HENLEY
UNIVERSITY OF READING

Real Estate & Planning

Working Papers in Real Estate & Planning 03/10

Paper Presented at Society of Property Researchers/RICS Cutting Edge Conference, 13 May 2010

Reconciling Model and Information Uncertainty in Development Appraisal

Byrne, P., McAllister, P. and Wyatt, P.

School of Real Estate & Planning
Henley Business School
University of Reading
Reading
RG6 5UD
UK
www.reading.ac.uk/rep
Email: p.wyatt@reading.ac.uk

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, simple and simplistic models may produce similar outputs to more robust and disaggregated models.

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 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 large-scale, macro-level Strategic Housing Land Availability Assessments require proposed plans to be achievable. However, the timeframe 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 models 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 become 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. Whilst 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.

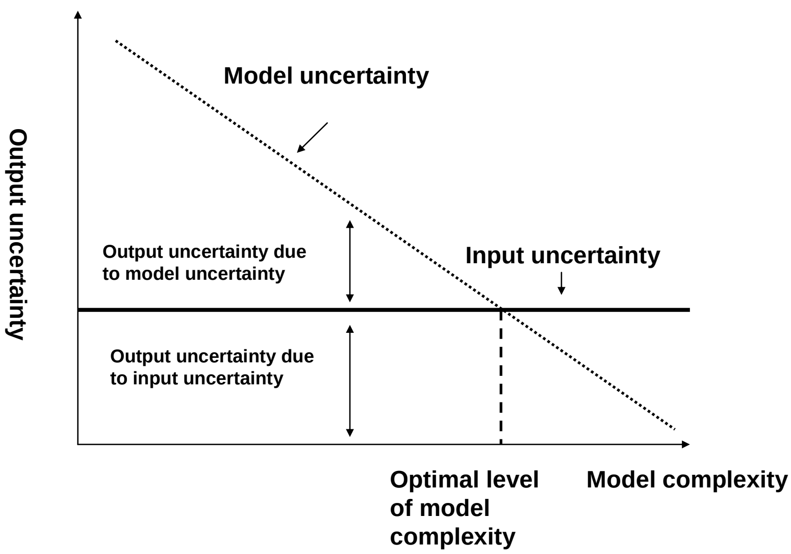
For linear models, whilst it is possible to calculate model output uncertainty as a function of the variances of inputs and their co-variances, the accuracy of the calculation depends upon knowing the functional form and basic statistics of the input variables. In this paper, we use a more flexible Monte 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 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.

Over two 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 yield 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 residual valuation of a development site is

$$LV_0 = \frac{1}{(1+r)^t}\left[\frac{DV_t}{(1+p)} - DC - I_{DC}\right] \qquad [1]$$

Where LV_0 = present net land value
DC = development costs
DV_t = net development value (NDV) at the end of t
I_c = interest charges on DC
p = profit as a percentage of DV
t = development period comprising lead-in period + construction period + void period ($t_{lp} + t_{cp} + t_{cp}$)
r = cost of finance

The variables can be transposed so that developer's profit can be 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. Appendix 1 outlines the range of information headings that has been found in a number of relatively disaggregated development viability appraisals. 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

$$LV_0 = R_0 + \sum_{i=1}^{n-1} \frac{R_i - p}{(1+r)^i} + \frac{DV_n}{(1+r)^n} \qquad [2]$$

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 is also 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. 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 mainstream 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 Brown and Matysiak, 2000; Geltner and Miller, 2000 for example). 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.

In conventional approaches to modelling development viability, it is standard practice to assume required profit in terms of a cash sum and 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.

In conventional approaches to modelling development viability, it is standard practice to assume all-debt financing. Again, this is in contrast with mainstream project appraisal where the value of the project's equity and the value added by financing are treated separately. 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.

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

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

[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.

