Residential developers: Competition, behaviour and the resulting urban landscape

F. Morgan[1], D. O'Sullivan[2]

[1] Landcare Research and the School of Geography,
Geology and Environmental Science
The University of Auckland
Private Bag 92019
Auckland, New Zealand
Telephone: (+6421) 270 4460
Fax: (+649) 373 7434
Email: f.morgan@auckland.ac.nz

[2] School of Geography, Geology and Environmental Science
The University of Auckland
Private Bag 92019
Auckland, New Zealand
Telephone: (+6421) 270 4460
Fax: (+649) 373 7434
Email: d.osullivan@auckland.ac.nz

1. Introduction

In the context of urban growth, expansion leads to more space being occupied and compaction results in increasing density and intensity (Batty and Xie, 2005). These dual processes of growth result in a number of complex geographic systems (such as land use, sprawl and land cover change) which have, and will continue to pose challenges for researchers to investigate (Torrens, 2003). Spatially explicit models are a useful analytical tool when examining the dynamics of a complex system. Their nature enables a complex system to be broken down into its component parts and examined from the 'bottom up'.

From a 'bottom up' perspective, it is widely acknowledged that property developers are the most important agent in the urban development process, involved in financing, planning, building and shaping the urban environment (Gillen and Fisher, 2002, Peiser, 1990, Coiacetto, 2000, Drewett, 1973). While developers are clearly important to the urban development process, existing research sees developers as an "undifferentiated whole, as if all developers were the same" (Coiacetto, 2000 – page 353). In particular, existing research often fails to examine the diversity of their types, strategies and behaviours (Coiacetto, 2001, Mohamed, 2009) and the effects this differentiation has at a spatial level.

Historical models of the urban development process are based around two approaches, neo-classical equilibrium and event-sequence (Gore and Nicholson, 1991, Healey, 1991). These models have focused on creating an idealised mechanical view of the process (Guy and Henneberry, 2000), an approach which fails to recognise the relationships between actors, their roles, and the complex effects they have upon each other (Doak and Karadimitriou, 2007, Gore and Nicholson, 1991, Healey, 1991). In investigating the complex nature of the urban development process, Healey and Barrett (1990) support a move towards examination of the strategies, actions and interests of key actors and how they interact with the broader structural forces inherent in the process (Adams et al., 1998). This approach has developed into what are now known as agency models of the urban development process.

This research has explored the application of multi-agent models in light of agency models of the urban development process. Multi-agent models are a powerful approach for examining and understanding how this diversity of developer types, strategies and behaviours has an effect at a spatial level, because they are well suited to simulating varied individual and group behaviours and traits (Jager and Janssen, 2003).

Consequently, multi-agent models provide a way of simulating different developer behaviours, types and strategies, which is in agreement with the move supported by Healey and Barrett (1990) and the wider notion of agency models of the urban development process. From this direction, we have designed a multi-agent model which explores from an abstract perspective, how ratios of developer capital and developer employed behaviours, encourage the expansion and compaction of cities.

2. Methodology

Implementing a spatial multi-agent model of the purchase, subdivision, building and disposal behaviours of residential property developers and the spatial consequences of these behaviours raise a number of issues (Morgan and O'Sullivan, 2008). One such issue, the unique data structure used to define the landscape upon which the developer agents act on, has been covered in a previous publication (Morgan and O'Sullivan, 2009).

The developer agents within the model all have access the same set of behaviours but based upon their level of capital, implement the behaviours in differing ways. These behaviours include how developers: assess the property market, evaluate parcels for purchase, manage their risk (in particular their land holdings), focus transactions within a defined territory, and the relative weighting they give to their information sources when making development decisions – such as their previous successes (or failures) or their market forecasts.

The modelling platform used to implement this approach is NetLogo (Figure 1), a multi-agent modelling platform developed by Northwestern University (Sklar, 2007, Wilensky, 1999). NetLogo is a 'sandbox' type modelling environment that is both easy to use and fast enough to prototype theoretical models (Railsback et al., 2006). While not natively multi-threaded, NetLogo is inherently scalable and numerous runs can be instigated on a cluster to reduce processing time. Agent behaviours can be examined through the included BehaviourSpace tool which automates the running of large scale experiments. Two experiments were conducted using this model.

The first experiment varied the ratio and capital of developers to examine how competition affects city structure. In the experiment, four setup attributes were varied – total capital available, developer capital – through a percentage of the total capital allotted by a Yule-Simon preferential attachment process (Simon, 1955), percentage of parcels up for sale per loop, and the size of the initial city. A random seed variable is used in association with these four initial attributes to define the developers and the cadastral landscape. All developer behaviours outlined above were included in this experiment.

