Regional Determinants of Exurban Land Use in the US Midwest

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Abstract

As urban areas continue to disperse and decentralize, new urban growth is increasingly occurring in peri-rural or exurban areas. The US Midwest (the East North-Central Regional Census Division) typifies the transformation of the countryside as agricultural employment declines, and both jobs and people move out into formerly rural areas proximate to larger urban centers. Many of the factors underlying this urbanization process are linked to higher-ordered processes at regional and even global scales. For example, rising household incomes, changing preferences for low-density development, adoption of new information and production technologies, and improved regional infrastructure are all associated with regional economic growth and are among the primary influences hypothesized to influence urbanization patterns. This analysis explores the association between regional factors and resulting exurban residential land use in areas within all Metropolitan Statistical Areas but outside core urbanized areas in the region, representing the potential commutershed and access to centers of commerce. First, a cross-tabulation of exurbanization and economic growth was conducted to develop a broad typology of the regional growth-exurbanization link for the period 1980 – 2000. Then, a panel regression model is estimated which specifies the density of residential and commercial/industrial land use in these exurban areas as a function of regional economic structure at the level of the MSA as a whole, controlling for relevant geographical and infrastructural factors. Lastly, a cross-sectional analysis using spatially explicit data is conducted for the year 2000 to test whether the spatial pattern (i.e., fragmented or compact) of exurban land use directly relates to these regional factors.

Introduction

As urban areas continue to disperse and decentralize, new urban growth is increasingly occurring in peri-urban or rural areas. This trend is referred to in a variety of ways, including urban expansion, urban dispersion, urbanization, exurbanization, counterurbanization or “population turnaround”—faster population growth in nonmetropolitan vs. metropolitan areas (Deller et al. 2001). While these trends waned in the 1980s, the 1990s saw renewed growth in semi-rural areas.

Many of the factors that are hypothesized to underlie exurbanization are linked to higher-ordered processes at regional and even global scales. For example, rising household incomes, adoption of new technologies and improved regional infrastructure can all be attributed to regional economic growth and labor markets that are also affected by globalization trends. This suggests that higher-order processes may differentially affect patterns of exurbanization across metropolitan regions. If so, then we should expect to find systematic differences in exurban development patterns across different types of regional economies, e.g., a metropolitan area with a formerly manufacturing rust-belt city vs. one with a high-tech, information-oriented city. On the other hand, other determinants of exurbanization are local and may constrain or mediate the effects of higher-ordered processes on local land use change. For example, depending on local zoning and land use controls or key actors involved in local land markets, the effects of higher-ordered processes on the spatial distribution of land use change may be quite different. Local governments must respond to growth pressures, and manage or mediate the local effects of growth. It is clear that social processes, including the process of exurban development, are specific to the historic and geographic contexts within which they occur.

While it is clear that regional processes shape local land market activity, a greater understanding of how regional processes play out on the exurban landscape and the mechanisms underlying exurbanization, as the nexus of urban and rural, regional and local, is needed. This research attempts to answer the question: How does regional economic growth and the distribution of economic activity across different sectors of the regional economy influence exurban development observed at the metropolitan level? To answer this question, we develop a model that relates exurban household density from 1980-2000 to hypothesized economic factors, controlling for local demography and the natural environment. In addition, we examine whether the relationships between the regional economy and metropolitan exurban density are stable across different types of metropolitan areas. In this analysis, we chose to focus specifically on residential development, though commercial and industrial land uses also occur in exurban areas.

