

Modeling Location Choices of Housing Builders in the Greater Toronto Area

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ABSTRACT

This paper presents an analysis of the spatial choice of housing builders in the Greater Toronto Area (GTA). A spatially disaggregate database of 126,462 new housing units built by 445 builders is used to analyze the determinants of the intra-metropolitan location of new housing. Housing starts are classified into four types: detached, semi-detached, condominiums, and row/link housing. An accessibility analysis shows that the GTA remains a mono-centric region, where accessibility for most activities declines with distance from the CBD.

The results show that high development taxes in the suburbs encourage low-rise, low-density development. The location choice of homebuilders differs by housing type. For instance, builders are more likely to choose high-density areas with high accessibility to jobs to locate new condominiums. They are also likely to supply detached (low-rise) housing in low-density areas with low accessibility to work and other activities. Neighborhood attributes help determine the type of housing likely to be built in the vicinity. Also, the location of low-rise residential units and planned residential construction is influenced by proximity to major transport corridors in the GTA. The location of condominiums is influenced by proximity to the subway system. Builders are attracted to zones with higher dwelling values where they can obtain higher values for their products. Spatial inertia in housing markets is presented, which implies that the presence of a type (e.g., single-detached) attracts more housing of that type to the vicinity.

INTRODUCTION AND BACKGROUND

Transportation planners and engineers are interested in the impact of residential construction on urban form. The location of new housing influences travel behavior, particularly trip length, and the choice of travel mode. Construction in the city core tends to create high-density neighborhoods that are easily served by public transit. Low-density construction at the urban fringe creates automobile-dependent communities, which cannot be served efficiently by public transit.

The GTA enjoys a pivotal position in Canada, given the strong concentration of housing activity in the region. The largest housing market in Canada, it represents 55% of new home sales in Ontario and 25% of new home sales nationwide. The state of California, in comparison, is responsible for only 10% of new US housing sales. The residential construction industry in the GTA is a \$12 billion enterprise, which creates 250,000 jobs (1).

A spatially disaggregate database, compiled from many sources, is used to estimate spatial models of builders' location choice. This paper presents the analysis of new housing construction in the GTA during January 1997 and April 2001. The study includes rental and non-rental housing starts in the GTA, comprised of the Toronto and Oshawa Census Metropolitan Areas (CMAs) as well as the municipality of Burlington, which falls under the Hamilton CMA.

LITERATURE REVIEW

Research in housing supply is scarce (2). Even scarcer is research that uses spatially and temporally disaggregate data to study new housing construction. Aggregate data cannot show spatial variation in housing supply within a metropolitan housing market. More often than not, research relies on non-spatial data sets based on quarterly or annually reported housing starts regressed on macro-economic indicators and average demographic attributes. Aggregate data on housing supply has helped explain the linkages between macro-economic indicators and the supply activity. However, such data are not enough to explain the micro-level behavior that governs housing markets. The basic question of when and where the producers of housing space (builders) provide new housing cannot be answered with aggregate data.

The other stream of research in housing supply pursues integrated land use transportation models (integrated models for short), such as MUSSA and UrbanSim. These models analyze new housing construction on a spatially disaggregate level, thus accounting for its intra-metropolitan distribution. In the following paragraphs, a brief review of time series analysis of new housing is presented, which is followed by a brief review of treatment of housing supply in integrated models.

Research in housing supply has explored the effects of land use restrictions (3), jobs growth in the suburban fringe (4), 'credit crunches' (5), and infrastructure availability (6) on new housing construction. In the long run, an increase in demand for housing does not increase real house prices (7, 8). Short-term changes in housing supply and demand deserve more attention because these changes play an important role in builder's decision-making. For example, an excess supply of single detached housing may exert downward pressure on rental income for

multi-unit residential property (9). In the short term, new housing construction might also increase the value of neighboring houses above their 'equilibrium' prices.

Housing starts should be modeled as a function of change in prices rather than the price levels. Similarly, change in construction costs, rather than the level of construction costs, should be used to estimate starts (10). Housing supply analysis should also account for the factor market of land. Traditional econometric models of housing starts often disregard land values, perhaps because reliable land price data are often unavailable.

The growth in housing stock renders developable land even scarcer and more expensive, thus increasing the price of new dwelling units. Increase in the price of new dwellings will encourage more construction until the "the current stock catches up with this long run supply schedule" (11). In addition, real estate markets take several years to clear. Given the resultant disequilibrium, housing price is not a "sufficient statistic" and therefore vacancy rates, mortgage rates, and other macro-economic factors should be in the model. In equilibrium conditions, these factors are captured by price, which then becomes a sufficient statistic. Also, the value of new construction is a better predictor of housing starts than that of the resale market. Housing starts are cost elastic, which suggests that higher construction costs reduce residential construction (12).

Development taxes result in low densities (13), though development delays do not always affect densities. Ontario survey data show that most builders in Toronto base their building type and lot size decisions partly on development taxes, and cite such taxes as their motive to build low-density residential projects in the suburbs. Builders argue that revenues from residential development depend mainly on lot-frontage, resulting in larger lot-frontages in areas with high development taxes. The marginal increases in revenue from a greater number of developable lots are outstripped by development taxes.

The role of land availability is crucial to housing starts. The rate of capitalization of fiscal variables and amenities is higher in cities or towns where developable land is scarce, i.e. the elasticity of land supply is low (14). Denser cities report higher capitalization of fiscal variables than cities with low population densities. Also, the coefficient for change in housing values is significantly higher for developed locations, i.e. cities with less developable land, than the coefficient for undeveloped cities. Econometric studies have shown that the price elasticity of residential land is less than one. Higher price elasticity of residential land at -1.6 has also been reported in the literature (15).

