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**Heterogeneous Developers, Spatial Interactions, and Land Development Outcomes under  
Uncertainty**

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*Selected Paper prepared for presentation at the Agricultural & Applied Economics  
Association's 2012 AAEA Annual Meeting, Seattle, Washington, August 12-14, 2012*

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# **Heterogeneous Developers, Spatial Interactions, and Land Development Outcomes under Uncertainty**

## **Abstract**

Land development is a central topic in environmental, resource, urban and regional economics, yet our empirical knowledge of people behind land development, the developers, and the supply of urban land is limited. In response I develop a model of exurban land developers to test the spatial interactions of heterogeneous developers in exurban areas. Using estimation techniques that identify a parameter isolate the spatial competition and interaction effect I am able to determine the effects of developer behavior. I find significant evidence of land developers competing spatially as they locate across an exurban county.

Keywords: Land Developer; Housing supply; Exurban development

“Market areas arise through the interplay of purely economic forces, some working toward concentration and others towards dispersion”

–Losch 1941, *Economics of Location*

## **Introduction**

Land development is a central topic in environmental, resource, urban and regional economics, yet our empirical knowledge of people behind land development, the developers, and the supply of urban land is limited. Land developers are the economic agents responsible for the timing, location, and amount of residential houses in the market. Although many researchers implore improved studies on developers and the supply side of land development (Dipasquale 1999; Rosenthal 1999; Sevelka 2004; Mohamed 2009), and while numerous theoretical models of land developers have been posited (Eckart 1985; Henderson and Slade 1993; Henderson and Mitra 1996; Henderson and Thisse 2001; DeCoster and Strange 2011), in the last twenty years few empirical studies of land developers exist. This dearth of empirical work is understandable considering the difficulties involved in obtaining land developer data, but also disconcerting given the important welfare effects associated with land development. I attempt to empirically study land developers by modeling their location choice in an exurban county. I identify an effect indicating developers compete spatially rather than agglomerate.

Research on land developer behavior has significant implications for policy and influencing the abundant land use models that already exist. Land developers alter the landscape in ways few others are able, and their behavior ultimately determines the effectiveness of zoning, land conservation programs, open space programs, and septic regulations among others. Developer behavior is particularly relevant in exurban region as exurban land development is a relatively recent phenomenon and the resulting sprawl has lead to contention between developers and policymakers.

I focus on land developers in an exurban northern county of Greater Baltimore. Developers in the exurbs are heterogeneous. During the housing boom of the 1990's and early 2000's there were many new entrants to the land development scene as anyone connected to real estate was likely to consider developing land. Exurban land developments frequently consist of subdivisions of only a few lots, allowing individuals to try their hand at development without huge credit availability and without undertaking the same level of risk as in a multi-million dollar city development. Not surprisingly there are a substantial number of small developers completing only one small subdivision, which over time collectively shaped the landscape significantly. Meanwhile a handful of long-term developers worked within the county over long-periods of time constructing multiple developments, as a full-time profession rather than a one-off opportunity to profit.

This study investigates the different approaches of these heterogeneous exurban developers and the interaction, competition, and outcomes that stem from this heterogeneity. The research question I am asking is how the heterogeneity of land developers impacts the spatial layout of the county. I model spatial competition and interactions among developers and test for spatial agglomeration effects or spatial competition effects. Categorizing developers into two discrete types, I am able to identify the spatial interaction between developers in the residential subdivision process. I find developers compete spatially, suggestive that one of the ways land developers may differentiate their product is to choose unique locations away from other developed land. Finding spatial competition effects allows policymakers to have a better understanding the decisionmaking process for land developers and will allow for potential welfare calculations among developers.

## **Literature Review**

Realistic theoretical examination of developers is difficult and even simplified development games without heterogeneity quickly become intractable when developers decide the timing, spatial location, and intensity of subdivisions. Also economists must integrate industrial organization theory based on the number of developers in a region and their market power. For example, modeling land developers behavior in Hong Kong, where four land developers are responsible for virtually all developments contrasts sharply with modeling developers with less market power in Maryland's exurban counties but where large subdivisions still influence the supply curve for the region, which differs still from development in Texas where few regulations and widespread growth may represent a competitive market. Additional complicating factors include modeling the role other actors play in development. Policy makers and regulators are agents who force or restrict developers' behavior in certain ways. Developers may negotiate and actively interact with policy makers (Ruming 2010), or they may passively respond to regulations via their development plans as commonly modeled.