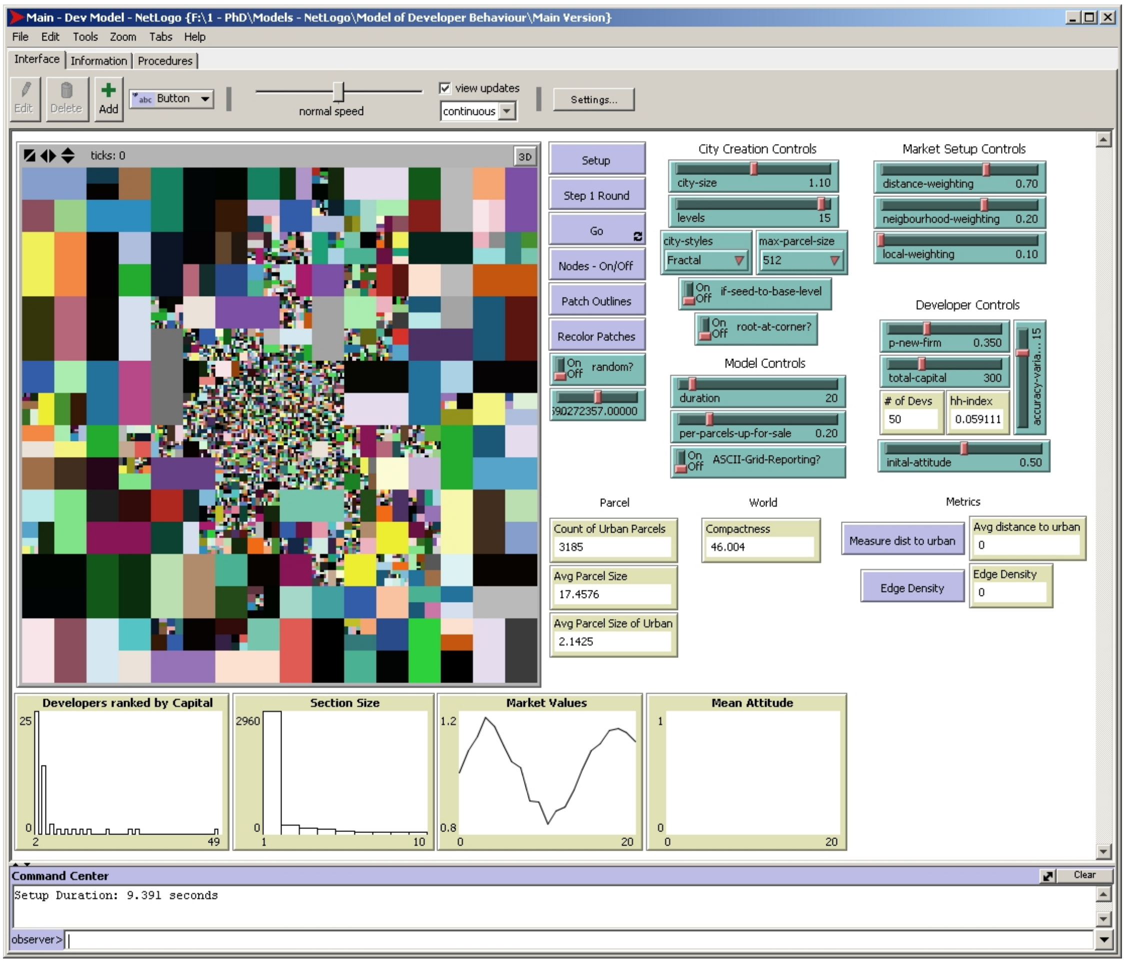

Figure 1. Model of developer behaviour implemented within NetLogo.

The second experiment alternated the various behaviours available to the developer to ascertain if the inclusion or exclusion of a behaviour, changes the way in which the resulting urban landscapes are constructed. Three of the four setup attributes were fixed, based upon the results in the first experiment, with only city size varied for validation. Each run iterates through the various combinations of the five behaviours, replacing them with a completely random approach.

To analyse the changes developer agents make to the cadastral landscape, we calculated a number of landscape metrics through the analysis of two outputs from NetLogo, ASCII grids indicating cadastral parcel sizes and a binary 'urban' landscape (Figure 2). The landscape metrics were calculated with an 4-cell neighbourhood definition using IAN (Dezonia and Mladenoff, 2004), a raster image analysis program. It is important to note that the landscape metrics for each set of unique setup attributes used in the analysis below is the mean value from twenty different random seeds to ensure an unbiased result.