Integrated transportation land use models

Comprehensive reviews of integrated transportation land use models are now available (16, 17, 18, 19). Modules for housing supply are part of most integrated models. A variety of modeling techniques have been applied in operational integrated models. Rule-based models provide new housing in response to the demand for residential space, subject to capacity constraints regarding land availability and zoning bylaws. Yet these models are not behavioral and therefore real-life builders are not explicitly modeled in rule-based (deterministic) models.

The other major category of integrated models applies discrete choice methods to model the spatial choices of agents, some using microsimulation in combination with discrete choice frameworks. Urbansim (a microsimulation-based integrated model) assumes that households demand residential space while developers or builders supply space in response (19). Household behavior is micro-simulated using a synthetic sample drawn from a population of households. This simulates urban development as a “dynamic process over time and space as opposed to cross-sectional or equilibrium approach” (20). MUSSA, another integrated model, advances the bid-rent theory to a bid-choice theory where agents choose the alternatives (e.g., location) that maximize their consumer surplus (21).

In integrated models, builders are treated as profit-maximisers. Building stock prices are endogenously determined for each zone. The land market is modeled as the interaction between demand for space by businesses and households, and the supply of land. Demand and supply components are modeled using random utility theory. The developer’s model converts vacant or already built land into structures, through which a stream of housing services are generated. The ratio of demand to supply for each type of structure in each zone results in proportional price adjustments for each type of structure.

In operational integrated models, the developer’s behavior, however, is not based on a sample of real builders or developers. A class of agents, defined as builders, respond to demand for residential space by constructing new housing. This treatment of supply preempts operational integrated models from exploring the behavior of builders, who consider factors beyond price signals to determine where to build.

Builders often focus on neighborhoods and municipalities in which they have built before, a phenomenon that is called “state dependency” in the discrete choice parlance. Earlier dealings with municipal authorities ease the project approval process for builders. Similarly, builders specialize in housing types, e.g. low-rise or high-rise. Land holdings often restrict the focus of builders to areas where they already own land, having speculatively purchased it with the intent to develop later. These behaviors are not accounted for in most operational integrated models.

Furthermore, integrated models divide real estate markets into discrete zones. Often the choice of spatial scale is driven by the availability of data. UrbanSim imposes a 150-meter grid on the urban space; MEPLAN, another integrated model, uses a similar grid system. This ad hoc spatial classification has serious implications for plottage and plattage; real builders do not evaluate parcels on a 150-meter square grid. It can be argued that builders’ behavior can best be modeled on a spatial scale at which builders operate.

METHODOLOGY

The choice set is based on the Transportation Tomorrow Survey (TTS) zone system. It is argued that builders evaluate locations based on neighborhoods and not parcels or grids. The TTS zone system approximates the neighborhood structure in the GTA and conforms to topological details such as ravines. TTS zones in close proximity to Pearson International Airport are not valid locations for new housing, and are therefore excluded from the choice set.

A random sample of alternatives is drawn from the feasible choice set. This is consistent with earlier research that has proposed using a random sample to reduce alternatives in the choice set (22).

The new breed of integrated models relies on agent-based microsimulation, which is appropriate in cases where many agents are active in the market. It is argued that there are not active agents (builders) in a metropolitan housing market to generate a representative synthetic database. This renders the simulation process incapable of truly reproducing the behavior of participating agents. A small number of builders engaging in heterogenous behavior could affect the validity of microsimulation models.

This paper does not restrict supply of new housing to the urban fringe. The explanatory data analysis shows that new housing construction in the GTA is not confined to the boundary of the built area and reveals unique locational patterns, which vary by type of housing.

DATA ASSEMBLY

Data for spatial modeling of housing starts were obtained from RealNet Canada Inc., which records and maintains data on housing starts/sales for construction projects involving more than 10 units. The data include details on the location of newly built residential projects with some attributes of builders, type of housing, units built, average lot size and the like.

Development taxes data by housing type for Census Subdivisions in the GTA are obtained from the Urban Land Institute. Land inventory data are obtained from the Ministry of Municipal Affairs and Housing in Ontario. Land inventory databases account for housing units that are in the pipeline, i.e., going through various stages of planning approval.

Spatially disaggregate data on demographic attributes are derived from Statistics Canada's 1996 Census geographical files. Similarly, travel behaviour data are extracted from the 1996 TTS. The 1996 Traffic Analysis Zone (TAZ) system, devised by TTS, has been used as the basis for spatial analysis in this research. All spatial data are either aggregated or disaggregated to the 1996 TAZ level.

Accessibility profiles for each TAZ are created for activities such as work, school, green spaces and leisure centers, and retail. Activity profiles are based on gravity type measures where the attractiveness of performing an activity in a different zone is discounted by the average travel time to that zone. Zone-to-zone travel times are derived from running an assignment module in the GTA model in EMME/2, which is maintained at the Joint Program in Transportation at the University of Toronto. Land use data are provided by DMTI Spatial Inc. Spatially disaggregate

data on retail enterprises are supplied by the Centre for the Study of Commercial Activity at Ryerson University. Similarly, accessibility to transportation infrastructure such as subways and highways from each zone is estimated using GIS. In addition, distance from the CBD to the centroid of the TAZ is also calculated using GIS.

Developers' profit maximisation function depends on some estimate of revenue from the sale of units. The underlying hypothesis is that builders will locate projects in zones where they can generate the maximum revenue from the sale of new homes. Such disaggregate data, however, are not available and thus resale values are used as a proxy for new home values. To control for various structural attributes, neighborhood characteristics and accessibility premiums, hedonic models of housing values disaggregated by housing type are developed.