Land developers decisions originate in the urban economic city formation framework. Early theoretical models were developed by Alonso, Muth, and Mills. Heavily influenced by these theories, Fujita and Ogawa (1982) Fujita and Thisse (1986), Henderson and Slade (1993) began to theoretical model land developers within this framework where land developers choose to develop both a residential and business district. But the model falls apart as more and more large centers are built, leading to increased productivity and unbounded increasing city sizes. To correct, they introduce a congestion function, specified in the labor costs function as increasing opportunity cost to hiring labor. The firms must compensate workers with higher wages as congestion increases which causes quality of life to decrease. Once developers are given

sequential entry, the city is no longer symmetrical as the first developer can capture a greater portion of the market.

Similarly Henderson and Mitra (1996) model developer this incomplete market through the formation of edge cities, which coincides with the idea that market power may exist in the housing supply market (2003). If developers have complete control the resulting spatial equilibrium will be pareto efficient (Henderson 1988), however, this will not be true if the market power is endogenous (Helsley and Strange 1997). In this case developers experience spillover effects and cannot control all the land in the city. By limiting developers, cities exhibit random sizes with developers not efficiently using resources. Also, land-prices shift such that parcels at the beginning of a development are more valuable due to the potential to earn extra profit on the following lots' development.

Henderson and Thisse (2001) suggest developers differentiate by quality and utilize different pricing schemes in order to compete for residents. As developers compete there may be a first-mover advantage resulting in decentralized cities and rapid expansion (Heubeck 2007). Additionally a certain form of spatial interactions emerges as the result of heterogeneity among developers' reputation and experience (DeCoster and Strange 2011).

Developer heterogeneity is an important factor when considering the decisionmaking process. Rolph (1973) found small developers tend not to be experimental, but rather stick to the same development patterns. Large scale developers locate in more stable, high demand areas and are more likely to try different types of development projects.

Developers are entrepreneurs and natural risk takers. A significant factor increasing risk is the uncertainty involved in the waiting process for subdivision approval (Sevelka 2004). Large-scale development is particularly prone to risk. Peiser (1984) finds development risk

analyzes risk increases exponentially as size and duration increase. This may inspire developers to shorten developments duration, towards one-shot developments, or seek smaller developments, which could be one of the reasons why small developers have been found to be more efficient and cost effective (Psilander 2007).

Alternatively small developers could be inherently more risky, since they lack the ability to hedge against potential failure (Ball 2003). Large developers are able to negotiate and develop long-term relationships with land owners allowing potential strategic spatial land use decisions that are not possible for small developers. This can lead to inter-developer competition—where a strategic move on the part of a large developer in a locality, may block another developer's move due to the fear of local oversupply.

Maurani and Amit-Cohen (2011) find different developer types have different patterns of open space in their development. In a similar vein Mohamed (2009) finds exurban developers in particular due to their size and cost structure may build larger lots than planners find optimal. This difference might be accentuated due to different developer sizes. Smaller but repeat developers may have the best working relationship with the planners, and while the smallest developers rarely interact with planners, large developers may use their size to influence planners (Ruming 2010). Large developers also tend to be more prevalent where larger parcels are available, where markets are more active, and where there are straightforward land-use regulations (Somerville 1999). Firm size rises with market activity and land supply and falls with decentralized regulations on land-use. Additionally there may be economics of scale in both building and due to better access to credit (Somerville 1999).

