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Prices, policies, and place: What drives greenfield development?

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ABSTRACT

While the recent global financial crisis heightened awareness of the linkages between global financial capital and urban spatial pattern, the timing of urban development – largely thought to be market driven – is not fully understood. Parcel-level studies of urban land-use change, which often use hazard models to investigate if and when development occurs, offer an opportunity to juxtapose the extent to which decisions to develop individual plots of farmland into housing are driven by market forces, the unique characteristics of the land and its intraurban location, or policies such as transportation infrastructure and municipal annexation. Using residential completion data in the Phoenix, Arizona region from 1992 to 2014, a period of dramatic commodity, fuel, and home price swings, and land cover imagery, we develop a parcel-level hazard model to gauge the relative impacts of market, policy, and place-based drivers of land change. We find limited evidence of induced development associated with freeway planning, that annexation and development are closely linked and moreso during economic booms, high fuel prices spur development in the region's core, and agricultural and urban land rents affect the timing of development. This study advances our understanding of development decision- making, policy impacts, and urban land-use change modeling and provides an empirical connection between local and global drivers of Greenfield development.

1. Introduction

Urbanization, suburbanization, and land fragmentation affect ecological functions such as hydrology and biogeochemistry (Grimm et al., 2008) as well as the social environment, built environment, and even global financial markets (Aalbers, 2009). However, land development decisions are spatially disaggregated, involving individual landowners who decide whether and when to convert parcels of land from one use to another (Irwin, 2010). Economic performance, particularly in the United States, is fundamentally tied to the housing market and in turn to the unique geographies of where housing is built (Martin, 2010). The recent global financial crisis demonstrated how the increasingly financialized industry of residential development directly impacts neighborhoods in terms of foreclosures and stalled (Crump et al., 2013; Immergluck, 2010; Kane, York et al., 2014). Put differently, urban spatial pattern is thought to be sensitive to booms, busts, and macroeconomic shocks, and perhaps increasingly so. Meanwhile lot sizes, building durability, landscaping, and transportation infrastructure are largely a product of the historical period during which development in an area first took place (Adams, 1970; Kane et al., 2014a,b,c). Spatially disaggregated land change models are yet to specifically compare global and regional-level financial indicators with spatial and institutional change drivers such as intraurban location, soil quality, and municipal annexation. In this study, we focus on how the housing and agricultural commodities markets impact land change, while comparing against policy-based and place-based drivers of development.

Greenfield development, which often refers to the conversion of agricultural land to urban uses (principally residential uses) has long been a rallying cry for environmentalists (Benfield et al., 2001). Farmland preservationists, conservationists, and proponents of food security have considered the loss of agricultural land – and in particular agricultural land near urban areas – to be a major concern (Godfray et al., 2010; Jeer, 1997). Specific policies aimed at preserving farmland have been proposed and implemented by government entities (Liu and Lynch, 2011), while zoning, a more general tool, has been used toward this and other goals but is often seen as ineffective or ambiguous in terms of its overall effect (Butsic et al., 2011; Talen, 2012; York and Munroe, 2010). Large-lot zoning at the urban fringe in combination with fragmented municipal boundaries have been identified as causes of an expanded urban footprint which is often characterized as urban sprawl (Carruthers, 2003). Meanwhile Greenfield development is generally considered to be less expensive, more desirable, and easier to finance by developers than infill or brownfield development

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(Leinberger and Alfonzo, 2012; Peiser, 2001).

Spatially disaggregated models of land change (i.e. those conducted at the level of individual land parcels) have investigated critiques of urban sprawl, evolving preferences for neighboring land, and specific zoning policies by linking the development of parcels across a city to their locational attributes, regulations on their use, and other factors (Irwin and Bockstael, 2002; Kane, York et al., 2014; Newburn and Berck, 2006; Seto and Fragkias, 2005). Survival analysis, also known as hazard modeling, is a parsimonious means of capturing the time-varying aspects of development trajectories to understand longer-term trends. Land change studies using survival analysis have successfully related time-varying factors like population density or regulatory costs to the length of time before a unit of land converts (An and Brown, 2008; Wrenn et al., 2012). We investigate the development of housing on agricultural land in the Phoenix, Arizona, USA metropolitan area during a period of tremendous swings in agricultural commodity, housing, and oil prices allowing us to disentangle the relationships between greenfield development prices, policies, and place. Using remotely-sensed imagery to identify agricultural land, a Cox hazard model identifies if and when a unit of agricultural land experienced a conversion to residential use at any time between January 1992 and December 2014.

2. Land conversion model

The conversion of agricultural land is a complex process involving numerous actors, policies, and decisions. Most simply, a developer offers to purchase a farmer's land if he determines that his expected future returns from constructing housing are greater than the cost of acquisition and development. A farmer sells his land to a developer if the price offered is greater than his expectation of future agricultural rents. The land would be subdivided with homes built and sold in relatively short order. During the housing construction boom of the late 1990s and early 2000s, high returns ensured that the requisite title transfers, zoning changes, platting, and construction that constitute this process took place quickly and efficiently.