Our study region for this proposed research is the Midwest, specifically the North East-Central Census region (Illinois, Indiana, Michigan, Ohio and Wisconsin). This region warrants particular study due to its interesting trends in economic and population growth and urbanization over recent decades. Between the late 1970s and mid 1990s, employment trends in the Midwest mirrored those of the US: sharp losses in agricultural and manufacturing employment due to significant restructuring in those industries and globalization processes. However, despite high unemployment figures until the late 1980s, the region saw a considerable turn-around in economic growth. Some authors (e.g., Parr et al.2002) have attributed this rebound to profound increases in trade among these states with concomitant industrial restructuring (i.e., vertical and horizontal integration). Many of the cities in the region have effectively transformed themselves from manufacturing to service sectors (Federal Reserve Bank of Chicago 1996), but unequally so and manufacturing and agriculture remain important sectors of the regional economy. Two of the states in our study area, Ohio and Michigan, ranked among the top ten fastest urbanizing states (in terms of total acres of new urban land) in the U.S. in the 1990's (National Resources Inventory, USDA). They both increased their total urban land by 11% between 1992-1997 despite very low population growth rates of 4.7% and 6.9% respectively. On the other hand, Indiana and Illinois both added less urban land, but the rate of new urban land consumption roughly matched their rate of population growth (Irwin and Reece 2002). Thus, interesting variations exist among the metropolitan regions of this study region in terms of economic growth, population growth and urban land development.

The questions addressed by this research are: (1) How much do these hypothesized factors correspond to actual variations in exurban household density? and (2) Is there evidence of structural instability within this sample; i.e., do the theoretical factors generally associated with exurbanization of residential land use exhibit differential impact depending upon key characteristics of the MSAs?

Processes and Mechanisms of Exurbia

This section provides a review of the literature relevant to regional economic process and their impact on the land. We break up this discussion into the impacts of industrial and commercial restructuring, corresponding residential land-use changes, and finally rural aspects of this exurbanization process.

Industrial and Commercial Land-Use Changes

Urban expansion and counterurbanization[1] in the U.S. have been attributed to a variety of factors. Low transportation costs, due to the low cost of automobiles, an extensive roads network, and deregulation of key transportation industries in the late 1970s, have substantially loosened the constraints traditionally imposed by distance (Parr, et al. 2002). Changes in production, including new manufacturing technologies that favor horizontal production processes, have driven manufacturing firms to relocate in exurban areas where land costs are lower and large contiguous tracts of land are available (Nelson 1992). Advances in information and telecommunication technologies (IT) have allowed many firms to substitute physical proximity with IT in their production and distribution processes, pushing these firms to locate in exurban areas where land and labor costs are lower (U.S. Congress, Office of Technology Assessment 1995). These trends have led to a polycentric urban structure of suburban subcenters and "edge cities" (Berry and Kim 1993, Dear and Flusty 1998). Employment decentralization has thus enlarged the associated commutershed and extent of proximate exurban areas.

Advances in information technology (IT), to the extent that they substitute for face-to-face interactions, are hypothesized to loosen urban agglomeration benefits and lead to greater dispersion of firms (Gordon and Richardson, 1997; Phelps 2004). Parr et al. (2002) provide evidence from the Midwest of changes in transportation costs along with changes in firm structure from single to multi-establishment ownership leading to a "hollowing out" of regional economies, in which intraregional transactions among establishments decline and interregional transactions increase. The result is the weakening of intrametropolitan agglomeration economies and the emergence of agglomeration economies that extend across regions. Others have provided evidence of IT impacts at a

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[1] We refer to these trends as "exurbanization," by which we mean the conversion of rural land in urban fringe and exurban areas to urban uses. We define the term exurban to signify semi-rural regions beyond city suburbs, but within the commutershed of an urban area.

metropolitan scale. For example, Sohn et al. (2002) use regression analysis with zip code level data on retail, manufacturing and service establishments in the Chicago metropolitan area to analyze the effects of IT on urban spatial structure. They find that limited accessibility of well-equipped information networks asserted an agglomerative effect on firm location. Cohen (1998) finds a centralizing tendency of IT due to more complex information in international merchant banking, a sector with many new financial products that require highly complex negotiations.