Accessibility is difficult to define and measure. Unlike population levels, which can be measured directly, accessibility remains rather abstract and cannot be quantified with simple solutions (such as a binary variable for a subway station in the zone). Also, measures of accessibility are often correlated with each other and therefore may not be used simultaneously in the models. For example, zones with high accessibility to retail might also have high accessibility to work and the two variables can introduce multicollinearity in the model.

Factor analysis addresses the above-mentioned concerns. It creates proxies for an abstract phenomenon, originally quantified indirectly by many variables, by collapsing those variables into one or more factors. These factors act as a proxy for the underlying phenomenon. Another advantage is that the estimated factors are orthogonal to each other and therefore do not pose risk of multicollinearity. Using the Factor Analysis, accessibility variables/indices are collapsed into seven factors.

DESCRIPTIVE ANALYSIS

The housing starts market in the GTA has followed boom-and-bust cycles. Starts declined significantly during the last recession in the early 1990s. In the past few years, macro-economic indicators have slowed down--yet housing starts have soared since 1995, perhaps because of low interest rates and stable new housing prices.

Condominiums or multiples dominate the new housing market in the high-density City of Toronto, while single-family housing dominates the market in low-density outer regions. The new housing market consisted mainly of non-rental housing, with the exception of a brief period in the early 90's when state-sponsored rental units were constructed en masse. There has been a slight recovery in rental starts witnessed only in 2001.

The database includes 445 builders constructing 1384 unique housing projects containing 126,462 units during the period January 1997 - April 2001. About 116 builders undertook high-rise construction while 329 builders built single-family units. Each record in the data set contains information on an individual real estate project with details on housing type, sale price expectations, and name of the builder.

New housing construction is mainly concentrated in the central municipalities (Table 1). The old City of Toronto reports fewer projects (153) than other municipalities but its total units supplied is the highest (20,171), due to the dominance of apartments in that market. Outer

suburbs such as Mississauga, Vaughan, and Brampton also record a significant share of new housing construction.

Large builders dominate the real estate market in the GTA. 22 large builders are responsible for almost 400 housing projects containing 50,000 new units (Table 2). Not all builders are active during every year of the study period. For example, 94 builders reported new construction in 1997, whereas 189 builders started new housing projects in 2000. Single-detached housing is the dominant housing type with 39% of the market share followed by condominiums at 31% (Table 3). Detached projects, averaging 90 units per project, trail behind condominium projects, with 166 units for each project.

Spatial trends in new housing construction

Most housing starts during the study period are found in the old City of Toronto, Mississauga, Brampton, North York, and Vaughan (Figure 1)—north- and south-west of the Toronto CBD. Whitby presents a unique example of leap-frogging: builders have bypassed Pickering and Ajax to build farther away from the city centre.

Condominiums are concentrated along the Yonge Street corridor, due to its central location and subway service. Apartment units are being constructed mainly in the central city where land acquisition costs are high. Semi-detached projects are mainly found in the outer suburbs, concentrated in Mississauga and Brampton along major transportation routes. Link/row housing is located in inner and outer suburbs. Green lines in Figure 1 identify highways, whereas red lines identify major arterials. Residential projects are concentrated along east-west corridors (especially Highway 401) in the GTA. In Whitby, Brampton, Mississauga, Markham, and Vaughan residential projects have also concentrated along highways and major arterial intersections.

Though labor and material costs do not always vary over space in an urban real estate market, development taxes do. Builders, being utility maximizers, treat these as costs and, all else being equal, will try to locate new projects where development taxes are lowest. In the outer suburbs of the GTA, developers pay significantly higher development taxes for condominiums than in the City of Toronto—the charge per unit in Toronto is less than half of that in Markham. For high-rise projects, builders have preferred the high-density City of Toronto. For low-rise projects, they have preferred the outer suburbs.

The spatial choice of a builder is influenced by the cost of land. Land rents are considerably higher in the City of Toronto when compared with rents in the outer suburbs. High-rise construction requires less land per unit developed. This should explain, to an extent, builders' decision to build condominiums in the City of Toronto.

Even before concepts such as 'smart growth' entered the academic lexicon, builders in the GTA had reversed the trend of constructing housing on huge lots. The reversal was due to the new Goods and Services Tax (GST), which increased new housing values. Traditional suburban development accommodated 3 to 4 residential units per acre (upa). The new trend for smaller lots has resulted in 7 to 11 upa. Most low-rise construction in the GTA is being carried on lots with street frontage of 40 feet or less, promoting higher average residential densities. In

Portland, Oregon, 42% of new low-rise homes were built on lots greater than 50 feet (O'Hanlon, 2001).

A spatial analysis of the residential land inventory in the GTA was undertaken to explain future residential development patterns. Land inventory data show the intentions of future construction and spatial choice preferences of builders. Most development applications are for residential projects in the outer suburbs (Figure 2). Development applications to the north of the city are along major arterials or highways. The analysis of residential inventory by housing type shows that developable land for low-rise projects in the pipeline is found in low-density outer suburbs. Applications for most new high-rise residential developments are made in the central city.

Though accessibility premiums influence the utility of households, it is argued that builders cannot afford to be oblivious to the accessibility of possible development sites. It is further argued that the proposed location of a new residential project, in a developer's decision-making, must meet a certain implicit threshold of accessibility. Recent starts and future planned construction projects have evolved along major transportation corridors, which serve as a proxy for accessibility. Using the inter-zonal travel times estimated from the EMME/2 assignment algorithms, gravity-type indices are estimated for accessibility to work, school, shopping, and nature (parks and other green space). The accessibility surface for work shows that zones in the CBD enjoy the highest accessibility to work (Figure 3). Accessibility to nature is higher for zones in the outer suburbs and the lowest for zones in the central areas. The spatial distribution of accessibility to shopping and school is similar to that of work.