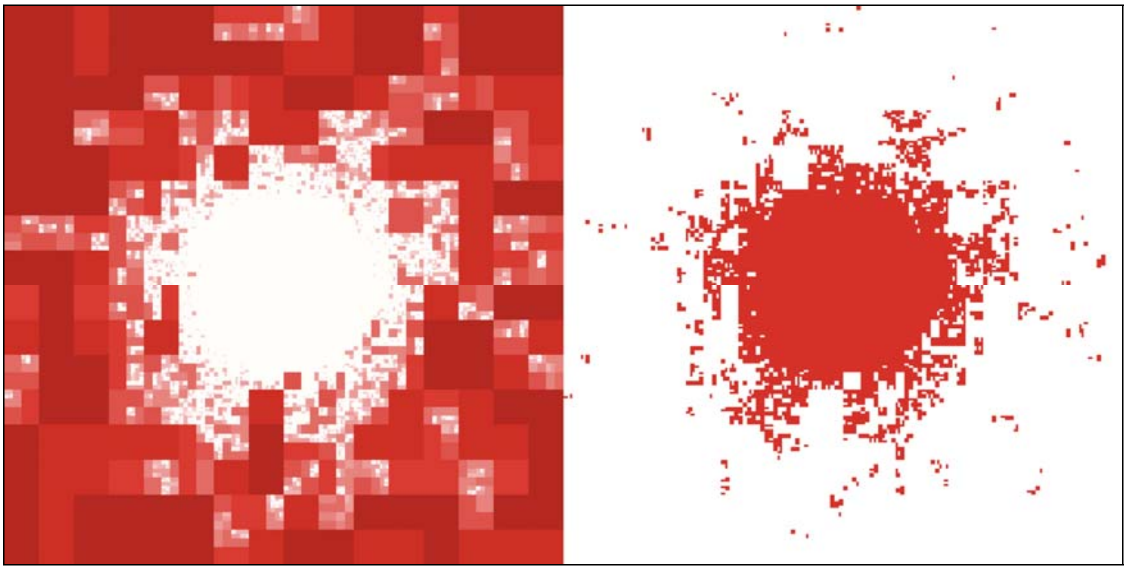

Figure 2. Example outputs from the model: cadastral parcel sizes on the left and the binary ‘urban’ landscape on the right which consists of the three smallest parcel sizes.

For the first experiment, a number of developer metrics were also calculated within NetLogo, in particular the Herfindahl-Hirschman Index (Hirschman, 1945). The Herfindahl-Hirschman Index (HHI) is used to calculate the level of developer competition to enable comparisons to be drawn between runs with varying levels of total and developer capital. Using R (R Development Core Team, 2009) the landscape metrics were analysed using a principle component analysis (PCA) to examine how the ratio and type of developer agents had changed the landscape. The resulting clusters were compared with the average HHI for the unique setup attributes.

Statistical analysis for the second experiment on the role individual behaviours have on the urban landscape is ongoing.

3. Results and Discussion

After using PCA, the landscape metrics for each set of unique setup attributes form a number of distinct clusters which highlight the role that the ratio of developer capital has on the cadastral landscape. These clusters reveal a number of results. An expected result is that the size of the initial city plays a significant role in constraining development opportunities. This trait is especially prevalent when levels of competition are high and there are no developers with a level of capital large enough to fragment the landscape into smaller more affordable parcels for other developers.

The cadastral parcel size PCA shows increasing homogenisation of the cadastral landscape (increasing contagion and decreasing polygon/perimeter area ratios) when there are increased levels of capital in the market.

Increasing the percentage of parcels up for sale per loop substantially changes the structure of the resulting cadastral landscape. In the case of the runs with a low HHI (i.e. high levels of competition) the cadastral parcel size contagion metric (the measure of the degree to which the cadastral parcels are clumped into homogenous polygons) increases markedly when the percentage of parcels up for sale per loop is decreased. The inverse occurs in runs with a high HHI.

It appears that with fewer options to choose from and a large number of developers with similar levels of capital, the majority of developers prefer to develop parcels along the urban fringe and also choose to mimic the surrounding urban parcel size (increasing the level of contagion) rather that increase their risk (and potentially reward) in developing a more intensive product. With more parcels up for sale per loop and a less competition the level of leap-frog type development increases with developers investing more capital in land-banking opportunities away from the urban fringe.

