Simulating the UK housing market

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Abstract

This paper provides an analysis of the current structure of the UK property industry and those drivers of liquidity within that market. The focus of the paper is on property sales, as opposed to rentals, and the factors that drive the constituents of the market to revolve and evolve through being under construction through various state changes to being demolished and their land being again available for further development. The paper describes the main factors that have gone into the production of a System Dynamics simulation of the property industry. The role and potential areas of impact of governmental policy are outlined. The effects of tightening worldwide credit regimes on the UK construction industry are included in the model. The relationships between the credit crunch and the behaviour of the construction industry are identified and are explored. The analysis presented in the paper concludes with potential scenarios for determining the future behaviour of the market.

Key words: Property, Real estate, UK, cycles, System Dynamics

Introduction

The UK property market is in a parlous state. Perceived wisdom, often despite historical evidence, has been that bricks and mortar were always a sound investment. Property prices have alternately outpaced and been outpaced by retail price inflation over the period 1975-2008 (Nationwide, 2009), (Office for National Statistics, 2009, Table 5.1). Though, viewing property purchase as a purely financial transaction would be misleading. Property purchase is often more than a financial investment. Buying a property may allow the purchaser to have a degree of security and independence as well as a place to live. As property prices in the UK have risen at sometimes dizzying rates (see figure 1) the financial aspects of home ownership have assumed an increasing importance.

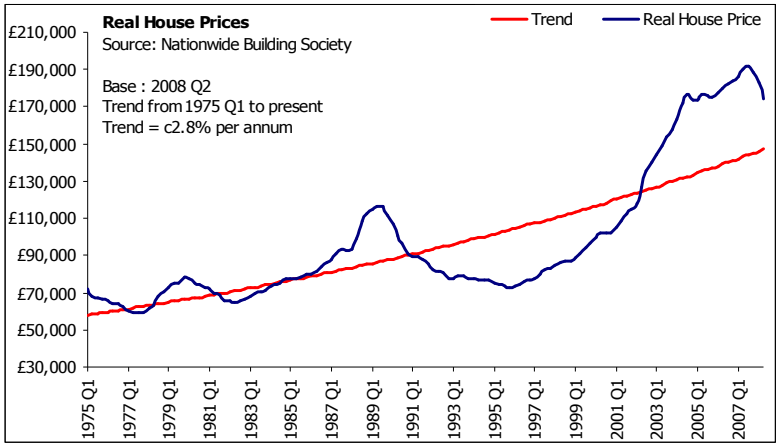

Figure 1: Real House prices, 2008 (Nationwide, 2009)

Until end 2007 equity tied up in property was being released to fund lifestyles that were built on assumptions of continuing house price growth (figure 1) and easy availability of credit (figure 2). In the 10 years to Q3 2008 equity withdrawal from property[1] peaked at 8.6% in Q4 2003 of post-tax household income and reached a low of -2.4% (a net repayment) in Q3 2008 (Bank of England, 2009(a)).

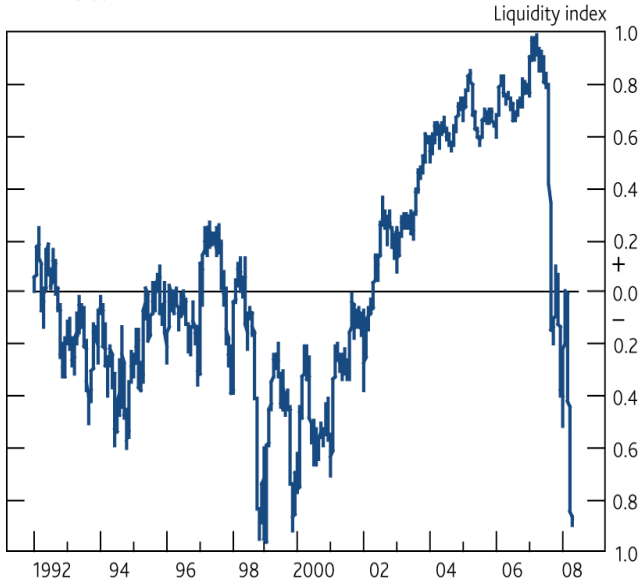

Figure 2: **Bank of England, Bloomberg, Chicago Board Options Exchange, Debt Management Office, London Stock Exchange, Merrill Lynch, Thomson Datastream and Bank calculations.** [2]

[1] "Housing equity withdrawal (HEW) is new borrowing secured on dwellings that is not invested in the housing market (e.g. not used for house purchase or home improvements), so it represents additional funds available for reinvestment or to finance consumption spending. " (BoE, 2009)

[2] (a) The liquidity index shows the number of standard deviations from the mean. It is a simple unweighted average of nine liquidity measures, normalised on the period 1999–2004. The series shown is an exponentially weighted moving average. The indicator is more reliable after 1997 as it is based on a greater number of underlying measures.