MODELLING RESULTS

The data set consists of 150 variables and 1384 observations. Each decision-maker's choice set includes nine randomly simulated alternatives from the reduced choice set of 706 zones and the chosen alternative, which is the zone where housing was built. Most explanatory variables are attributes of choice (zones). The characteristics of the individual decision-maker have not been used as regressors because of data constraints.

In the traditional land use transportation modeling framework, the "causal" relationship between land use and travel demand is well established. However, feedback from travel demand models into land use models is still in the experimental stage. This paper argues that homebuilders' choices dictate future urban landscapes; accessibility indices in builders' utility functions is providing feedback from travel demand models into spatial choice frameworks.

The detached housing model is presented in Table 4 showing a model fit of $\rho^2 = 0.202$. Variables in the model meet a priori expectations. However, the coefficient for variable OPEN_PER is insignificant. The model suggests that availability of developable land, green space, and the inventory of units in the pipeline have each made zones more conducive to detached developments. However, variables showing physical development in the zone (e.g., intersection density, length of roads) have all returned negative coefficients, suggesting builders of detached housing are more likely to choose green-field alternatives. Builders of detached housing prefer zones with a high inventory of detached units (INV_DET). Furthermore, zones

with high green space accessibility in the outer suburbs are more likely to be chosen for new detached projects.

The percentage of housing stock of some type will attract more housing of that type in a zone. This phenomenon is identified as **spatial inertia**. In detached housing models, the spatial inertia variable (FHOLDPER) returns a statistically significant coefficient suggesting that zones with a high percentage of detached housing will attract more detached housing.

Variables indicative of zones with low auto-ownership, which is a result of urban form and transit availability, return significant negative coefficients, suggesting that builders of detached housing are less likely to choose such zones. Again, zones with low auto-ownership in the GTA are central areas with high land values. The variable PMA_INVE returns a positive coefficient, suggesting that developers are more likely to choose zones where they have previously applied for new construction. Similarly, zones with high accessibility to schools are also likely to attract detached real estate development.

In other models for detached housing (not reported in this paper), the propensity to locate detached housing in a zone increases with distance from CBD and with higher detached housing values. This implies that the developers would like to locate new detached projects in areas that offer high-detached property values at some distance from the CBD. Zones in proximity to subway lines are not the preferred choice for detached units because SWAY_BUF returns a negative coefficient. In addition, the accessibility factor AUTOFREE also returns a negative coefficient, suggesting that areas depicting low auto-ownership will not be likely choices for new detached residential developments.

The data set for semi-detached housing consists of 241 semi-detached housing projects in the GTA. All variables return expected coefficients. Adjusted ρ^2 for semi-detached housing is 0.207. Some variables in the model have returned counter-intuitive results. For example, PMA_RES (area zoned as residential in each zone) returns a negative coefficient. The positive coefficient for PMA_IND suggests that developers of semi-detached housing are likely to prefer zones where land is zoned as industrial. This may be because industrial land can be rezoned residential. In contrast, zones with predominantly residential land uses may indicate that the zone is built out.

The coefficient for the variable SEMI (inventory of semi-detached units) is statistically significant, suggesting that developers are likely to choose zones where semi-detached housing units are going through the approval process. Similarly, developers are likely to choose zones with higher semi-detached housing values, as suggested by the statistically significant positive coefficient for SEMI_F. The presence of 'power centers' is correlated with that of semi-detached housing. Population density, proximity to work centers, the subway and large regional malls is negatively correlated with semi-detached housing. Higher development taxes also deter semi-detached builders, though the coefficient for this variable is not statistically significant.

Row/link housing is being constructed in the suburbs and in the central city. The variety of locations returns a poor model fit, with a ρ^2 of just 0.101. Variables representing spatial inertia (FHOLDPER and CONDOPER) return negative coefficients, which is a departure from what have been observed for detached and semi-detached location models. At the least, these

results are suggesting that the location decisions for row/link housing are distinct from those for detached and semi-detached.

Again, zones with considerable built space (POPDENS) are less likely to be selected for new row/link housing projects. Similarly, zones near highways and malls are also less likely to attract row/link housing projects. The coefficient for the variable PMA_RES is positive, yet slightly insignificant. Also, the odds of locating row/link housing in zones identified for their inventory of developable land is higher than the rest, which is deduced from the positive coefficient of PMA_INVE. The coefficients for variables OTHERS_F and RETPOWER are statistically insignificant yet positive. Developers of row/link housing are not deterred by development charges. The coefficient for variable DC_OTHER is statistically significant and positive.

The location choice model for condominium builders offers the best fit with an adjusted ρ^2 of 0.373. The negative coefficient for D_CBD suggests that zones located at greater distances from the CBD are less likely to receive new condominium housing. Similarly, odds of locating new condominium housing in zones with high accessibility to green space are lower than the rest. Builders favor zones with condominium units in the approval process for locating new condominium housing.

Proximity to subways and highways attracts builders of condominium housing, which is evident from the positive coefficients on SWAY_BUF and HWAY2K_B. The hypothesis of spatial inertia holds well for condominium housing. Odds of providing new apartment housing in zones with a preponderance of high-rise stock are higher than the rest.

A positive correlation between the location of white-collar work nodes and the location of condominiums is observed. The model suggests that zones with white-collar jobs are more likely to receive new condominium housing projects than the rest. Zones with high condominium values for housing stock are more likely to receive condominium housing. Accessibility to retail centers is also positively correlated with the location of new condominium housing.

