many of the other inputs are ratios of these key inputs. For instance, asset disposal fees are expressed as a percentage of revenue; professional fees are expressed as a percentage of construction costs; profit is assumed to be a percentage of cost or revenue. In essence, estimates of future fees are affected by uncertainty in: current levels of the input variable (e.g. construction costs), estimated change in the level of the input variable (e.g. building cost inflation), the parameter (e.g. fee rates) and future changes in the parameters. As a consequence these ratios inputs are also stochastic variables.

There has been little published work on viability modelling in the real estate development literature. One exception is Leishmann, Jones and Fraser (2000) who extended the work of Antwi and Henneberry (1995). Drawing upon a database of actual land prices paid in the west of Scotland between 1989 and 1995, they simulated house builder appraisals in a number of scenarios. They were attempting to assess the extent to which housing developers exhibited perfect foresight, trend extrapolation or current price-taking behaviour by comparing hypothetical development appraisals with actual land price outcomes. The results were inconclusive in that, due to the stability of the particular market investigated, the perfect foresight and current price taking models both produced equivalent best performance in terms of correlation with actual land prices.

5. Research Method

In order to test these ideas, suitable appraisal examples are necessary. This is of itself not trivial, in the sense that they need to reflect both the simple (conventional) approach alongside a cash flow, but with sufficient detail (complexity) in both to allow for the introduction of a 'depth' of uncertainty that reflects the real world, but with modelable simplification. Two examples are used at this stage.

Example 1 may seem trivial. Table 1 shows a 'back of envelope' type appraisal where much of the detail of calculation is hidden within individual cells, and there is little disaggregation of the varying elements in the system. The determined output is a land value. This residual is subjected to a risk analysis, and the results of this analysis are discussed in Section 6 below. Risk in this appraisal is modelled in three stages. First, a set of uncertain variables is characterised by Normal distributions. But several of these are each conditional upon 'change' factors, for example the rent level at letting is uncertain, but so also is rental 'growth', so in a second stage those factors are also modelled stochastically. In the second stage of this example several of the distributions are altered, and in the third stage correlations are introduced into the system.

In any risk analysis, a main consideration will be the form of the probability distributions that express the uncertainties in the system. This has been seen persistently as a major difficulty in developing models of this kind. It is necessary to specify a considerable number of distributions in these models, and practically the justification of the form of any or all of them is a problem that is common to all risk analyses. The literature tends to use easily managed distributions, e.g. Normal, Triangular, rather than attempting any systematic understanding as to which distributions might be most appropriate or correct. This paper, as presently constructed, is little different. Here the variable distributions are modelled in their simplest form, to try to understand their relative importance in the calculations. The simulations were carried out using Crystal Ball (CB) within Excel. The sampling method was Monte Carlo, and the sample size was 10000 trials[2].

The distributions used in Example 1 are Normal, LogNormal, Triangular and BetaPERT, in some cases constrained or truncated to satisfy obvious measurement issues, such as the need for positive values only. In most cases the rule has been to use the CD default values for the parameters of the distributions; best estimate for the Mean and ±10% of the Mean as

[2] Full specifications of the input variables are available from the authors for all the models in the paper.

the estimated standard deviation. The preferred measure of output risk is the standard deviation of the simulated sample. It is this, and the Coefficient of Variation, that we will concentrate on in reviewing the results.

Example 2 is a relatively short timescale commercial office development assumed to be in the centre of London. Its main characteristics are laid out in Table 2. This shows the variables and their initial values. Although more complicated than Example 1, this is technically still not particularly intricate because it is intended to test the issues discussed earlier in the paper. As such it does have easily recognisable limitations, most of which are deliberate and some of which will be examined in more detail below. It will be noted that the costs include a significant public sector contribution, known at a 'Section 106' payment in the UK.