However these two founding assumptions; indefinitely rising property prices and easy availability of credit, proved false. This falsity is illustrated in the tail end of the two figures 1 and 2 above. In addition to impacting on the UK consumer the UK construction industry has been knocked back by the reduction in general liquidity and the crippling of the UK consumers' ability to purchase property.

United Kingdom Construction Industry £billion 2003-2007		
Year	**£ billion**	**% Growth**
2003	35.6	
2004	42.2	18.40%
2005	44.6	5.70%
2006	47.0	5.50%
2007	50.6	7.50%
CAGR, 2003-2007:		**9.2%**

Table 1: Datamonitor 2008[3]

All of which adds to the overall picture of decline, if not crisis, in the UK construction industry and related sectors. Table 1 shows the behaviour of the UK construction industry up to end 2007.

Market analysis using System Dynamics

System Dynamics is a simulation methodology that relies on identifying the structure of a problem and allowing that structure to determine emergent behaviour. This is as opposed to the many data driven methodologies. Data is primarily used within System Dynamics to calibrate the simulation models and to give context to the output.

A defining feature of System Dynamics is the incorporation of feedback which leads directly to the notion that any part of a system that is within a feedback loop does, to some extent, determine its own behaviour. From the System Dynamics society website we have the following description "Feedback refers to the situation of X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects. One cannot study the link between X and Y and, independently, the link between Y and X and predict how the system will behave. Only the study of the whole system as a feedback system will lead to correct results".

The advantages of using System Dynamics are the same as those of any other simulation technique. Principally, experiments can be carried out within the simulation that would be impractical or impossible within the real system.

The actual simulation model used within System Dynamics is a mathematical model which is usually implemented with specialist software.[4]

The methodology used to apply System Dynamics is that outlined in (Sterman, 2001), table 2. The remainder of this paper focuses on the implementation of this methodology to the UK property market.

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[3] "The homebuilding industry comprises residential construction, such as apartment blocks, property estates and individual home developments, as well as prefabricated houses and semi-fixed manufactured homes." (Datamonitor, 2008)

[4] The software used in this analysis is Stella v9.1 though other packages are available

Limitations of the technique are that in most cases the simulation will be a simplification of reality and therefore inaccurate to some extent and that it can be difficult to validate the model; though matching model output to some known behaviour (this known behaviour is termed reference mode) is used as a partial validation measure. To put this latter point in context there is no methodology, technique or other means to accurately predict future behaviour in any complex domain area with consistent accuracy.

Phase 1 - Problem Articulation	Structuring the problem; determining the main variables, bounding the scope; specifying the time frame; defining the reference mode – 'typical' behaviour.
Phase 2 - Formulation of dynamic hypothesis	Develop maps/causal loop/influence diagrams of the relations between the factors; identify the main feedback structures; generate hypotheses explaining the behaviour in terms of the feedback processes.
Phase 3 - Formulation of simulation model	Generate a representation in terms of stocks and flows; estimate all necessary relationships and parameter values; develop a computer model and test for consistency.
Phase 4 – Testing and validation	Comparison with reference mode; robustness under extreme conditions; sensitivity to parameters; initial conditions.
Phase 5 – Using the model – Policy design and evaluation	Specify possible scenarios; develop alternative strategies and policies; do what-if analyses; check sensitivity and interaction of policies.

Table 2: System Dynamics methodology (Sterman, 2001)

Problem articulation

This paper focuses on two main factors; the UK construction industry and secondly the availability of financial liquidity to support that industry. It is the purpose of this paper to examine how these two principle factors overlap each other and either enhance or dampen the effects of the other.

It is beyond the scope of this paper to model in any great detail the effects of the credit crunch these are instead entered by the user.

This paper proposes an analysis of the UK property market with a focus on the movements within the property stock. Initial analysis has indicated that a few states and the movements between those states are the foundations of the structure of the property market. Empirical research indicates that there are three key states which any particular property can be in.