CONCLUSIONS

Results from the estimated models show that the spatial choices of real estate builders differ by housing type. A combination of attributes may make a site suitable for detached housing projects. However, the same site may not be suitable for high-rise housing, which is unique and distinct. Variables serving as a proxy for urban form return negative coefficients for detached, semi-detached, and row/link housing, while the same variables return positive coefficients for condominiums. Similarly, the model fit has varied by type of housing as well. Condominium models offered the best fit, while row/link housing offered the poorest fit suggesting that models are not able to fully capture the decision-making process behind the location of row/link housing. The sporadic spatial distribution of row/link housing has contributed to the weak model fit.

The concept of spatial inertia in housing markets is presented, which states that housing stock of a particular type acts as a magnet to attract more housing of that type to the vicinity.

Estimated models have offered evidence for spatial inertia, which influences the location decisions of housing builders in the GTA.

This paper introduces new data sources for the study of urban form and its relationship with accessibility. The use of spatially disaggregate data on housing construction capturing the choices of real builders sheds light on how builders and developers operate in the real world. Similarly, data on land inventory accounts for speculation in the decision-making of builders and serves as a futures markets for the development of new housing. Unlike large integrated models, which are data hungry and impose a spatial hierarchy (grid structure) for data collection and analysis, this paper uses readily available data.

This paper has value for academics and practitioners alike. The data used in this research is available for most cities from government agencies. The econometric models and spatial data manipulation in the paper can be performed using available econometric and spatial analysis software. This allows practitioners to test these models and approaches in other metropolitan areas. The approach adopted in this paper has made possible to test hypothesis of profit maximization and impact of development charges and will help researchers in developing advanced models of builder's spatial choice.

FUTURE WORK

This research is part of a larger initiative to study the behavior of housing builders. Other research initiatives include how builders decide the amount, timing, and type of new housing (23).

Future research involves developing a nested model of housing type and location, and linking it to a land supply model. In addition, a survey of builders is being planned to capture builder-specific attributes in the next series of models.

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REFERENCES

1. O'Hanlon, P. (2001). What did we do before Smart Growth? We built smarter. Toronto. Ref Type: Pamphlet
2. DiPasquale, Denise. (1999). Why don't we know more about housing supply? *Journal of Real Estate Finance and Economics*. 18(1), 9-23.
3. Pollakowski, Henry O.; Wachter, Susan M. (1990). The Effects of Land-use Constraints on Housing Prices; Land-use Controls. *Land Economics* 66(3), 315-324.
4. Voith, R. (1996). The suburban housing market: The effects of city and suburban job growth. *Business Review*, 26(1), 13-25.
5. Mayer, Chris B., and C. Tsurriel Somerville. (1996). Land Development and the Supply of New Housing: Unifying Empirical and Theoretical Models of Housing Supply, Working Paper, UBC Centre for Real Estate and Urban Economics.
6. Stover, Mark Edward. (1986). The Price Elasticity of the Supply of Single-Family Detached Urban Housing, *Journal of Urban Economics* 20(3), 331-340.
7. Muth, Richard. (1960). The Demand for Non-Farm Housing, In A.C. Harberger, ed. *The Demand for Durable Goods*. Chicago: University of Chicago Press.
8. Follain, James R. (1979). The Price Elasticity of the Long-Run Supply of New Housing Construction, *Land Economics* 55(2), 190-199.
9. Weber, William, Devaney, Mike. (1996). Can consumer sentiment surveys forecast housing starts? *Appraisal Journal* 64(4), 343-350.
10. Mayer, C. J. and Somerville, C. T. (2000). Residential Construction: Using the Urban Growth Model to Estimate Housing Supply. *Journal of Urban Economics*, 48(1), 85-109.
11. DiPasquale, Denise, and William C. Wheaton. (1994). Housing Market Dynamics and the Future of Housing Prices, *Journal of Urban Economics* 35(1), 1-27.
12. Somerville, C. T. (1999). Residential construction costs and the supply of new housing: Endogeneity and bias in Construction Cost Indexes. *Journal of Real Estate Finance and Economics*, 18(1), 43-62.
13. Skaburskis, A. and Tomalty, R. (2000). The effects of property taxes and development cost charges on urban development: Perspectives of planners, developers and finance officers in Toronto and Ottawa. *Canadian Journal of Regional Science*, XXIII(2), 303-325.
14. Hilber, C. A. & Mayer, C. J. ((1991):). Land supply and capitalization.
Ref Type: Unpublished Work
15. Gyourko, J. & Voith, R. (2000). The price elasticity of the demand for residential land.
Ref Type: Unpublished Work
16. Miller, E. J., Kriger, D. S., & Hunt, J. D. (1998). *Integrated urban models for simulation of transit and land-use policies* (Rep. No. TCRP PROJECT H-12). Toronto: Joint Program in Transportation, University of Toronto.
17. Wegener, M., (1995). Current and Future Land Use Models, *Travel Model Improvement Program: Land Use Modeling Conference Proceedings*, pp. 13-40, U.S. Department of Transportation, U.S. Environmental Protection Agency.
18. Southworth, Frank. (1995). A technical review of urban land use-transportation models as tools for evaluating vehicle travel reduction strategies. World Wide Web [On-line].
19. Waddell, P. (2002). UrbanSim: Modeling urban development for land use, transportation and environment planning. *APA Journal*, 68, 297-314.

20. Waddell, P. (1998a) The Oregon prototype metropolitan land use model.
Ref Type: Unpublished Work.
21. Martinez, F. J. (1996). MUSSA: Land use model for Santiago City. *Transportation Research Record, 1552*, 126-134.
22. McFadden, D. (1978). Modelling the Choice of Residential Location. *Special Interaction Theory and Planning Models*. A., Karlqvist, L. Lundqvist, F. Snikers, and J.W. Weibull, eds., Amsterdam, North Holland. 75-96.
23. Haider, M. *Spatio-Temporal Modelling of Determinants of Owner-Occupied Housing Supply*, Ph.D. thesis, Department of Civil Engineering, University of Toronto, Toronto, 2003.