For the purposes of modelling uncertainty it is not so much the absolute values that the key input variables take but the extent to which they might vary and the correlations between them that are the crucial elements. Notwithstanding the proviso that historical costs and values may be poor proxies for future estimates, time series data for these key variables provide some empirical basis for forecasting. It is possible to examine movements in London rents and yields from IPD data. Annual growth in office rents between 1990 and 2007 averaged 0.98 per cent with a standard deviation of 9.17 per cent. Between 2005 and 2007 the figures were 4.73 and 14.59 respectively (IPD, 2008). Because development activity typically involves shorter time horizons than standing investment activity there is some rationale for taking a shorter term view of movements in the key variables. On this basis, the average and standard deviation over the least three years was used. Over the same three-year time period, the initial yield for offices in London averaged 4.49 per cent per annum with a standard deviation of 0.42 per cent. The cost of constructing a high quality, medium-rise, air-conditioned office building on a speculative basis in the centre of London ranges between £1,730 and £2,200 per square metre, producing a mid-point cost of £1,965 per square metre and a range of £470 (Davis Langdon, 2010). Annual inflation in construction costs averaged 5.80 per cent between 2006 and 2008 with a standard deviation of 0.01 per cent (between 1990 and 2008 the figures were 4.63 per cent and 0.02 per cent).

The example has been constructed using five viability models, incorporating progressively more uncertainty in the model. The goal is to determine whether this increasing uncertainty is reflected in the model output. The standard models discount costs and revenues at a finance rate and the alternative models discount at a target rate of return.

Standard residual model
Aggregated standard cash flow model
Aggregated alternative cash flow model
Disaggregated standard cash flow model
Disaggregated alternative cash flow model

All of the results of Example 2 are presented in terms of a conventional residual and also as various styles of cash flow. In each case the outcome is the residual land value. In every case the principal need (and problem) is to model the uncertainty in the variables in a reasonable way. By 'reasonable' we mean a way that reflects our imperfect knowledge of each variable's performance and the requirement to 'forecast', in some sense, their outcomes since, if we are unable to do that, we cannot do risk analysis!

6. Results

Taking Example 1 first. The results of the simulation experiments are shown in summary in Table 6. In Model 1, the first column shows a number of variables and the distributions used to model their uncertainty. This represents a sort of baseline of risk in the system. In the second column, further volatility is added as described above, and the effect on the overall risk in the system is immediately seen in an increase in the standard deviation (SD) from about 577k to 810k.

In Model 2, the input distributions of some of the variables are changed to better reflect the forms that these factors are likely to have. This enables us to see that the distribution selected for each factor can have a marked effect on the overall risk profile of the appraisal, as here for example, the SD rises again to more than 900k.

In Model 3, some variables are correlated. Measurement of the scale of the correlations is a significant factor in constructing a sensible model in this case, but is potentially of great importance because the multi-layered interdependence between factors can have a marked influence on the output. This is seen in this example, with other no other changes in the model structure, the SD again rises to above 1.1m. Some small part of that may be attributable to the sampling process, but it is overwhelmingly a function of the intercorrelation structure(s).

For Example 2, the first set of results are shown in Table 7. Here the sequence of models each adds one stochastic variable to the system, starting with the variables that add most to the variance. Usually this is the ARY, although in some cases the second variable, rental value, randomly produces a rather greater effect. The third variable is building cost, which although somewhat significant in terms of it contribution, is much less important that the previous two. These three variables cumulatively and consistently contribute at least 98% to the over risk in all of the models. In other words, the utility of studying the risk performance of any other variables might seem to be a waste of time and effort. But this is not so. The final variable added is rental growth and this dramatically affects the results in this example. This is of course because of its very volatile statistics; a relatively low mean (4.79), but a very large standard deviation (14.59). Taken with the fact, noted above, that rental value is a crucial variable then the forecast volatility of the change in that variable, increases the overall risk of the appraisal by more than three times!

In Table 8, the amount of uncertainty in the models is stepped up substantially. This takes the number of stochastic variables to 20, by supposing that the majority of variables in the basic model contain uncertainty. The 20 variable case for the cash flow shows a marginal **decrease** in the coefficient of variation, principally because the mean value of the sample has fallen, but the standard deviation is lower than in the seven variable case.