Implications for Residential Land Use

Rising real incomes over time have led to greater demand for larger, newer houses with larger lots, all of which are most often found in outer suburban and exurban areas. Although such residences imply longer commutes, many households have willingly chosen lower density housing located at the periphery of urban areas (Filion, Bunting and Warriner 1999). Households have become more footloose, leading to an increased demand for residential living in areas with high-valued rural or environmental amenities (Shumway and Otterstron 2001, Carruthers and Vias 2005).

Fiscal and social problems, including higher crime rates, deteriorating infrastructure, declining schools and racial tensions, have pushed households outward in search of better public services and more homogeneous communities (Anas et al. 1998). The quality and quantity of local public services available within a jurisdiction influences demand for development; therefore, differences across local political jurisdictions will influence household location and the relative demand for new housing and land (Tiebout, 1956). The “flight from blight” hypothesis explains urban expansion as the result of households fleeing perceived urban ills, e.g., higher crime rates, lower school quality, racial conflict and fiscal problems (Mieszkowski and Mills, 1993). Fragmented local governance has exacerbated decentralization by increasing the number of separate suburban jurisdictions from which households can choose (Carruthers and Ulfarsson 2002). In response to outward population movements, some service firms have followed high-skilled labor to the urban fringes and beyond. Retail firms have naturally followed urban consumers to these areas as well. Lastly, physical geography clearly influences urban form, e.g., mountains and coasts constrain urban expansion (Fulton, et al. 2001).

A number of determinants of land use change operate at a local (e.g., jurisdictional) level, which provides the local context in which land use change occurs. Land use controls, which determine the potential uses of a parcel and constrain allowable density of development, can impact the returns to development. Zoning and zoning spillovers are important factors in shaping the pattern of land use and landscape fragmentation (Munroe et al. 2005, Carruthers and Ulfarsson 2002). Land-use change is also indirectly impacted by a myriad of other policies that are not designed specifically to manage land use. For example, because they increase accessibility of more rural areas, road building and expansion can have substantial effects on patterns of urbanization (Sanchez 2004). Differences in other policies, such as local tax policies and the provision of local public goods, and simply local political fragmentation, can also influence the distribution of land use change across local jurisdictions. Lastly, the preservation of natural areas can also influence the subsequent pattern of land use change (Irwin and Bockstael 2004).

Finally, there can be substantial regional and interregional feedbacks to all these processes. Factors influencing the regional structure of economic activity have profound implications for trends in the housing market. It is a well accepted fact that wage differentials may draw migrants which have implications for the demand for land. At the same time, trends in the land market, such as housing price bubbles, have the potential to drive people out into the fringes or out of the region altogether (Johnes and Hyclak 1999).

Rural Implications for Exurbanization

The counterpart to urban growth pressures at the urban fringe is of course the activity and dynamism of rural regional economies. The opportunity cost of exurban development is influenced by economic restructuring of rural economies and the use of land for rural-based production activities. Economies of scale in agricultural production, driven by mechanization and biotechnology advances, have greatly reduced the demand for farm labor and the number of farms and farm operators. In addition, despite federal farm subsidies, globalization has increased the competitiveness of agricultural commodity markets and has made it increasingly difficult for domestic farmers to remain profitable. These forces have favored expansion only in those areas of the U.S. that are the most viable for agriculture and have led to land conversion out of agriculture in many other areas. On the other hand, rising incomes and weakened urban agglomeration economies have led to an increased demand for rural and environmental amenities among urban households. This increased demand for a more rural or natural environment has transformed some rural areas with high-valued environmental amenities into recreation and tourism-based places, e.g., the “New West” (Shumway and Otterstron 2001). In some cases, jobs have followed households to these locations and there is some evidence that the attraction of environmental amenities has driven regional economic growth (Carruthers and Vias 2005, Malecki and Bradbury 1992). Lastly, new types of rural-urban linkages become possible with exurban residential development; examples would include farmer’s markets, tourist-based activities such as “pick your own apples” orchards, and the like. Such linkages can enable some small-scale agriculture targeted at exurban landowners in certain areas.