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)

4.2 Input Uncertainty in Development Viability Modelling

The persistence of assumptions that lack rigour 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, this may be so high that there are no benefits in terms of reduced uncertainty in model output from improving the assumptions of the cash flow method. Given substantial uncertainty about projected costs and values, there may be little motive or incentives for developers to improve their model structures or increase the level of complexity.

Nearly all the inputs into development viability models are saturated with uncertainty. There are two main sources of intrinsic input uncertainty. Firstly, modellers are uncertain about current levels of costs and revenues. In addition, there is also forecast uncertainty associated with future cost and price change (inflation). The implications of such input uncertainty have long been recognised within the real estate profession. In 1966, a leading judge commented "... once valuers are let loose upon residual valuations, however honest the valuers and reasoned their arguments, they can prove almost anything" (*First Garden City Ltd v The Letchworth Garden City Corporation, 1966*). It was for this reason that the Lands Tribunal rejected the residual method as opinion evidence, unless there was no simpler method of valuation available.

In addition, many of the inputs into viability models are essentially ratios of other inputs. For instance, asset disposal fees are expressed as a percentage of revenues; professional fees are expressed as a percentage of construction costs; profit is assumed to be a percentage of cost or revenue etc. These percentage ratios are parameters that are also stochastic variables. 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.

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 the best performance in terms of correlation with actual land prices.

5. Research Method

In order to test these ideas, a suitable appraisal example is clearly necessary. This of itself is not trivial, in the sense that it needs to reflect both the simple (conventional) approach alongside a cash flow with sufficient detail (complexity) in both to allow for the introduction of a ‘depth’ of uncertainty that reflects the real world situation, but with modelable simplification.

The current example is a relatively short timescale commercial office development in the centre of a major UK city. Its main characteristics are laid out in Table 1. This shows the variables and their initial values in this example. As can be seen the example is not particularly complicated, 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 there is a significant Section 106 value component.

All of the results 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.

The example has been constructed using a number of variants, each of which has more uncertainty input to the model. The goal is to determine whether increasing uncertainty is reflected in the model output.

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

In every case the principal need (and problem) is to model the uncertainty in the variables in a reasonable way. By ‘reasonable’ here 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!

In any risk analysis, a main consideration will be the form of the probability distributions that express the uncertainties in the system. This has persistently been seen as a major difficulty in developing models of this kind. It is necessary to specify a considerable number of distributions in this model, 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 no 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.

The distributions used in these experiments are Lognormal or Normal, in some cases constrained or truncated to satisfy obvious measurement issues, such as the need for positive values only. Otherwise in every case 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 the estimated standard deviation. The preferred measure of output risk is the standard deviation (SD) of the simulated sample. It is this, and the Coefficient of Variation, that we will concentrate on in reviewing the results.

6. Results

The results of the experiments are shown in summary in Table 5. In the top part of the table, 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.

In the second part of the table, the degree of uncertainty in the models is stepped up substantially, in two stages. The first takes the number of stochastic variables to 18, by supposing that the majority of variables in the basic model contain uncertainty. The 18 variable case for the cash flow shows an increase 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.

At the next stage, the Section 106 element, previously expressed by a single (uncertain) value, is disaggregated into the components in Table 2, again supposing that their scale in the model is uncertain. This leads to a model with 35 stochastic variables, but results in little change to the overall risk performance of the appraisal.

Finally, this model specification is re-run, but with the two principal risk-bearing variables, Rent and ARY correlated strongly negative (-0.7). here as is usually the case when interdependency is added to a risk analysis, the SD increases, but so does the Mean, as the sampling system weighs combinations of values to reflect the size of the relationship. This effect is greater and of potentially more significance than attempting to model the totality of uncertainty in such systems.

7. Concluding Remarks

Development viability appraisals are now an important nexus in the UK's planning system. Whilst this has resulted in growing scrutiny of their method and inputs from local authorities, planning inspectors, central government agencies and professional institutions *inter alia,* there 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.