Finally, this model specification is re-run, but with the two principal risk-bearing variables, Rent and ARY correlated strongly negative (-0.7). Here, the expectation when interdependency is added to a risk analysis is that the standard deviation will be increased, but so might the mean, as the sampling system weighs combinations of values to reflect the size of the relationship. This effect is usually greater and of potentially more significance than attempting to model the totality of uncertainty in such systems, but in this case the performance of the Rental growth variable completely overwhelms the correlation effect.

7. Conclusions

Development viability appraisals are now an important nexus in the UK's planning system. Whilst this has resulted in growing scrutiny of their methods and inputs by local authorities, planning inspectors, central government agencies and professional institutions *inter alia,* there still seems to be little consistency in model composition in practice. Within the professional and academic real estate communities, it has long been recognised that there are limitations in development viability modelling. Development viability appraisals are prone to substantial input uncertainty and significant weaknesses in terms of model structure. Whilst input uncertainty varies with timescale and nature of each particular scheme, it is widely accepted that there is significant uncertainty in the key assumptions of costs and revenues. Given this input uncertainty, the focus of this paper has been on whether the use of simplistic and simple models to assess development viability can be justified given high levels of input uncertainty.

Largely due to high levels of input uncertainty, it is a common finding in other disciplines that simple, aggregated models can display equifinality with complex, disaggregated models. We also find evidence of equifinality in the outputs of a simple, aggregated model of development viability relative to more complex, disaggregated models. However, this finding cannot be considered definitive.

The results presented in this paper represent the early output of the first stage of a larger project that will seek to deconstruct and then reconstruct the development viability appraisal process in an analytically rigorous way. The ultimate goal will be simplicity in analysis and especially explanation, given the range of prospective audiences that will increasingly need to have this kind of analysis put before them. What that level of simplicity will actually be cannot be sensibly articulated at this point, but as has been shown, even at an apparently basic level, the complexity of the risk and uncertainty measures in typical projects can lead to formidable problems of consistency and reliability that need to be understood far more systematically, before they can be interpreted and explained properly.

Further testing will be needed to model more complex developments such as those which involve longer timeframes and phasing. In addition, the simulation approach used thus far does not include development period uncertainty. In order to be more sure that our conclusions are robust, we need to assess the extent to which the findings involve valid inferences rather than being a function of our informed, but ultimately subjective, estimates of estimated variances, distributions and correlations.

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Table 1: Example 1: A Basic Residual

Inputs

Interest rate	8%	
Development period:		
lead-in period	0.25	
building period	1.5	
void period	0.25	
Rent	479,400	
Rental growth (% p.a.)	0.00%	
Forecast rent	479,400	
Yield	6%	
Yield forecast	6.00%	
Developer's profit	20%	
Development costs	2,114,000	
Cost inflation (% p.a.)	0.00%	
Forecast costs	2,114,000	

Calculations

PV		0.8573
DV (net of costs)		7,555,556
Interest over bldg period		129,344
Interest over void period		43,580

Output

Land value	3,437,390	

Table 2: Example 2: a more complex development appraisal with cashflow analysis

Variables	
Areas:	
Gross Internal Area (GIA) (ft2)	150,000
Efficiency ratio (net/gross area)	85%
Net Internal Area (NIA) (ft2)	127,500
Construction costs:	
Site Preparation	£0
Building costs (£/ft2)	£184
External works	£0
Contingencies (% of all construction costs)	5.00%
S106	£8,000,000
Fees:	
Professional fees: (% construction costs)	10.00%
Letting Agent's Fee (% ERV)	10.00%
Letting Legal Fee (% ERV)	5.00%
Marketing & Promotion	£5,000
Sale Agent's Fee (% NDV)	0.75%
Sale Legal Fee	£30,000
Investment Purchaser's Costs (% NDV)	5.75%
Planning	£15,000
Building Regs	£10,000
Land acquisition costs (% site purchase price)	5.75%