The most economically rigorous studies on the supply side of housing requires the assumption that developers operate in a competitive market (Irwin and Bockstael 2004, Klaiber



and Phaneuf 2012, Lerbs 2012). Most of these models focus on land market outcomes in terms of land and housing prices or land development outcomes, such as the role of spatial interactions among developments (Irwin and Bockstael 2002). The supply-side approaches usually model the landowner, representing a combination of owner, land developer, and homebuilder (e.g., Cunningham 2007, Murphy 2010, Geniaux et al 2011). Recently attempts have gone further in statistically analyzing the developer. Wrenn and Irwin (2012) analyze developers' choices of subdivision size as influenced by zoning and regulatory policies. Klaiber and Phaneuf (2012) model housing supply and demand in a general equilibrium analysis of housing incorporating a combined developer-cum-homebuilder economic agent in the supply side.

The literature has given us theory on why and how cities form but despite the researchers above, little has been tested about how land developers interact in their decisionmaking process. There is a clear gap between the rigorous housing supply literature and the theoretical models of land developer behavior. This article is an attempt to help fill in a piece of that gap by testing a theoretically driven model of land developers' spatial interactions.

## **Theoretical Framework**

The spatial competition model of the firm is rooted on Hotelling's (1929) seminal work through the idea of interactive decisionmaking firms were modeled as spatial competitors (Fujita and Thisse 2000). Firms select their location knowing that they will later select their price. Hotelling's equilibrium result lead to agglomeration and two firms located in the center of the space (i.e. the CBD). However, under different functional form assumptions of travel costs a unique equilibrium can exist at *any* location pair. d'Aspremont et al (1979) provides an example that generates an equilibrium where two firms locate at the farthest location from each other, thus

theoretically proving under the linear city framework the results of agglomeration or dispersion are possible. Similarly spatial equilibriums are examined with a circular rather than linear city assumption (Salop 1979). Both sets of models assume price competition rather than quantity competition among firms.

Cournot models incorporate quantity competition and are the most common model of oligopoly behavior in non-spatial contexts. But this proves difficult to translate to spatial context and only recently have location outcomes been considered under *spatial* Cournot competition (Anderson and Neven 1991). The initial theoretical results provide evidence of a resulting spatial agglomeration; however, Pal (1998) countered by analyzing the problem using a circular city and found equilibrium outcomes of dispersion. It turns out that many equilibrium location patterns are possible in both linear and circular city models when modeling Cournot behavior (Gupta 2004)

It is important to discuss this theoretical debate about the resulting location outcomes in spatial competition models because this motivates the empirical question under investigation: do residential land developers compete in such a way that leads to dispersion or agglomeration? Based on the aforementioned research both outcomes are theoretically plausible and can be justified depending on the parameterization and assumptions of the models. Thus the model for this article will not *a priori* assume that dispersion or agglomeration will be found, conveniently there are theoretical explanations for both potential outcomes, and given the unique of the land development in exurban regions there isn't substantial economic literature to be suggestive of the direction of spatial interactions among developers<sup>1</sup>.

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<sup>1</sup> Prior to estimating the model I conducted interviews with 12 developers and planners in exurban regions of Maryland. Anecdotal evidence provided in the interviews suggests developers

The setup of the model (Gupta 2004) is based on a uniform distribution of consumers in either a circular or linear market. The market demand at a specific point is given by the general form  $p(x) = a - bQ(x)$ , where  $a$  and  $b$  are positive constants.  $Q(x)$  is the quantity of residential units supplied at location  $x$ , and  $p(x)$  is the market price at  $x$ . The vector  $z = (z_1, \dots, z_n)$  denotes the location of the  $n$  developments, and  $z_i$  denotes the location of all developments not  $i$ . Assuming constant marginal and average costs normalized to zero, and linear transportation costs ( $t = 1$ ).

Each developer chooses location in the first stage and then after observing all developer's location choices, then chooses optimal quantity of residential lots. The developers are profit maximizing entities choosing  $q_i(x)$  to maximize  $(p(x) - c_i(x)) * q_i(x)$ , where  $c_i(x)$  is the minimum distance to the next development, which in this case is the delivered marginal cost of firm  $i$ . The resulting first order conditions yield an aggregate profit function:  $\pi_i = \int \pi_i(x, z_i, z_{-i}) dx$ . An equilibrium is the set of locations that maximizes the aggregate profit function for all  $i$ .