Further testing is needed to model more complex developments such as those which involve longer timeframes and phasing. In addition, the simulation approach used did 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.

References

Antwi, A. and Henneberry, J. (1995). Developers, Non-Linearity and Asymmetry in the Development Cycle, *Journal of Property Research* **12**, 217–39.

Beven, K. and Freer, J. (2001). Equifinality, data assimilation, and uncertainty estimation in mechanistic modelling of complex environmental systems using the GLUE methodology, *Journal of Hydrology*, **249, 1-4**, 11-29.

Box, P. and Draper, N. (1987) *Empirical Model-Building and Response Surfaces*, Wiley, London.

Brown, G and Matysiak, G. (2000) *Real Estate Investment: a Capital Budgeting Approach*, Financial Times Prentice Hall, Harlow.

Geltner, D. and Miller, N. (2000) *Commercial Real Estate Analysis and Investments*, South-Western University Press.

Hendry, D. and Clements, M. (2003). Economic Forecasting: Some Lessons from Recent Research, *Economic Modelling*, **20**, 301-329.

Homes and Communities Agency (2009) *Investment and Planning Obligations: Responding to the Downturn, Good Practice Note,* Homes and Communities Agency, London.

Leishman, C., Jones, C. and Fraser, W. (2000). The influence of uncertainty in house builder behaviour and residential land values, *Journal of Property Research*, **17,** 147-168.

Prisley, S. and Mortimer, M. (2004). A synthesis of literature on models for policy applications, with implications for forest carbon accounting, *Forest Ecology and Management*, **198**, 89-103.

Richardson, A. and Hollinger, R. (2005). Statistical modeling of ecosystem respiration using eddy covariance data: Maximum likelihood parameter estimation, and Monte Carlo simulation of model and parameter uncertainty, applied to three simple models, *Agricultural and Forest Meteorology*, **131, 3-4**, 191-208.

Wyatt, P. (2007) *Property Valuation in an Economic Context*, Blackwell Publishing,

Table 1: Development Viability Appraisals: base line variables, and Residual values.

Development Valuation

Variables			
Areas:		**Values:**	
Gross Internal Area (GIA) (ft2)	12,000	Estimated rent / ft2	£47.00
Efficiency ratio (net/gross area)	85%	All Risks Yield	6.00%
Net Internal Area (NIA) (ft2)	10,200		
		Appraisal specific inputs:	
Construction costs:		Developer's profit (% costs):	20.00%
Site Preparation	£0	Site acquisition price	£3,117,872
Building costs (£/ft2)	£150		
External works	£0	**Finance:**	
Contingencies (% of all construction costs)	5.00%	Short term finance rate (annual)	8.00%
S106	£10,000	Short term finance rate (quarterly)	1.94%
Fees:		**Time:**	
Professional fees: (% construction costs)	10.00%	Lead-in period (yrs)	0.25
Letting Agent's Fee (% ERV)	10.00%	Building period (yrs)	1.50
Letting Legal Fee (% ERV)	5.00%	Letting void (yrs)	0.25
Marketing & Promotion	£5,000	Total Development Period (yrs)	2.00
Sale Agent's Fee (% NDV)	0.75%		
Sale Legal Fee	£30,000		
Investment Purchaser's Costs (% NDV)	5.75%	**Outputs (from Res (Land) and Res (Profit) worksheets):**	
Planning	£15,000	Residual land value	£3,117,872
Building Regs	£10,000	Residual profit	£1,079,612
Land acquisition costs (% site purchase price)	5.75%		