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Table 1: Starts by municipality in the GTA

Municipality	Units	Projects	Units/Project
Toronto (Old City)	20171	153	132
Mississauga	16458	192	86
Vaughan	13785	155	89
Brampton	13276	121	110
North York	11351	67	169
Richmond Hill	8234	100	82
Markham	8051	103	78
Scarborough	4506	53	85
Oakville	4456	62	72
Whitby	4296	62	69
Burlington	3267	46	71
Etobicoke	3220	31	104
Milton	2499	20	125
Ajax	1900	20	95
Caledon	1863	27	69
Oshawa	1593	25	64
Clarington	1554	29	54
Halton Hills	1508	21	72
Aurora	1083	21	52
Newmarket	1056	21	50
Pickering	879	24	37
Georgina	675	15	45
Scugog	370	7	53
Uxbridge	213	6	36
King	131	2	66
Whitchurch-Stouffville	67	1	67
	126,462	1,384	91

Table 2: List of large homebuilders in the GTA

22 Large Developers	Units	Projects
Mattamy Homes	6945	34
Tridel	6126	27
Greenpark Homes	5815	51
Monarch	2673	18
Aspen Ridge Homes	2509	20
Great Gulf Homes	2410	20
Menkes	2379	18
Conservatory Group	2240	20
H & R Dev.	2073	17
Sundial Homes	1778	21
Pemberton Group	1743	10
Arista Homes	1616	12
Intracorp	1525	17
Fieldgate Homes	1402	14
Daniels Corporation	1344	17
National Homes	1292	14
Townwood Homes	1121	10
Touchstone Homes	1117	13
Regal Crest Homes	998	12
Baycliffe Homes	954	12
Ballantry Homes	884	11
Wycliffe Homes	436	9
	49380	397

Table 3: Breakdown of new housing construction by type of housing

Type	Units	Projects	Percent %	Units/Project
Townhouse	18703	312	14.80%	60
Detached	49130	546	38.80%	90
Semi Detached	16797	241	13.30%	70
Link	2384	48	1.90%	50
Condominium	39448	237	31.20%	166
Total	126,462	1,384		91

Table 4: Multinomial logit models of builder's location choice

Detached Housing			Semi-detached Housing			Row-Link Housing			Condominium Housing		
Variable	Coefficient	T-stat	Variable	Coefficient	T-stat	Variable	Coefficient	T-stat	Variable	Coefficient	T-stat
FHOLDPER	2.10E-03	1.459	POPDENS	-5.21E-05	-2.286	FHOLDPER	-8.84E-03	-5.001	D CBD	-2.06E-02	-2.074
VEHOPER	-0.0401	-3.746	SWAY_BUF	-0.712358235	-1.682	POPDENS	-1.40874E-05	-1.329	APT_F	2.76641E-06	2.377
NO_LICEN	-0.0180	-2.517	MALL_BUF	-0.3258709	-1.307	NO_LICEN	-0.012161059	-1.952	APT	0.000465571	4.402
ROAD_LEN	-0.0051	-0.764	DC_SINGS	-2.57E-05	-1.087	HWAY2K_B	-3.05E-01	-2.422	S_GREEN	-2.46E-01	-3.824
INT_DENS	-0.0027	-4.315	WORKZONE	-0.859224809	-3.672	MALL_BUF	-0.391019561	-2.167	SWAY_BUF	0.813839656	3.565
OPEN_PER	0.0013	0.823	RETPOWER	0.137188853	1.8	PMA_RES	0.357176751	1.526	HWAY2K_B	0.795393511	3.694
PMA_INVE	7.53E-04	6.449	SEMI	1.34E-03	3.854	PMA_INVE	3.98E-04	2.8	CONDOPER	6.83E-03	2.252
S_GREEN	0.0964	3.018	BUILTUP	-0.242765652	-1.265	GREEN	-0.392142297	-2.634	PROF	0.000260136	4.126
M_SCHOOL	0.0143	3.441	PMA_INVE	1.12E-03	6.122	OTHER	1.30E-03	5.931	APT_F	2.77E-06	2.377
RET_DENS	-0.0034	-3.422	SEMI_F	6.05E-06	2.816	DC_OTHER	3.19E-05	1.963	SHOPCENT	1.05E-01	1.761
INV_DET	8.09E-05	2.243	PMA_IND	1.286039239	2.597	OTHERS_F	7.16597E-07	0.336			
			PMA_RES	-7.56E-02	-0.234	RETPOWER	6.30E-03	0.132			
Observations	546			241			360			237	
Log-L with no coefficients	-1257.2115			-554.9230			-828.9306			-545.7127	
Log-L for the model	-1000.4209			-437.8372			-742.6640			-340.8120	
Rho-Squared	0.2043			0.2110			0.1041			0.3755	
Adj. Rho-Squared	0.2025			0.2066			0.1007			0.3730	