Land developers must make the decision of where to locate and then observing the location choice of all other developments the developer chooses the quantity of residential lots to supply in that location. Firms will not all aggregate at a single location, but instead there exist aggregation points where a subset of firms locate. This is more realistic for land developers as certain locations may be conducive to more agglomerative effects that come from living in proximity to others thus allowing for easier distribution of services such as schools, parks, and other amenities.

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may disperse spatially to limit spatial competition; however, the interviews weren't focused on this issue and provide at best heuristic support for spatial dispersion effects.

## **Model**

The direct estimation of the aforementioned theoretical model would require extensive knowledge of the profits and costs of land developers. In a variety of other industries this has proved possible as spatial competition models of firms has recently become an important topic in field of empirical industrial organization. Researchers have applied advanced statistical techniques combined with robust data to actually estimate degree of market power arising from spatial competition and uncover some initial welfare implications (Davis 2006; Clemenz and Gugler 2006; Pinkse, Slade, and Brett 2002). These approaches require detailed data on firm prices and costs which is not readily available from land developers.

Due to the lack of detailed data on costs and profits I must approach the problem in an indirect fashion. I model the location choice of the firm using profit comparisons between locations. Coinciding with the industrial location literature I use the random utility (profit) framework, which specifically assumes that land developers choose a location from a distinct choice set (Guimaraes, Figueriredo, and Woodward 2004). Most literature on industrial location relies on aggregation of data at a state-level, but recently approaches have found agglomerative effects using less aggregated data (e.g. municipal level) (Guimaraes, Figueriredo, and Woodward 2000).

Land developers fit the industrial location literature fairly well, but exhibit unique properties that may result in different location outcomes (Kenney 1972). Developers are producers of housing units, but their production cycle is relatively short. Once the housing lots are produced, they are sold off (either individuals or homebuilders typically purchase the undeveloped lots), and the developer can no longer produce more goods in that same location. A new location must be chosen to continue production. Land developers who develop many

subdivisions are forced to be mobile which is a unique aspect that differs from the traditional industrial location framework. This relative short-term production cycle also modifies the role of location in the decision-making process. Given the location choice decision, the land developer may be modeled as a firm choosing a location in a similar way to an individual makes a recreational site choice decision. The firm considers all possible location possibilities and chooses the site that maximizes their profit given the decisions made by all other developers.

To approach the problem I begin with a random utility (profit) framework. The model is adapted from Timmins and Murdoch (2007). A land developer is faced with a decision to locate a new residential subdivision. Each land developer maximizes their profit by choosing the location  $j$  given the decisions of all other land developers. Each subdivision built by the developer is an independent observation with an associated profit. Thus the profit from developer  $j$  is modeled as

$$\pi_{ij} = \delta_j + X_j' \Gamma(Z_i) + \Phi(Z_i) \sigma_j + \Theta(Z_i) DC_{ij} + \varepsilon_{ij} \quad (1)$$

where

$$\delta_j = X_j' \beta + \alpha \sigma_j + \xi_j \quad (2)$$

$$\Gamma(Z_i) = Z_i' \gamma \quad \Phi(Z_i) = Z_i' \phi \quad \Theta(Z_i) = \theta_0 + Z_i' \theta_1 \quad (3)$$

The variables in the above equation as defined as follows:  $Z_i$  is a vector of developer specific attributes;  $X_j$  is a vector of site specific attributes;  $DC_{ij}$  is the development costs for developer  $i$  in site location  $j$ . There are two errors terms in the profit function:  $\varepsilon_{ij}$  is the standard

idiosyncratic error term, while  $\xi_j$  represents unobservables specifically related to site location  $j$ .  $\delta_j$  can be viewed as the baseline profits that a developer could earn at location  $j$ .

The key variable of interest for this model is  $\sigma_j$ , which represents the share (percentage) of developers who will chose location  $j$ . The sign of the coefficient,  $\alpha$ , determines whether there are spatial dispersion effects ( $\alpha < 0$ ) or whether there are spatial agglomeration effects ( $\alpha > 0$ ). For example if  $\alpha < 0$  then developers obtain higher profits by locating farther away from other developments *ceteris peribus*.