Table 2: Section 106 variables used

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 3: 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 @	6.00%	16.6667			
Gross development value (GDV)			£95,625,000		
less purchaser's costs (@ % NDV)	5.75%		£5,199,468		
Net development value (NDV)					£90,425,532
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		£150,000			
Building Regs		£50,000			
			£3,098,000		
Total Costs and Fees:				£40,078,000	
Interest:					
on half total costs and fees for whole building period @	8.00%	£2,452,151			
on total costs & finance for void & rent free periods @	8.00%	£826,214			
Total Interest Payable (£'s):				£3,278,365	
Letting & Sale Costs:					
Letting agent's fee (% ERV)	10.00%	£573,750			
Letting Legal fee (% ERV)	5.00%	£286,875			
Marketing (£'s)		£100,000			
Sale agent's fee (% NDV)	0.75%	£678,191			
Sale legal fee		£300,000			
Total Letting & Sales Fees (£'s):				£1,938,816	
Total Development Costs:				£45,295,181	
plus **Developer's profit on Total Development Costs (%):**	20.00%			£9,059,036	
					£54,354,218
Future residual balance (Inc. profit on land)					£36,071,314
less **Developer's profit on Land Costs (%):**	20.00%				£6,011,886
Future balance (Inc.interest on land & acquisition costs)					£30,059,429
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:					£25,771,115
less Acquisition Costs (% land acquisition bid price)	5.75%				£1,401,266
Residual valuation for site					**£24,369,849**

Table 4: 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 growth (% 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	-£705,590	*-£705,590*
Commercial sale legal fee	£0	£0	£0	£0	£0	£0	£0	£0	-£30,000	*-£30,000*
Borrowing at		-£5,630	-£67,558	-£274,124	-£242,082	-£123,856	-£61,928	£0	-£31,106	*-£806,284*
										-£42,310,498
Dev profit									*-£8,462,100*	
REVENUE										
Net Development Value - Commercial	£0	£0	£0	£0	£0	£0	£0	£0	£94,078,723	*£94,078,723*
Net cash flow		-£295,430	-£3,545,157	-£14,384,924	-£12,703,482	-£6,499,456	-£3,249,728		£83,984,302	*£43,306,126*
		-£289,800	-£3,411,329	-£13,578,123	-£11,762,483	-£5,903,333	-£2,895,418		£72,003,003	*£25,700,416*

Table 5: Stepped increase in uncertainty

	1			2			3			4	
	Cashflow	Conventional		Cashflow	Conventional		Cashflow	Conventional		Cashflow	Conventional
Mean	**£26,556,793**	**£25,469,168**		£25,953,080	£25,086,924		£25,921,353	£25,067,388		£25,946,829	£25,073,473
Median	**£26,072,997**	**£25,102,004**		£25,010,262	£24,368,565		£25,253,809	£24,525,961		£25,219,426	£24,505,219
Standard Deviation	**£8,117,431**	**£6,160,497**		£11,425,913	£8,679,880		£12,154,077	£9,093,696		£12,170,100	£9,105,020
Coeff. of Variability	**0.3057**	**0.2419**		0.440	0.346		0.4689	0.3628		0.469	0.3631
Minimum	**£2,717,487**	**£7,376,994**		-£6,424,740	£482,819		-£12,298,565	-£2,529,175		-£9,539,716	-£771,712
Maximum	**£65,570,015**	**£55,077,160**		£81,004,802	£66,896,827		£86,548,050	£71,369,248		£77,998,557	£64,784,891

	5			6			7	
	Cashflow	Conventional		Cashflow	Conventional		Cashflow	Conventional
Mean	£25,674,080	£24,875,586		£26,029,058	£25,141,442		£25,863,643	£25,012,543
Median	£24,998,986	£24,311,363		£25,507,011	£24,691,916		£25,265,679	£24,559,392
Standard Deviation	£12,178,790	£9,111,344		£12,012,749	£8,988,480		£12,206,644	£9,120,024
Coeff. of Variability	0.4744	0.3663		0.4615	0.3575		0.472	0.3646
Minimum	-£14,850,572	-£5,049,064		-£14,452,337	-£4,478,253		-£16,874,336	-£6,021,632
Maximum	£85,374,850	£69,829,008		£84,233,217	£68,771,093		£76,718,124	£63,325,274