Values:	
Estimated rent / ft2	£45.00
All Risks Yield	4.49%
Appraisal specific inputs:	
Developer's profit (% costs):	20.00%
Finance:	
Short term finance rate (annual)	8.00%
Short term finance rate (quarterly)	1.94%
Time:	
Lead-in period (yrs)	0.25
Building period (yrs)	1.50
Letting void (yrs)	0.25
Total Development Period (yrs)	2.00
Other Inputs:	
Target Rate (per Annum)	15%
Debt Proportion	100%
Building cost inflation (%pa)	2%
Rental Growth (%pa)	2%

Table 3: Some Typical Section 106 Agreement elements

Typical S106 variables
Provision of open space
Landscaping
General environmental improvements
Ecology, countryside management, etc.
Temporary highway works
Permanent highway works
Traffic management / calming
Parking provision
Green transport / travel plans
Provision and improvement of public rights of way
Community art
Town centre management
Public toilets
Waste and recycling facilities
Regeneration initiatives
Public transport contribution

Table 4: Conventional Residual

Residual valuation to calculate site value					
Development value:					
Gross Internal Area (GIA) (ft2)	150,000				
Net Internal Area (NIA) (ft2)	127,500				
Estimated rent / ft2 (ERV)	£45				
		£5,737,500			
Capitalised into perpetuity @	4.49%	22.2717			
Gross development value (GDV)			£127,783,964		
less purchaser's costs (@ % NDV)	5.75%		£6,948,064		
Net development value (NDV)					£120,835,900
Construction Costs:					
Building Costs (£/ft2 GIA)	£184	£27,600,000			
Other construction costs		£0			
Contingency @ % above costs	5.00%	£1,380,000			
			£28,980,000		
Other costs:					
S106		£8,000,000			
Site Preparation		£0			
			£8,000,000		
Fees:					
Professional fees: (@ % above costs)	10.00%	£2,898,000			
Planning		£15,000			
Building Regs		£10,000			
			£2,923,000		
Total Costs and Fees:				£39,903,000	
Interest:					
on half total costs and fees for whole building period @	8.00%	£2,441,444			
on total costs & finance for void & rent free periods @	8.00%	£822,606			
Total Interest Payable (£'s):				£3,264,050	
Letting & Sale Costs:					
Letting agent's fee (% ERV)	10.00%	£573,750			
Letting Legal fee (% ERV)	5.00%	£286,875			
Marketing (£'s)		£5,000			
Sale agent's fee (% NDV)	0.75%	£906,269			
Sale legal fee		£30,000			
Total Letting & Sales Fees (£'s):				£1,801,894	
Total Development Costs:				£44,968,944	
plus **Developer's profit on Total Development Costs (%):**	20.00%			£8,993,789	
					£53,962,733
Future residual balance (Inc. profit on land)					£66,873,167
less **Developer's profit on Land Costs (%):**	20.00%				£11,145,528
Future balance (Inc.interest on land & acquisition costs)					£55,727,639
less interest on land and acquisition costs for total development and void period (yrs): (PV £1 'n' yrs @ 'i' %)	8.00%	2.00			0.8573
Present residual balance for land and acquisition costs:					£47,777,469
less Acquisition Costs (% land acquisition bid price)	5.75%				£2,597,829
Residual valuation for site					**£45,179,639**

Table 5: Residual cash flow

Residual Cash Flow	
Target rate of return (per annum)	15.00%
Debt proportion	100.00%
Building cost inflation (% p.a.)	2.00%
Rental grow th (% p.a.)	2.00%

Spread of Costs, Fees, Revenue and Growth

Quarters	0	1	2	3	4	5	6	7	8	*TOTALS*
Land Price	100%	0%	0%	0%	0%	0%	0%	0%	0%	*100%*
Site Preparation	100%	0%	0%	0%	0%	0%	0%	0%	0%	*100%*
Building Costs	0%	0%	10%	20%	40%	20%	10%	0%	0%	*100%*
Professional Fees (construction costs)	0%	10%	20%	10%	30%	20%	10%	0%	0%	*100%*
Marketing	0%	0%	0%	0%	0%	0%	0%	0%	100%	*100%*
Lettings	0%	0%	0%	0%	0%	0%	0%	0%	100%	*100%*
Revenue - Commercial	0%	0%	0%	0%	0%	0%	0%	0%	100%	*100%*