This model is operationalized into a heterogeneous parameters discrete choice model. The model relies on a Nash-equilibrium result where each developer cannot chose a different location that would yield greater profits. The resulting estimation assumes an extreme value error structure that allows for the expression of the probability that a land developer,  $i$ , develops in a specific location  $j$  as

$$P(\pi_{ij} \geq \pi_{il} \forall l \neq j | X, Z_i, DC_i) = \frac{\exp \{ \delta_j + X_j \Gamma(Z_i) + \Phi(Z_i) \sigma_j + \Theta(Z_i) DC_{ij} \}}{\sum_{l=1}^J \exp \{ \delta_l + X_l \Gamma(Z_i) + \Phi(Z_i) \sigma_l + \Theta(Z_i) DC_{il} \}} \quad (4)$$

The average probability that a developer chooses a specific location site gives the predicted share of developers at each location,

$$\sigma_j = \frac{1}{N} P(\pi_{ij} \geq \pi_{il} \forall l \neq j | X, Z_i, DC_i) \forall j. \quad (5)$$

Bayer and Timmins (2005) present the equilibrium arguments and through Brower's fixed point theorem there exists a unique set of  $\sigma_j$ 's that characterize the unique equilibrium

under spatial dispersion effects. However, in the case of spatial agglomeration this equilibrium may not be unique. This is important since there is theoretical motivation that could justify a spatial dispersion effect or a spatial agglomeration effect. Thusly if I found agglomerative effects I cannot definitely state whether the equilibrium estimated will be a unique equilibrium. The estimation technique is valid under both assumptions, but the interpretation of the results is sensitive to the specific equilibrium if agglomerative forces are found.

Equation (4) above is estimated by maximum likelihood (Bayer and Timmins 2008)

$$L(\delta, \gamma, \phi, \theta | Z, X, Y, DC) = \prod_{i \in N} \prod_{j=1}^J [P(\pi_{ij} \geq \pi_{il} \forall l \neq j | X, Z_i, DC_i)]^{Y_{ij}}, \quad (6)$$

where there are  $N$  total developments, and each developer can choose to develop one of the  $J$  locations. If developer  $i$  chooses to develop in location  $j$  then  $Y_{ij} = 1$ , else  $Y_{ij} = 0$ . The resulting set of parameters  $(\delta, \gamma, \phi, \theta)$  is used to calculate the baseline profits at each location,  $\delta_j$ . Following Timmins and Murdoch (2007) I use the BLP contraction mapping (Berry 1994; Berry, Levinsohn and Pakes. 1995) to estimate the  $\delta_j$  such that the predicted share of developers,  $\sigma_j$ , in each site location,  $j$ , equals the actual share.

An important consideration is the potential endogeneity of the share of developers,  $\sigma_j$ . The share of developers at location site  $j$ , is almost certainly correlated with the location sites unobservable characteristics  $\xi_j$ . In this stage of the regression endogeneity is not a concern as the location specific fixed effect,  $\delta_j$  soaks up any potential correlation. However, the fixed effect,  $\delta_j$ , interpreted as the baseline profits at each location  $j$ , includes the parameter we are interested in uncovering; the spatial interaction between developers,  $\alpha$ . Thus the resulting regression must be

solved using instrumental variables in order to generate unbiased estimates of the parameters  $\alpha$  and  $\beta$ . If instrumental variables are not used the OLS regression solving

$$\delta_j = X_j'\beta + \alpha\sigma_j + \xi_j \quad (7)$$

will tend to have an upward bias on  $\alpha$ , since the better locations will have a higher baseline profits and be more likely to attract land developers  $cov(\sigma_j, \xi_j) > 0$ . Thus the estimates may provide incorrect evidence of agglomeration when there are actually spatial dispersion effects. If there are agglomeration effects, the magnitude of these effects will be overstated in the OLS estimates.