Market factors and policies both impact the speed and complexity of the process. In this region, as in much of the United States, land that is being farmed is assessed based on agricultural rents resulting in a very low property tax burden for the owner. In contrast, vacant land that is not in production is assessed based on its potential for income-producing urbanized uses such as housing, resulting in a tax burden several times higher (Agricultural Property Manual, 2012). In Arizona it has been common practice for developers or investors to purchase property and lease it back to a farmer in order to maintain tax benefits while maintaining the flexibility to build housing should market conditions improve. In this region, agricultural zoning is not used to slow development pressure and is easy to change. A recent study of farmers and other stakeholders (Bausch et al., 2015) overwhelmingly confirmed the perspective that expected returns – rather than land conservation or preservation policy – were the primary impetus for sale decisions.[1]

This study abstracts the transaction between farmer and developer and models only one actor: a landowner who can choose to convert a unit of farmland into housing. Arnott and Lewis (1979) first propose a model for when the owner of vacant land at the urban fringe should convert it to urban use. Capozza and Helsley (1989) propose an optimal timing model for agricultural land conversion in which the landowner's profit maximizing decision is to choose a date of conversion t^* which depends on agricultural rents, the cost of conversion, the value of accessibility, and the value of expected future rent increases. A recent adaptation using discrete units of land i is found in Wrenn and Irwin (2012):

$$\max \pi_{it} = \int_0^t A(x_{it}, t^*)e^{-rt} + (H(x_{it}, t^*) - C(x_{it}, t^*))e^{-rt} \tag{1}$$

where r is the discount rate, A is the value of agricultural rents, H is the rent that can be expected from housing, and C is the cost to convert the parcel. Each of A, H, and C depend on both the spatially-explicit characteristics of land unit i and also t^* which represents the conditions of the local housing market, agricultural commodities markets, and other regional and global conditions at the time of conversion. $H(x_{it})$ includes factors specific to land unit i such as intraurban location, proximity to transportation networks, and inclusion within the boundaries of a municipality. $A(x_{it})$ consists of the soil quality and the cost of water for irrigation. The latter is omitted due to data availability constraints, though water costs in the area are closely tied to energy costs as energy is used for pumping groundwater and moving surface water through irrigation systems (Scott et al., 2011). $C(x_{it})$ is left unexplored in this paper but would include any other variation across the study area in conversion costs of a land parcel.

Survival analysis has been recognized as a parsimonious method for understanding the spatially and temporally varying covariates affecting the landowner's conversion decision in Eq. (1). The probability of land surviving in agricultural use beyond time t can be given as the survival function, $S(t)$:

$$S(t) = \Pr(T > t) = exp\left\{-\int_0^t h(x)dx\right\} \tag{2}$$

where $h(x)$ refers to the hazard of land conversion, which can be thought of as a failure rate that is intrinsic to each individual i. In land change science, hazard refers to the cumulative risk of land conversion over the study period.

While a landowner's decision to convert farmland into housing operates continuously, the empirical specification is complicated because thousands of units of agricultural land are continuously at risk of conversion. In addition, conditions impacting hazard change over time such as the proximity of a land parcel to a freeway network when new roads are being built. The reality in land change science is that continuous information is unlikely to be available or manageable for every parcel of land over a long study period. Following An and Brown (2008), a discrete- time model such as a logit or complementary log-log specification can be used to approximate a continuous time process when the temporal resolution is fairly coarse – in this study land parcel characteristics are observed yearly. These discrete models converge to the continuous-time, semi-parametric Cox hazard model as the time interval decreases and ties can be efficiently estimated (Allison, 2010; Thompson, 1977). The hazard function $h_i(t)$ models the failure rate of each individual i and can be considered conditionally upon a set of covariates. The Cox model considers the logarithm of the hazards against a linear combination of k covariates:

$$Log h_i(t) = \alpha(t) + \beta_1 X_{i1} + \beta_2 X_{i2} + ... + \beta_k X_{ik} \tag{3}$$

Results reflect the cumulative impact of each covariate on the landowner's decision-making processes over the entire study period or until conversion. Strictly speaking, the Cox model relies on an assumption of proportional hazards – $h_i(t)$ is not directly observed or fit to a parametric baseline hazard function. Instead, partial likelihood estimation is used to compare the ratio of the hazard for individuals i and j as demonstrated below:

$$\frac{h_i(t)}{h_j(t)} = exp\{\beta_1(x_{i1} - x_j) + ... + \beta_k(x_{ik} - x_{jk})\} \tag{4}$$

Estimates area symptotically normal with minimal efficiency loss even in the case of tied data (Thompson, 1977). A challenge arises in land change applications since many factors impacting land conversion

[1] The Arizona Agricultural Property manual defines "qualified" agricultural purposes. The main criteria is based on use rather than ownership: the land must have been in economically feasible production for three of the past five years, per Arizona Revised Statute 42–13101. The manual stipulates an income capitalization approach to value with the stipulation that the valuation is "without any allowance for urban or market influences." This is the impetus for the common sale-leaseback arrangement.