Methodology

Two different regression analyses are used to study the relationship between observed exurban patterns and theoretical drivers of exurban land conversion. In both cases, we define exurban areas as those areas that are outside an urbanized area, but within a metropolitan area. The U.S. Census Bureau defines urbanized areas as consisting of a central place(s) and adjacent territory with a general population density of at least 1,000 people per square mile that together have a minimum residential population of at least 50,000 people. Thus, our working definition of exurban corresponds to areas that are outside core urban and suburban areas, but within close enough proximity of these places that they are likely to be economically dependent. Figure 1 illustrates these regions for our Midwest study region. Using this definition and 2000 Census data, the total exurban area in our study region is 122,934 square miles, approximately 33% of the total land area. Clark, Irwin and McChesney (2004) report that this exurban region contains an estimated 17% of the total population in entire Midwest region with an average exurban density of 105 persons per square mile and average exurban population of 150,279 persons per metropolitan area.

For the analyses below, the dependent variables relate just to activity in exurban areas, as we define them. In contrast, all explanatory variables are measured at the level of the entire MSA. The justification for this specification is that the functional metropolitan region as a whole affects exurban areas.

Measuring Exurban Land

While there is a general agreement that exurbia is low-density development beyond the urban fringe, yet still dependent on the core urban areas, there is not a straightforward measure of exurban land use. The function and structure of a center city or urban area is a constantly changing entity that may spread over time. Ideally, one might want to measure the functional relationships between an urban core and its peripheral areas, but in this analysis, we chose to use consistent geography in our study from 1980 – 2000, in an attempt to minimize additional error that would likely be introduced by updating the urban/exurban arenas in each time period. To develop this consistent geography, we decided to start with the most recent census data (2000) and work backwards. The census 2003 MSA definition represents an area comprised of counties where a significant portion of residents commute into the center city; this MSA definition is a reasonable proxy for the entire commutershed feeding into a city center. To define urban core vs. exurban area, we used the urbanized areas boundaries also for the 2000 census. "Exurban" areas are thus the MSA area excluding the urbanized area boundaries. The MSA boundaries in 2000 are the result of the urban development process over the course of the study period; thus, it makes conceptual sense to look at how those areas within current MSA, outside current urban boundaries, have changed over time. One bias that results from this geography, however, is that the 2000 urbanized area boundaries potentially include formerly rural or exurban area that have now been fully incorporated. However, we felt that this tradeoff was the most reasonable, in that we can focus on areas that we know now to be exurban, while also keeping consistent geography over time.

To measure exurban land use over time, we obtained Census population data from 1980, 1990 and 2000, all normalized to 2000 block groups so that block group comparisons were possible over time (Geolytics, 2004a; Geolytics, 2004b). We began with the number of households per block group for the entire MSA. We then removed those block groups that correspond with the urbanized area boundaries. When the urbanized area boundaries cross block group boundaries, an area-weighted assignment was made to "split" the block group across boundaries. Then, we summed the total number of households in these exurban areas, and divided by the total area of the exurban part of the MSA, leading to an exurban household density measure, which became the dependent variable in a panel analysis. A drawback of this approach is that it represents exurban pattern as an aggregate density measure and thus fails to capture variation in pattern at a finer scale. However, because we are looking at changes over time, we are limited to the Census data as a means of measuring exurban pattern consistently.