I account for the potential endogeneity with an instrumental variable estimator for equation (7). The instruments for location site  $j$  are the exogenous attributes for the other possible locations. These variables make a natural case for instrumental variables as they only way the other site attributes will influence the profits of developers are through they way these variables impact the share of land developers located at site  $j$ . The better the exogenous attributes are at influencing location site choice the greater power of the instrument. Following Bayer and Timmins (2008) estimation of the initial estimates for the set of parameters  $(\gamma, \beta, \theta_0, \theta_1)$  can be found by ignoring the potential endogeneity of the share of developers in location  $j$ . Using the initial guesses than allows one to instrument for the predicted share of developers  $\hat{\sigma}_j$  to be calculated in the following equation:

$$\hat{\sigma}_j = \frac{1}{N} \sum_i \frac{\exp \{X_j \hat{\Gamma}(Z_i) + X_j' \hat{\beta} + \hat{\Theta}(Z_i) DC_{ij}\}}{\sum_{l=1}^J \exp \{X_l \hat{\Gamma}(Z_i) + X_l' \hat{\beta} + \hat{\Theta}(Z_i) DC_{il}\}} \quad (8)$$



## **Data**

The study area for this article is Harford County, Maryland. The county is exurban, located just outside Baltimore City (see figure 1). Within the county are three small municipalities, all with population less than 15,000, the largest of which is Bel Air, centrally located in the county. Also notable is a large military base, Aberdeen Proving Grounds, in the south of the county. The entire county lies within the commuter shed for Baltimore City; the commuting time from the city to the County averages just over 30 minutes and nearly half of the population commutes to either Baltimore County or Baltimore City (2000 Census).

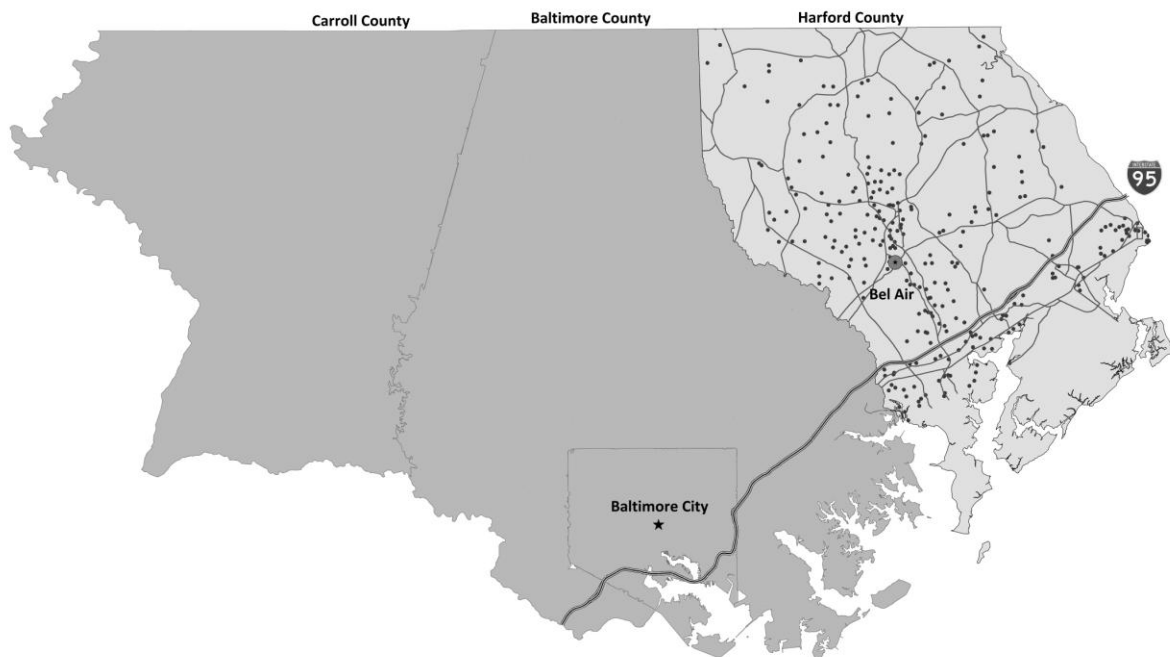
The county is commonly characterized as exurban due to its location, land use, large commuting population, and the county's rapid development. The population boom took place over the last half of the 20th century. During those 50 years nearly 1500 subdivisions were created with over 70,000 total lots. This article focuses on the 18-year time period 1990-2007 during which the population grew by over 30% and 276 subdivisions were built.