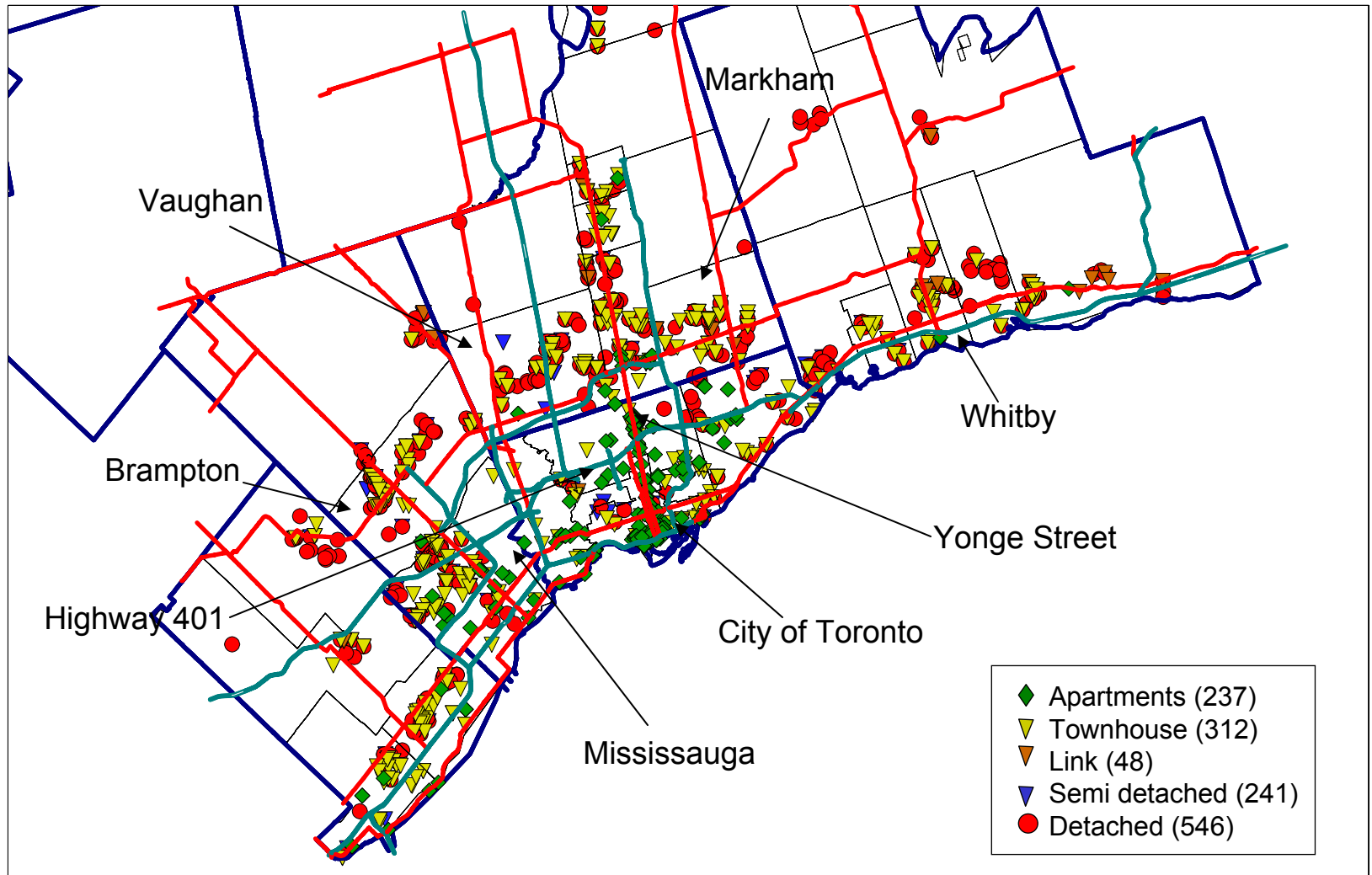


Figure 1: Location of all starts in the GTA and the transportation network

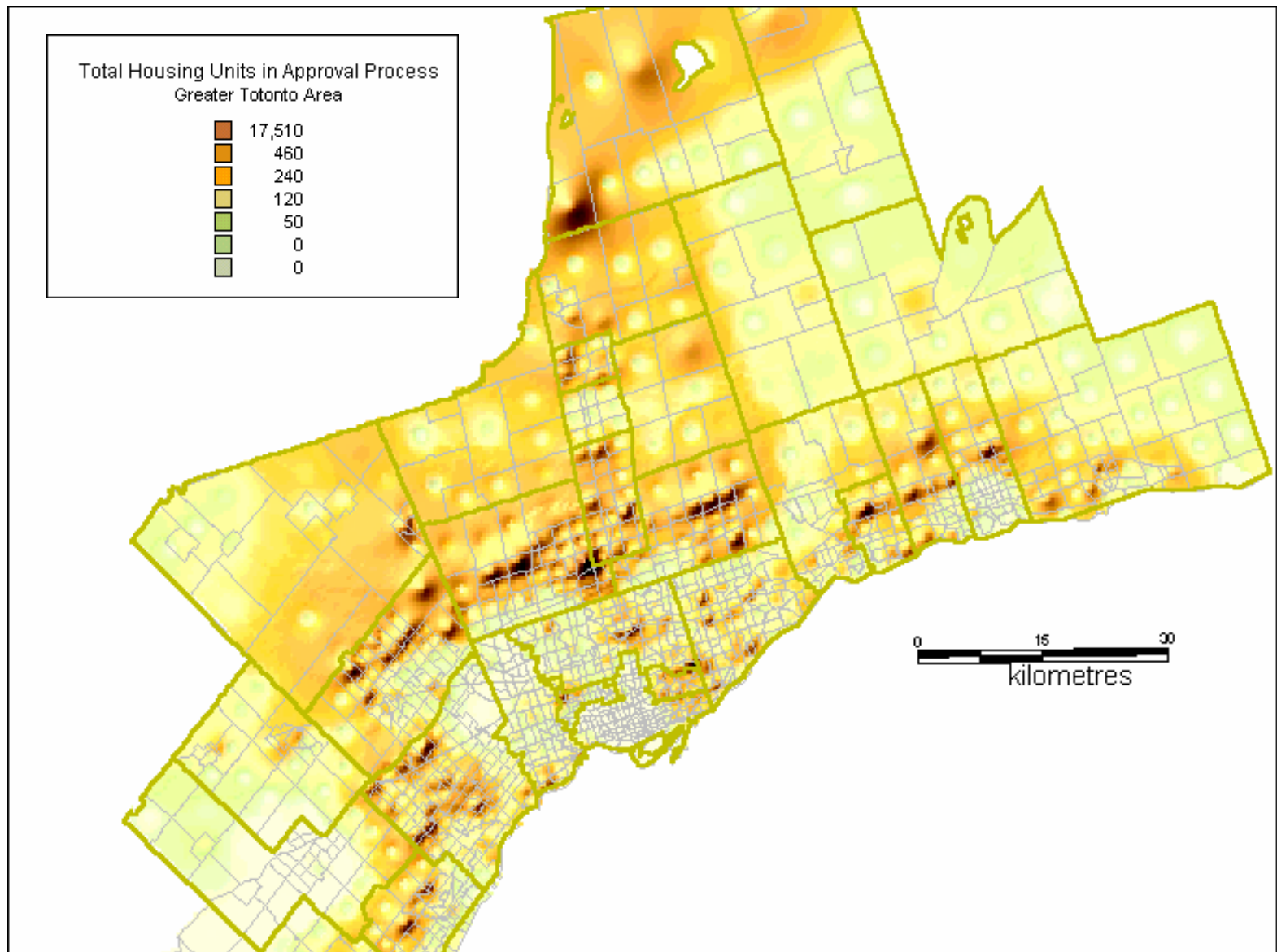