Properties can be 'under construction' which it is recognised is a flow itself with properties moving from initial groundbreaking to finishing touches. Properties can be 'available for sale' which means that they have been constructed but have not been demolished or otherwise removed from the market. Properties can be 'unavailable for sale' which means that they have been constructed but have not been demolished but are not available for sale on the open market.

Movements between these three states, as well as those entering and leaving the overall system, define the structure of the property market as used here. Properties can become part of, or leave, this system in one of two ways. Properties enter the system by being constructed. Properties leave the system by being demolished. It is recognised that all of the above represent a significant simplification of the real system but they are an attempt to capture the essence of the system with any unnecessary detail removed; thus aiding intuitive understanding.

Two further factors have been identified that impinge directly on the structure and behaviour of the property market. The first of these is the pool of prospective buyers. The number of prospective buyers constrains the property market; it is assumed that properties purchased cannot expand beyond the available buyer population. A limitation on this assumption is that buyers can make multiple purchases either to buy second homes or as buy-to-let investment properties. The importance of buy-to-let within the UK property market has been growing and is illustrated in figure 3.

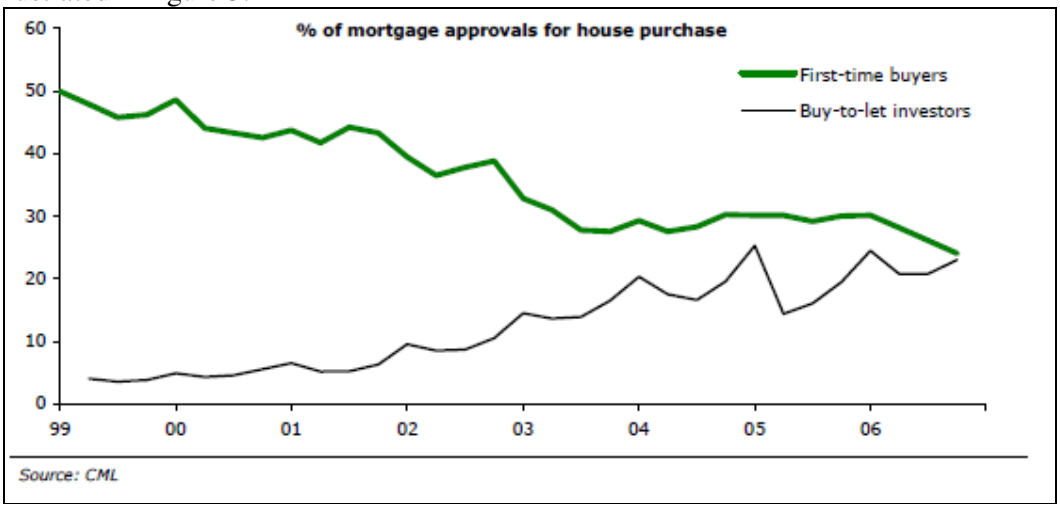


Figure 3: The rise of buy-to-let purchases (ABN AMRO, 2007)

The second major factor that impinges on the UK property market is the available land for construction of properties. It is assumed that the market cannot expand beyond the available property bank. A limitation on this assumption is that although physical land for building is unlikely to grow, in a meaningful way, population densities can; which is a de facto increase in the property bank if not in available land. That there is room to expand the property bank within the existing land mass is illustrated in figure 4.

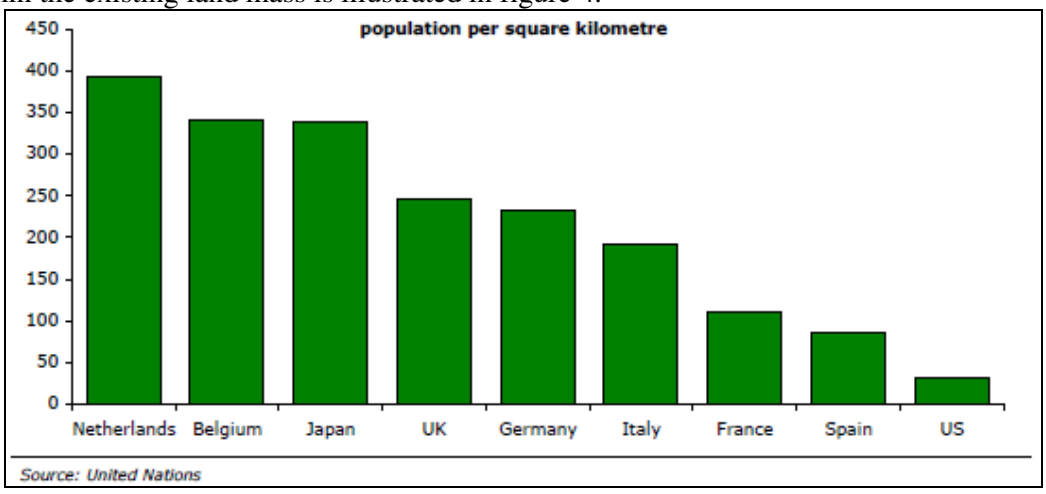


Figure 4: relative population densities (UN, 2006, ABN AMRO, 2007)