I collected the specific parcel-level data of subdivision histories to use in estimating this model. The Maryland Department of Planning provided parcel data which was linked to parcel boundary files provided by Harford County. The data consist of the basic details about each parcel such as location and parcel characteristics. I linked the parcel characteristics to the County Circuit Court's historical archive from which plat maps were downloaded to collect the subdivision history.

Additionally I was able to merge the name and address of the land developer to the subdivisions characteristics. Developers are notoriously difficult to study empirically since they frequently collaborate and create new development Limited Liability Corporations (LLCs) for each subdivision. Thus comparisons of the developer name and address is fraught with errors and

the data is difficult to reliably use for estimation. To mitigate this problem I used various matching techniques of the names and addresses as well as scanning all development and housing websites and newspaper and planning meeting archives to identify the main developers involved in each subdivision, thus creating a developer database for the county. Characteristics of the developers were then aggregated such as the number of developments, the number of lots, and the location of developments relative to their actual location. Developer costs were approximated by the access to roads and the travel time to the town of Bel Air, the county seat where permits must be filled and the center of the area where the County Government targets increased growth. This assumes that land farther from Bel Air will be costlier to develop, as it poses higher risk for permit approvals, and requires greater travel time to monitor the site.

Figure 1. Harford County



ArcGIS data layers were used to obtain land characteristics. Harford County's GIS division has data on sewer availability, forested land, and land use. Sewer availability is a dummy variable measuring whether a parcel has sewer and water access from the county and forested land is the percentage of the parcel that has forest. Soil data were collected through the National Resources Conservation Service (NRCS). Soil quality measures the percentage of each land parcel that is within the classified soil qualities. I use the highest soil quality in the model, treating the poorer soils as the baseline. I also constructed a slope variable by calculating the percentage of each site location that is sloped greater than 15%, typically the cutoff for development potential.

Table 1 summarizes the data for both location site characteristics and developer characteristics. The location characteristics are aggregated at the census tract level which is where the developers are assumed to make their location decision. An added benefit is that census tract variables are then available, such population density of the site location. I used data from the 39 census tracts in Harford County that had land available for development at the beginning of the study period.

Table 1

Data Summary

| Variable                  | Mean     | Std. Dev | Min    | Max       |
|---------------------------|----------|----------|--------|-----------|
| Location Characteristics  |          |          |        |           |
| <i>Acres</i>              | 5771.730 | 7509.737 | 45.540 | 36168.620 |
| <i>Population Density</i> | 4.630    | 13.153   | 0.190  | 82.861    |
| <i>High Quality Soil</i>  | 0.229    | 0.089    | 0.034  | 0.464     |
| <i>Sewer</i>              | 0.526    | 0.443    | 0      | 1         |
| Developer Characteristics |          |          |        |           |
| <i>Lot Quantity</i>       | 60.090   | 90.902   | 6      | 679       |
| <i>Repeat Developer</i>   | 0.413    | 0.493    | 0      | 1         |
| <i>Development Costs</i>  | 29.370   | 11.401   | 2.713  | 80.030    |

## Results and Discussion

I report results of the two stages of the regression. The first stage is the maximum likelihood parameter estimates for equation 1 seen in Table 2. I only include a few key interaction terms due to the second stage estimates introducing great flexibility. Interestingly larger developers measured by those who have higher lot yields are less affected by congestion than smaller developers. Development costs are very precisely measured in this regression.