Figure 2: Spatial distribution of land inventory in the GTA

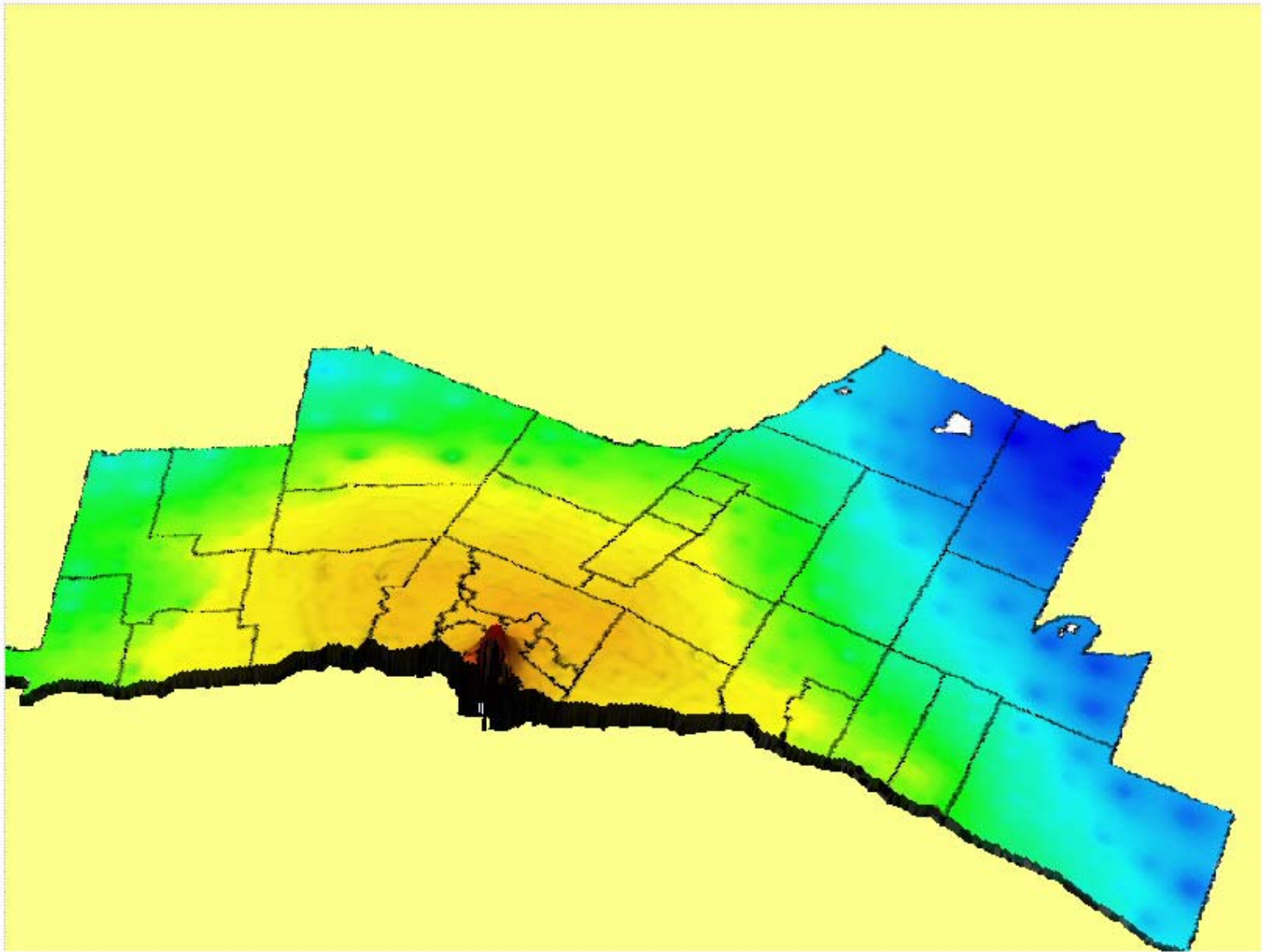


Figure 3: Spatial distribution of employment accessibility index (3-D rendering)