Cash-flow

	0	1	2	3	4	5	6	7	8	TOTALS
EXPENDITURE										
Site preparation costs (inc contingency)	£0	£0	£0	£0	£0	£0	£0	£0	£0	*£0*
Building costs	£0	£0	-£2,760,000	-£5,520,000	-£11,040,000	-£5,520,000	-£2,760,000			*-£27,599,999*
Contingency (% bldg costs)	£0	£0	-£138,000	-£276,000	-£552,000	-£276,000	-£138,000	£0	£0	*-£1,380,000*
Professional Fees (% bldg costs & contingency)	£0	-£289,800	-£579,600	-£289,800	-£869,400	-£579,600	-£289,800	£0	£0	*-£2,898,000*
S106				-£8,000,000						*-£8,000,000*
Planning				-£15,000						*-£15,000*
Building Regs				-£10,000						*-£10,000*
Marketing	£0	£0	£0	£0	£0	£0	£0	£0	-£5,000	*-£5,000*
Letting agent(s) fee	£0	£0	£0	£0	£0	£0	£0	£0	-£573,750	*-£573,750*
Letting legal fee	£0	£0	£0	£0	£0	£0	£0	£0	-£286,875	*-£286,875*
Commercial sale agent fee	£0	£0	£0	£0	£0	£0	£0	£0	-£942,883	*-£942,883*
Commercial sale legal fee	£0	£0	£0	£0	£0	£0	£0	£0	-£30,000	*-£30,000*
Borrow ing at		-£5,630	-£67,558	-£274,124	-£242,082	-£123,856	-£61,928	£0	-£35,716	*-£810,893*
										-£42,552,400
Dev profit									*-£8,510,480*	
REVENUE										
Net Development Value - Commercial	£0	£0	£0	£0	£0	£0	£0	£0	£125,717,670	*£125,717,670*
Net cash flow		-£295,430	-£3,545,157	-£14,384,924	-£12,703,482	-£6,499,456	-£3,249,728		£115,332,967	*£74,654,791*
		-£289,800	-£3,411,329	-£13,578,123	-£11,762,483	-£5,903,333	-£2,895,418		£98,879,430	*£52,528,463*

Table 6: Example 1: Uncertainty plus volatility plus correlation in a simple residual model

	Model 1		Model 2		Model 3		
Statistics	**Uncertainty**	**Volatility**	**Uncertainty**	**Volatility**	**Uncertainty**	**Volatility**	
Mean	3,437,574	**3,501,871**	3,421,996	**3,670,912**	3,431,053	**3,721,853**	
Median	3,441,073	**3,438,205**	3,414,307	**3,619,062**	3,433,779	**3,651,014**	
Standard Deviation	577,425	**810,685**	585,694	**904,511**	590,509	**1,136,220**	
Skewness	-0.0296	**0.4051**	0.0224	**0.3536**	0.0129	**0.4236**	
Kurtosis	3.02	**3.39**	2.96	**3.15**	2.9	**3.16**	
Coeff. of Variability	0.168	**0.232**	0.171	**0.246**	0.1721	**0.3053**	
Minimum	1,131,228	**459,504**	1,073,924	**706,155**	1,130,110	**511,420**	
Maximum	5,736,217	**7,415,856**	5,700,332	**8,042,676**	5,693,546	**8,769,812**	
Distributions							
Interest rate	Normal	Normal	Lognormal	Lognormal	Lognormal	Lognormal	
Development period:							
lead-in period	Normal	Normal	Lognormal	Lognormal	Lognormal	Lognormal	
building period	Normal	Normal	BetaPERT	BetaPERT	BetaPERT	BetaPERT	Corr. With Dev. Costs 0.75
void period	Normal	Normal	BetaPERT	BetaPERT	BetaPERT	BetaPERT	Corr. With Yield forecast 0.5
Rent	Normal	Normal	Normal	Normal	Normal	Normal	Corr. With Yield forecast -0.7
Rental growth (% p.a.)		Normal		Triangular		Triangular	
Forecast rent							
Yield							
Yield forecast		Normal		Lognormal		Lognormal	
Developer's profit							
Development costs	Normal	Normal	Normal	Normal	Normal	Normal	
Cost inflation (% p.a.)		Normal		Normal		Normal	