1	All Risks Yield
2	Estimated rent / ft2
3	Building costs (£/ft2)
4	Short term finance rate (quarterly)
5	S106
6	Building cost inflation (%pa)
7	Rental Growth (%pa)

	Disaggregated 18 variables		Disaggregated 35 variables		Disaggregated 35 variables Two variables correlated	
	Cashflow	Conventional	Cashflow	Conventional	Cashflow	Conventional
Mean	£23,063,276	£25,209,352	£26,445,440	£25,467,960	£26,860,764	£25,784,043
Median	£22,474,862	£24,643,522	£25,834,802	£24,913,773	£25,548,019	£24,784,082
Standard Deviation	£11,916,664	£9,200,352	£12,287,855	£9,168,830	£15,761,244	£11,854,413
Coeff. of Variability	0.5167	0.365	0.4646	0.36	0.5868	0.4598
Minimum	-£13,590,665	-£2,490,956	-£11,607,051	-£3,777,485	-£21,753,472	-£9,934,659
Maximum	£73,742,681	£66,703,302	£81,002,926	£67,049,646	£100,621,969	£82,026,916

Appendix 1

Detailed Revenues and Costs

LV = present gross land value – site acquisition costs

Site acquisition costs = site investigation fee + (land acquisition price x % agent and legal fees) + stamp duty

DV = GDV – purchaser's costs (disposal costs)

GDV = capitalised rent + gross sales receipts - total non-recov cost - ground rent + grant(s)

Capitalised rent [for each tenanted land use] = net annual rent / yield
Net annual rent = gross annual rent x (1 - % non-recov cost)
Gross annual rent = gross annual rent per unit area x area x efficiency ratio

Gross sales receipts [for each owner-occupied land use] =
Market capital values + (market capital values x % discount to market value for various categories of AH) – total non-Recov cost
Market capital value = No. units x unit sale price [for each property type]
Total non-recov cost = fixed non-recov cost (management costs, voids, bad debts, non-recoverable repairs on rented AH (% gross unit rent), including rented share of shared ownership AH

Ground rent = (leasehold gearing % x annual gross rent) + fixed ground rent deduction

Grant(s) = % Social Housing Grant for Social Rented Housing plus AH grant per unit plus any other sources of AH funding, etc.

Purchaser's costs (disposal costs) = capitalised rent – (residential sale price x % sale fee) + (rent x % letting fee) + (commercial sale price x % sale fee)

DC = building costs + external works + fees + other costs + contingency

Building costs = No. units x unit area x building cost per unit area [for each property type]

External works = site clearance and contamination remediation + engineering works + (cost of parking space x no. spaces) + (demolition cost per unit area x area) + (highway works per unit are x area) + (% building costs for utilities) + (cost of private garden landscaping x no. private gardens) + cost of public open space per unit area x area) + (cost of children's play area x area)

Fees = Professional fees + agents fees + development control fees

Professional fees = ((architect + QS + engineers + landscape architect) x summed total % building costs) + (legal + planning consultants + highway consultants + ecology consultants + archaeology consultants + finance consultants)

Development control fees = planning application + bldg regs + EIA

Other costs = S106 costs + Misc surveys + NHBC costs

S106 costs = Provision of open space + Payments for landscaping + General environmental improvements + Ecology, countryside management etc + Allotments + Sport facilities + Permanent highway works + Temporary highway works + Traffic management/calming + Parking provision + Green transport/travel plans + Provision and improvement of footpaths + Provision and improvement of cycle paths + Construction, funding of community centres + Community art + Town centre management + Childcare/creche facilities + Public toilets + Healhcare facilities + Waste and recycling features + Training and regeneration initiatives + Contribution to education + Amount per dwelling + Number of dwellings

NHBC = (residential market value x % market value)

Contingency = building costs x % contingency fee

Forecasts

- Cost inflation forecasts, broken down by land use
- Value inflation forecasts, broken down by land use