The elements described above are the main structural components of the UK property market.

In addition to these market components the property market exists within the wider social context of the UK. Whilst it is beyond the scope of this paper to take into account all of the wider social factors that impinge on the property market some factors assume an importance that cannot be ignored. The government, both at the local and national level, can enhance or reduce frictions in the market, decreasing or increasing the number of transactions, the general structure of the governmental interactions with the market is shown in figure 5. Governmental interactions with the property market have been divided into four broad groupings; taxation, monitoring, interventions and legislation. Government taxes both property income and capital

and constrains the market size through planning law which affects both new builds and changes to existing properties.

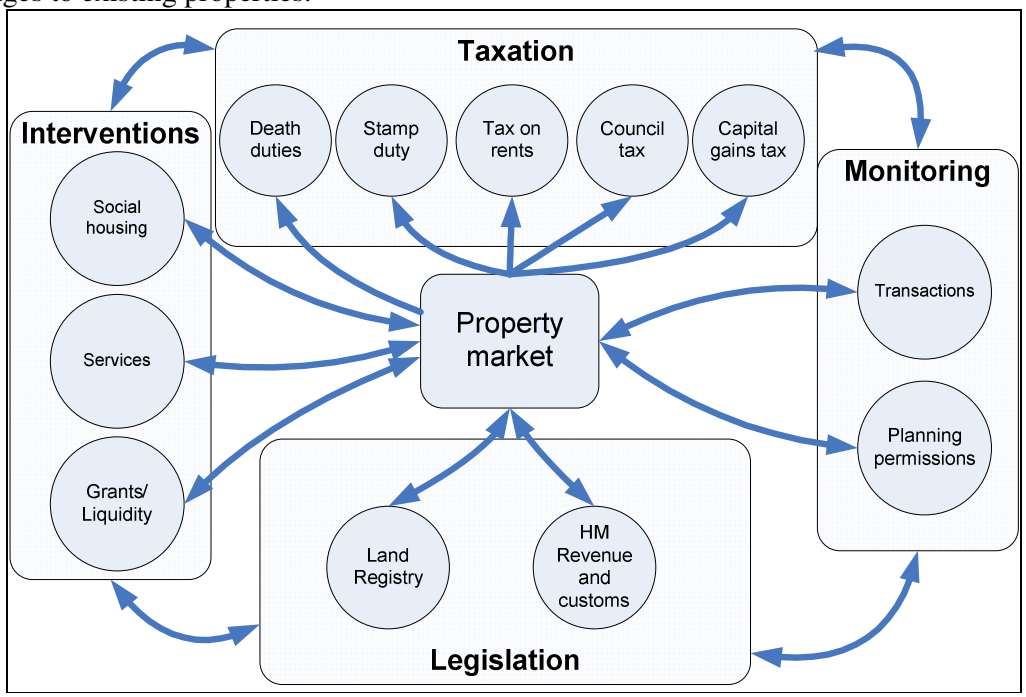


Figure 5: Local and national governmental interactions with the market

Where government interacts with the market then the possibility of applying leverage to manipulate the market also exists. For example manipulating stamp duty, a tax on selling/buying properties, can reduce/increase market friction and reduce/increase the liquidity of the market and the number of transactions. Amongst those relationships shown in figure 5 the government is, through the nationalised or semi-nationalised banking institutions, injecting a measure of financial liquidity into the market which will also increase market liquidity and the ability of would-be purchasers to become actual purchasers. Currently the level of this government inspired funding is very low (BBC,2009) and goes only a short way to replacing the commercial funding that has been withdrawn in order to allow the commercial banks to rebuild their balance sheets, (Rafferty, 2008), which had declined by 52% in January 2009 year on year (Council of Mortgage lenders, 2009).