Table 2

Maximum Likelihood Estimates (Eq. 1)

| Variables                 | Interaction         | Estimate | Std. Err. | t-stat  |
|---------------------------|---------------------|----------|-----------|---------|
| <i>Acres</i>              | <i>Lot Quantity</i> | -21.963  | 7.665     | -2.865  |
| <i>Population Density</i> | <i>Lot Quantity</i> | -37.942  | 19.850    | -1.911  |
| <i>High Quality Soil</i>  | <i>Lot Quantity</i> | -6.066   | 4.945     | -1.227  |
| <i>Share</i>              | <i>Lot Quantity</i> | 39.797   | 27.518    | 1.446   |
| <i>Development Cost</i>   |                     | -0.275   | 0.014     | -19.465 |

Table 3

OLS and IV Estimates (Eq. 7)

| Variables                 | OLS         |          |        | IV          |           |        |
|---------------------------|-------------|----------|--------|-------------|-----------|--------|
|                           | Coefficient | Std. Err | t-stat | Coefficient | Std. Err. | t-stat |
| <i>Constant</i>           | -0.708      | 1.829    | -0.387 | 3.118       | 1.403     | 2.222  |
| <i>Acres</i>              | -1.476      | 2.813    | -0.525 | 0.300       | 1.587     | 0.189  |
| <i>Population Density</i> | -12.959     | 3.149    | -4.115 | -16.994     | 1.864     | -9.118 |
| <i>High Quality Soil</i>  | 2.439       | 5.234    | 0.466  | 2.782       | 5.403     | 0.515  |
| <i>Sewer</i>              | -0.773      | 1.281    | -0.604 | -1.929      | 1.589     | -1.214 |
| <i>Share</i>              | 62.634      | 25.670   | 2.440  | -68.559     | 36.621    | -1.872 |

Table 3 shows the second stage estimates are for the OLS and the IV estimates of equation 7<sup>2</sup>. The key result from the two regressions in Table 3 is the parameter estimate for the variable *Share*, which represents the share of developers who chose each particular location for a development. The OLS regression yields a positive and significant parameter estimate suggestion

<sup>2</sup> For tractability I follow the numerical patch of Timmins and Murdoch (2007) for location sites that aren't developed during the course of study by adding a small increment ( $10^{-5}$ ) to the shares of those sites.

there may be signs of agglomeration among the developers. Evidence of agglomeration could easily be supported by the rich theory on location choice of firms, however the OLS estimates don't account for endogeneity between the share and the site specific error term.

Accounting for the endogeneity through IV estimation yields a negative estimate for the effect of a greater share of developers on the location choice. A negative ( $\alpha < 0$ ) parameter estimate is consistent with the theory that predicts spatial dispersion among developers. Intuitively developers in this context compete against one another spatially and try to locate in areas where they can capture large percentages of the market share.

Spatial competition among developers is consistent with pre-research interviews with developers. Developers mentioned working with other developers and knowing where other developers were building. Additionally developers may intentionally locate farther away from other developers as a means of differentiating their product from other developers.

As a caveat, a potential different story explaining the same effect I found here could be due to the commonly heard concept "not in my backyard". The idea behind "not in my backyard" is that residents prefer open space and at times adamantly oppose nearby developments. In Harford county prior to submission of a preliminary plan for development the developer must hold a community meeting to inform the community of the proposed plans and allow for questions from the community. Development plans have been railroaded in the past due to uproar in the community and developers are constantly aware of this potential.

## **Conclusion**

I investigate the spatial interaction effect of heterogeneous developers in exurban areas. Using estimation techniques that identify a parameter isolate the spatial competition and

interaction effect I am able to determine the effects of developer behavior. As far as I know this is the first empirically estimated spatial competition model of land developer. By overcoming significant data complications I am able to create a robust and accurate population of land developers for Harford County over the years 1990-2007 to enable estimation. Findings from this model provide intriguing implications for the driving forces of exurban development and urban sprawl. Policymakers interested in providing incentives for growth, such as Maryland's Smart Growth advocates, should consider the role that the heterogeneity and competition of developers have on the resulting land development outcomes and potential welfare of the community.

Future extensions of this work can include welfare calculations. Maryland has debated the merits of passing legislation eliminating all potential residential developments using septic tanks. These techniques could help inform that decision from land developers' perspectives by estimating the valuation of sites without public sewer and water access.

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