Table 7: Example 2: Stepped increase in risk bearing variable – up to seven variables

	1		2		3		4	
	Conventional	Cashflow	Conventional	Cashflow	Conventional	Cashflow	Conventional	Cashflow
Mean	£45,920,504	£53,504,669	£45,796,574	£53,341,425	£45,711,242	£53,196,765	£45,694,647	£53,179,017
Median	£45,110,494	£52,437,353	£45,103,577	£52,425,697	£44,929,722	£52,218,936	£44,825,633	£52,064,681
Standard Deviation	£7,803,124	£10,281,852	£11,144,647	£14,673,442	£11,393,279	£15,035,915	£11,465,718	£15,134,209
Skewness	0.6223	0.6223	0.3446	0.3451	0.453	0.4522	0.4704	0.4681
Kurtosis	3.83	3.83	3.18	3.19	3.57	3.57	3.49	3.49
Coeff. of Variability	0.1699	0.1922	0.2434	0.2751	0.2492	0.2826	0.2509	0.2846
Minimum	£23,150,855	£23,502,049	£13,034,505	£10,219,759	£7,234,292	£2,308,248	£11,244,373	£7,383,355
Maximum	£108,483,270	£135,941,028	£101,567,585	£126,791,962	£109,752,032	£137,966,987	£109,574,176	£137,395,776
	5		6		7			
	Conventional	Cashflow	Conventional	Cashflow	Conventional	Cashflow		
Mean	£45,682,013	£53,164,132	£45,555,312	£52,995,655	£45,780,073	£61,809,111	1	All Risks Yield
Median	£44,948,872	£52,234,050	£44,838,125	£52,092,048	£45,015,017	£58,189,833	2	Estimated rent / ft2
Standard Deviation	£11,338,803	£14,976,929	£11,365,594	£15,012,988	£11,521,513	£35,750,694	3	Building costs (£/ft2)
Skewness	0.372	0.3696	0.3815	0.3775	0.4388	0.6226	4	Short term finance rate
Kurtosis	3.31	3.3	3.25	3.25	3.44	3.63	5	S106
Coeff. of Variability	0.2482	0.2817	0.2495	0.2833	0.2517	0.5784	6	Building cost inflation
Minimum	£9,867,471	£5,527,143	£7,891,381	£3,291,030	£10,792,709	-£35,108,985	7	Rental Growth (%pa)
Maximum	£98,233,248	£122,655,464	£93,838,390	£116,543,747	£109,409,509	£244,648,367		

Table 8: Example 2: Increased risk profile: 20 variables

	Disaggregated 20 variables		Disaggregated 20 variables Two variables correlated	
	Conventional	**Cashflow**	**Conventional**	**Cashflow**
Mean	£45,092,151	£60,431,615	£45,261,918	£60,279,603
Median	£44,581,432	£57,067,313	£44,858,689	£56,899,922
Standard Deviation	£8,300,643	£34,463,725	£8,786,600	£34,187,908
Skewness	0.3377	0.5282	0.3152	0.5454
Kurtosis	3.31	3.37	3.31	3.51
Coeff. of Variability	0.1841	0.5703	0.1941	0.5672
Minimum	£16,228,988	-£32,753,263	£14,070,151	-£37,972,561
Maximum	£83,009,129	£225,980,263	£91,736,854	£246,678,883