Dynamic Hypotheses

The main loop of the property market is hypothesised and described in figure 6. From figure 6 it can be noted that all the main components of the market are related to each other and therefore are, to some extent, self defining. This overarching loop is the main feedback structure within the model. It can also be noted that the exchange of properties between available for sale and not available for sale is a main driver of transactions within the market.

This nested loop structure is a doubly positive reinforcing loop structure which if both loops are moving in tandem will drive the market ever higher (or lower) and will be a major determinant of market behaviour. The only constraint on this loop that is evident in figure 6 is the maximum size of the UK property bank. The property bank is similar but differentiated from a land bank. The property bank can increase due to changes in property density and physical size though there is likely to be no significant change in the UK land bank.

If the nested loops were to move in significantly different fashions, one positively reinforcing and one negative for example, the behaviour of the overall system will become complex.

In addition to the potential structural instability mentioned above further complexity will be introduced by the speed at which various components of the loop move in reference to each other. It will be evident that, for example, putting a property up for sale will be a speedier process than constructing a new property though the outcome may appear to be the same; one more property available for sale. This composite holistic/reductionist approach is described in (Raffferty, 2007).

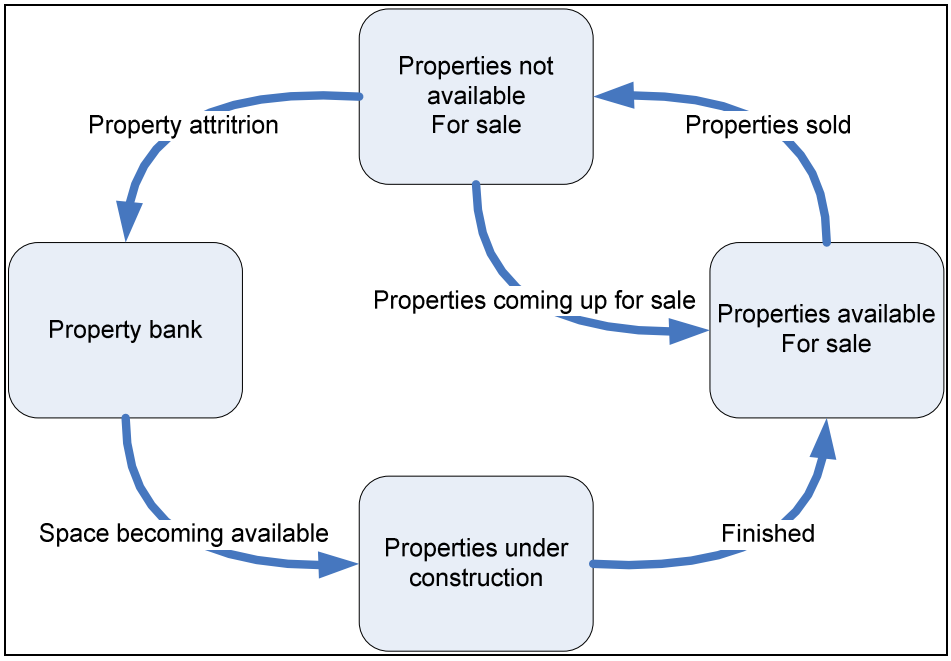


Figure 6: Main structure of the UK property market

In addition to this main loop there are two further constraining structures that feed into the structure described in figure 6. The first of these is the availability of finance which has decreased rapidly in recent times, see figure 2, and its place in the structure is illustrated in figure 7. Availability of finance affects both supply and demand; construction companies are unable to borrow to build and prospective buyers are unable to borrow to purchase; there are other more complex effects such as the unwillingness of buyers to sell for reducing prices. The second major constraining factor is the number of prospective buyers and their place in the structure of the market is also illustrated in figure 7.