While further analysis of this initial experiment is required to fully understand the results, it is already clear that the level of competition in the property developer market plays a substantial role in shaping the resulting urban landscape. Investigations into the role individual behaviours have on the landscape will hopefully be as rewarding.

4. Acknowledgements

The authors would like to thank Landcare Research and the University of Auckland for providing the financial resources for this research and attending this conference.

5. References

Adams, D., Disberry, A. & Hutchison, N. (1998) The impact of Land Management and Development strategies on Urban Regeneration prospects. *Cutting Edge Conference.* De Montfort University, Leicester, RICS Foundation.

Batty, M. & Xie, Y. (2005) Urban Growth using Cellular Automata Models. IN D. J., M., Batty, M. & Goodchild, M. F. (Eds.) *GIS, Spatial Analysis, and Modeling.* Redlands, CA, ESRI Press.

Coiacetto, E. J. (2000) Places shape place shapers? Real estate developers' outlooks concerning community, planning and development differ between places. *Planning Practice and Research,* 15**,** 353-374.

Coiacetto, E. J. (2001) Diversity in real estate developer behaviour: A case for research developer strategies. *Urban Policy and Research*, 19**,** 43-59.

Dezonia, B. & Mladenoff, D. J. (2004) IAN, Version 1.0.21. Department of Forest Ecology and Management, University of Wisconsin-Madison, Madison, USA.

Doak, A. J. & Karadimitriou, N. (2007) (Re)Development, Complexity and Networks: A Framework for Research. *Urban Studies*, 44.

Drewett, R. (1973) The developers: decision processes and land values and the suburban land market. IN Hall, P., Gracey, H., Drewett, R. & Thomas, R. (Eds.) *The Containment of Urban England, Volume II. The Planning System: Objectives, Operations, Impacts.* London, Allen and Unwin.

Gillen, M. & Fisher, P. (2002) Residential developer behaviour in land price determination. *Journal of Property Research,* 19**,** 39-59.

Gore, T. & Nicholson, D. (1991) Models of the land-development process: a critical review. *Environment & Planning A,* 23**,** 705-730.

Guy, S. & Henneberry, J. (2000) Understanding urban development processes: Integrating the economic and the social in property research. *Urban Studies,* 37**,** 2399-2416.

Healey, P. (1991) Models of the Development Process: a review. *Journal of Property Research,* 8**,** pp. 219 - 238.

Healey, P. & Barrett, S. M. (1990) Structure and agency in land and property development processes: some ideas for research. *Urban Studies,* 27**,** 89-104.

Hirschman, A. O. (1945) *National power and the strucutre of foreign trade,* Berkeley, CA, University of California Press.

Jager, W. & Janssen, M. (2003) The need for and development of behaviourally realistic agents. *Lecture Notes in Artificial Intelligence (Subseries of Lecture Notes in Computer Science).*

Mohamed, R. (2009) Why do residential developer prefer large exurban lots? Infrastrucutre costs and exurban development. *Environment & Planning B: Planning & Design,* 36**,** 12-29.

Morgan, F. & O'Sullivan, D. (2008) Property Developers: A behavioural supply-side investigation into the growth of the city. *Association of American Geographers, 2008 Annual Meeting.* Boston, Massachusetts.

Morgan, F. & O'Sullivan, D. (2009) Using binary space partitioning to generate urban spatial patterns. *4th International Conference on Computers in Urban Planning and Urban Management.* University of Hong Kong, Hong Kong.

Peiser, R. B. (1990) Who Plans America: Planners or Developers? . *Journal of the American Planning Association,* 56**,** 496-503.

R Development Core Team (2009) R: A Language and Environment for Statistical Computing. Vienna, Austria, R Foundation for Statistical Computing.

Railsback, S. F., Lytinen, S. L. & Jackson, S. K. (2006) Agent-based Simulation Platforms: Review and Development Recommendations. *SIMULATION,* 82**,** 609-623.

Simon, H. A. (1955) On a class of skew distribution functions. *Biometrika,* 42**,** 425–440.

Sklar, E. (2007) Software review: NetLogo, a multi-agent simulation environment. *Artificial Life,* 13**,** 303-311.

Torrens, P. (2003) Cellular automata and multi-agent systems as planning support tools. IN Geertman, S. & Stillwell, J. (Eds.) *Planning Support Systems in Practice. Advances in Spatial Science.*

Wilensky, U. (1999) NetLogo. http://ccl.northwestern.edu/netlogo. Center for Connected Learning and Computer-Based Modeling. Northwestern University, Evanston, IL.