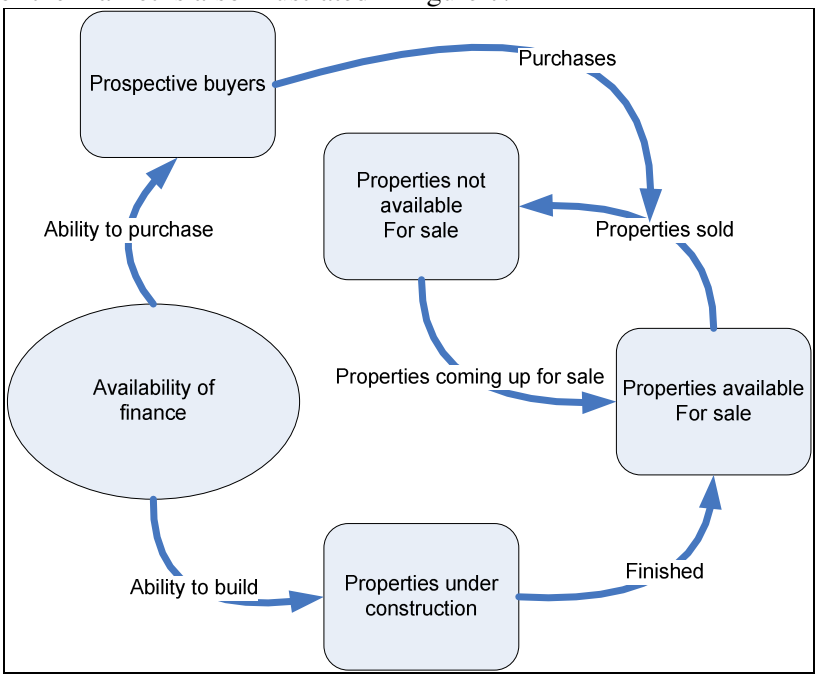


Figure 7: Influence of the availability of finance and prospective buyers

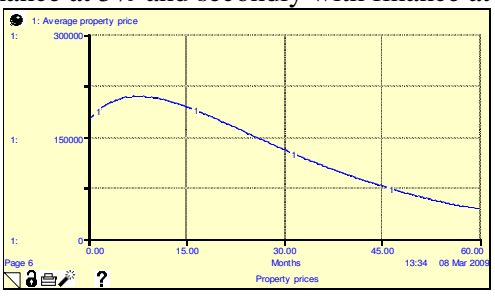
Formulation of the simulation model

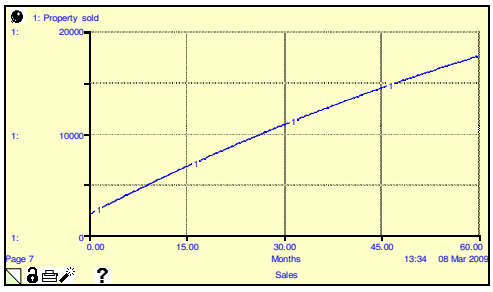
The simulation model was constructed around the basic structure illustrated in figures 6 and 7. Although the simulation model is a simplification of the reality it contains more detail than the structure illustrated in figures 6 and 7. In particular an additional structure was devised to add a model of property price behaviour. This was not essential to the model but was adjudged to be a good means of communicating system behaviour. Property price behaviour is determined by property sales and the amount of available property which is modified by the historic tendency of UK consumers to purchase property and their ability to purchase. Ability to purchase being largely determined by the availability of finance as illustrated in figure 6 above.

Testing and validation

The simulation model was designed to run for a period of 5 years starting from quarter 1 of 2007. This timeframe allowed any transient effects to be put into context and general behaviour of the model to be determined. Starting the model in Q1 of 2007 allowed for some comparison to be made with historic behaviour whilst still providing a substantial forecasting window. Starting the simulation within a time period where actual data was available allowed for accurate calibration of the model.

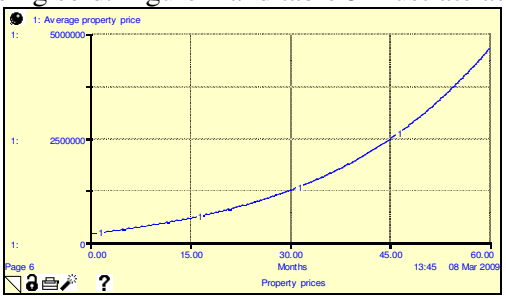
The model was thoroughly tested using sensitivity analysis based principally around availability of finance. The model was tested in two fairly extreme liquidity modes; first with finance at 5% and secondly with finance at 95%.

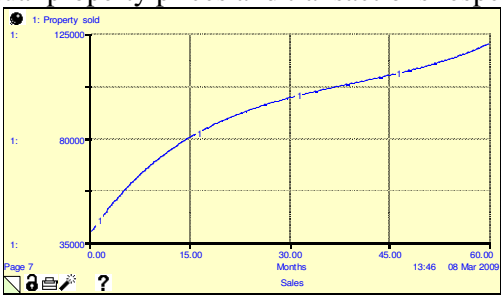




Figures 8a and 8b: Behaviour at the 5% liquidity level, property prices (a) and sales (b)

In figure 8a property prices start at £175,554 which was the average UK property price at Q1 2007 and prices ended at £42,508. In figure 8b sales per month are shown; these start at 2,071 and end at 17,571 showing a substantial increase in the rate at which properties sell though this behaviour represents a decrease in the percentage of properties available for sale actually being sold. Figure 1 and table 3 illustrate actual property prices and transactions respectively.





Figures 9a and 9b: Behaviour at the 95% liquidity level, property prices (a) and sales (b)

In figure 9a property prices start at £175,554 which was the average UK property price at Q1 2007 and prices ended at £4,627,888. In figure 9b sales per month are shown; these start at

39,346 and end at 120,683 showing a substantial increase in total properties but also showing an increase in the percentage of properties available for sale actually being sold. Figures 9a and b represent a direct contradiction of figures 8a and b which is what would be expected. Further tests were carried out which illustrated a variety of behaviours somewhere between the two illustrated above and the model was found to behave in a manner consistent with known behaviour between the extremes.

To validate the model against reference mode (known behaviour) for number of transactions, as described in table 3, which is on average 1.7m per annum the following setting can be applied; approve 47.322% of mortgage applications and to increase the rate of churn, rate becoming available = 0.01269. This scenario also results in house prices increasing from £175k to £195k; an 11.4% increase. Actual house prices in a similar prior period, 2002-2006, increased from £157,627 to £174,518 (Nationwide, 2008), a 10.7% increase. By increasing the granularity of the changes in the sensitivity analysis an exact match is possible with reference data.

Using the model

Within the UK, measures are currently being considered which would increase liquidity, both financial and in property sales, in order to stimulate the overall economy. These include the government instructing the nationalised, or semi-nationalised, banks to pump more money into the mortgage markets during this time of illiquidity and to propose tighter regulation to constrain that liquidity should liquidity levels again become high.

The main aspects of policy that this model addresses are the determination of the levels of liquidity and churn that need to be applied in the market to show a sustainable level of liquidity in property transactions. At the start of the simulation the number of transactions that were taking place annually in the property market was approximately 1.711m per annum, see table 3.

Numbers: thousands

Year	Last month in quarter														
	June			September			December			March			Year		
	Non Liable	Liable[2]	Total	Non Liable	Liable[2]	Total	Non Liable	Liable[2]	Total	Non Liable	Liable[2]	Total	Non Liable	Liable[2]	Total
2005-06	140	202	342	176	265	442	172	258	429	155	223	378	643	948	1591
2006-07	169	259	428	180	316	495	175	310	485	166	279	445	690	1164	1854
2007-08	162	292	454	165	335	499	151	286	437	115	182	297	593	1095	1688
2008-09	117	186	304	106	144	250[3]	128	89	217[3]						

[1] Stamp duty land tax certificates issued for UK property transactions with consideration or net present value of rent of £40,000 or above
[2] Liable to stamp duty land tax because consideration is above the stamp duty land tax threshold and reliefs do not extinguish liability.
[3] Stamp duty land tax treshold raised from £125,000 to £175,000 for residential transactions with an effective date on or after 3 September 2008 and before 3 September 2009.

Table 3: Property transactions above £40,000, (HMRC, 2009)

Extrapolating the data from table 3 on annual property transactions over 5 years, the length of the simulation, gives a total over 5 years of 8.555m property transactions. We have a target rate of transactions of 8.55m over the life of the simulation.

For house prices we have a historic increase of 10.4% over 5 years and a government target for consumer price inflation (CPI) currently standing at 2% (HM Treasury, 2009) with actual CPI at 3.1% (December 2008) (Bank of England, 2009 (c)) At the outset of the simulation property prices are at £175,554 and applying the government's 2% target to this we would end up with an average price of £193,826; this will be the target property price.

To achieve these targets within the simulation using the available liquidity and rate at which properties come to market we need to set these values to 0.477 and 0.01301 respectively. This results in a total of transactions over the period of 8.54m and a final average property price of

£195k. These outputs are within 10 thousand property transactions and £1k of average price target. Given that the model is a simplification of reality these estimates are deemed to be within acceptable limits.

In practical terms these values would allow the government to set targets for accepting mortgage applications of 47.7% overall and introducing targets for increasing the number of property transactions from the current (2007-8) level of 1.688m to 1.711m. The government has the nationalised and semi-nationalised banks available to manipulate the mortgage market and taxation policies (stamp duty, tax relief on mortgages) to manipulate the number of transactions.

Discussion

Looking at figure 1 and the introductory text it is clear that the property market is cyclical, there is ample evidence from the literature to support this assertion (Meen, 2000), and this cyclical behaviour has been addressed in the System Dynamics literature as well (Sterman, 1986). There is no doubt that cyclical behaviour causes problems, particularly for speculators and short term investors, who gamble on rising prices. It is also true that in times of general economic malaise, such as we have now, downward cycles in house prices hurt those starting out on the property ladder (Andrew and Meen, 2003); job losses and salary cuts force sales in unfavourable conditions. Negative equity prevents the release of finance into the economy and produces a negatively reinforcing loop circulating around house prices and financial liquidity.

Even with these unwanted effects is it right that governments should seek to dampen property market cycles by increasing control and constraints on markets? The answer is that markets are currently controlled and constrained by governments even if the market arose naturally; so effectively there would be little change. If this interpretation is accepted then it is postulated that the big picture analysis provided by Systems Thinking and the more formal models of System Dynamics provide a better basis for a joined-up approach to managing the market than other techniques.

A more pertinent question may be exactly how should the market be designed? Whilst the answer to this question is largely beyond the scope of this paper the analysis described and the resultant model provide a mechanism to facilitate that design.

Conclusions

It is likely to be to the national benefit that property bubbles and subsequent troughs such as that experienced in recent years and illustrated in figure 1 are to be avoided.

As a result of experimentation with the simulation model it emerged that the two main levers affecting the housing market are a fairly low but consistent level of financing and a high level of transactions which keeps the market liquid.

The model is particularly sensitive to changes in the number of transactions; a high level of transactions keeps prices down by keeping the property market highly liquid. This is desirable but currently unachievable due to the lack of financial liquidity provided by the commercial financial institutions. However, a high level of transactions can also be a feature of readily available finance which can generate high levels of property price inflation.

The model presented can be manipulated to create a set of conditions that would allow a particular aspect of behaviour to emerge. One such aspect is illustrated at the top of this page.

References

ABN-AMRO, Euro vision, ABN AMRO Bank NV, 2007

Andrew M and Meen G, Housing transactions and the changing decisions of young households in Britain: The Microeconomic evidence, Real Estate economics, Volume 31, Number 1, 2003

Bank of England(a), Bank of England Quarterly Bulletin 2008 Q3, A tale of two cycles, 2008

Bank of England(b), Housing Equity Withdrawal Q3 2008, Downloaded from http://www.bankofengland.co.uk/statistics/hew/2008/sep/ 21st March 2009

Bank of England(c), Quarterly inflation report, Bank of England, 2009

BBC, Rock to revive mortgage lending, Downloaded from http://news.bbc.co.uk/1/hi/business/7904748.stm 15th March 2009

Construction Statistics Annual, Office for National statistics, No. 9, 2008

Council of mortgage lenders, Gross lending declined in January, Downloaded from http://www.cml.org.uk/cml/media/press/2144, 13th March 2009

Datamonitor 2008, Homebuilding UK, July 2008

HM Revenue and Customs, Property transactions in the UK valued at £40,000 or above, Downloaded from http://www.hmrc.gov.uk/stats/survey_of_prop/table16-5.pdf, 13th march 2009

HM Treasury, Monetary Policy Committee, Downloaded from http://www.hm-treasury.gov.uk/statement_chx_050309.htm 13th March 2009

Meen G, Housing cycles and efficiency, Scottish Journal of political economy, Volume 47, Number 2, May 2000

Nationwide Building society, UK House prices since 1952, Downloaded from http://www.nationwide.co.uk/hpi/downloads/UK_house_price_since_1952.xls 21st March 2009

Office for national statistics, Focus on consumer price indices: Data for January 2009, Office for National Statistics, 2009

Rafferty M, Reductionism, Holism and System Dynamics, Proceedings of the 2007 Annual System Dynamics Conference, System Dynamics Society, 2007

Rafferty M, Northern Rock: A case study in banking policy during times of duress, Proceedings of the 2008 Annual System Dynamics Conference, System Dynamics Society, 2008

Sterman J D, The economic long wave: theory and evidence, System Dynamics review, No. 2 Summer 1986, 1986

Sterman J D, Business Dynamics, McGraw-Hill, 2001

United Nations, World Population Prospects: The 2006 Revision, United Nations, 2006