To further examine the finer scale pattern of exurban population density, we conducted a separate cross-sectional analysis using a relatively new database of spatially explicit population. The LandScan population distribution model was created by the US Department of Energy's Oak Ridge National Laboratory. This model estimates worldwide ambient populations at a 30" by 30" resolution (approximately 0.69 km square in the lower 48 states), which is the finest-scale global population data produced to date (Bhaduri, Bright, Coleman and Dobson, 2002). Population is allocated to this grid by assigning a probability coefficient to each cell which is applied to census counts. The probability coefficients for each cell are based on factors that contribute to population density, e.g. transportation networks, land cover, slope, and nighttime lights. This spatially explicit database allows us explicitly to examine *pattern*, i.e., configuration, of exurban development, rather than simple *quantity*, which yields additional information regarding the nature of exurban land uses, and their potential social and environmental impact. The exurban area within an MSA minus the core urbanized area is treated as a landscape, and contiguous cells with population densities within a specified density band represent *patches* of exurban land use. Because these patches are binary representations (exurban, other), the size and shape of a patch will be influenced by the specified population density chosen to represent "exurban". In this case, extensive prior research in the state of Ohio has indicated that a definition relating 40 – 325 persons per square mile is appropriate, which corresponds approximately to a range of one house per 5 – 40 acres. In the region, there is most often a minimum lot size requirement of 5 acres, and 40 acres is an approximation of the minimum size for a viable farm in the region.

The spatial configuration of exurban patches in the exurban landscape for each MSA was measured using Fragstats software (McGarigal and Marks 1994). Two metrics were calculated: patch density and the landscape shape index (LSI). Patch density is simply the number of patches per area, normalized so that comparisons across landscapes of varying size are possible; it is defined as:

$$PD = \frac{N}{A}(10,000)(100), \qquad (1)$$

where *PD* is patch density, *N* is the number of patches in the landscape, and *A* is the area in m^2. This measure, while a useful for overall density comparisons, does not provide much information about the compactedness of the patches themselves. Therefore, we also calculated the landscape shape index, which measure the relative fragmentation of a particular landscape:

$$LSI = \frac{E}{\min E} \quad , \qquad (2)$$

where *E* is the total length of edge in the landscape. This index provides a measure of total edge or edge density, and is standardized so that comparison across landscapes can be made. It directly measures how compact or fragmented a landscape is overall with respect to exurban population densities.

Physical Infrastructure

There is some debate regarding the direction of causality in theorizing how physical infrastructure shapes, and is shaped by, exurban land conversion. These processes are likely autocatalytic; that is to say, once a road is built, it tends to influence further land development patterns. In this analysis, we attempted simply to measure the associations between the infrastructure of urban decentralization and the resulting exurban patterns. We include two controls for these effects. The first is the density of the road network (length of roads per area) for the entire MSA. The second is the estimated number of ISP providers for the metropolitan area (available for 2000 only), obtained from FCC data[2].

Amenities and the Natural Environment

Significant literature demonstrates that exurbanization tends to be more likely in areas that are more attractive to increasingly footloose households and business. To capture the effect of the natural

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[2] Federal Communications Commission, Local Telephone Competition and Broadband Deployment data available at: http://www.fcc.gov/wcb/iatd/comp.html

environment, we employed three variables that were derived from a USDA Economic Research Service study: the number of sunny days in January, mean temperature in July, and the percent of land area in water.

Demographic Characteristics

There are a number of demographic characteristics that are assumed to be related to the exurbanization process. Residential exurban households may often be highly educated, with higher average incomes. Some research has shown that variations in racial composition may be an indicator of the exurban process; households often relocate from more densely urban areas into exurban to escape any number of perceived urban ills (often referred to as "white flight"). Therefore, in a region surrounding an urban area, we may expect the racial composition of exurbia to be predominately white. Greater unemployment in the MSA is expected to be negatively related to the amount of exurban land. Returns to residential development are expected to be increasing over time due to increases in population from inter- and intraregional in-migration that raise the demand for housing in the region. Likewise, increases in the incomes of in-migrating urban households will also increase the demand for exurban land and housing.

Labor Market Characteristics

In this analysis, we considered several types of employment factors. The first regarded to potential employment opportunities in the MSA at large with regard to high technology industry. To the extent that high technology firms will use information technologies to facilitate the exchange of information, there are clear reasons to hypothesize that this will loosen the localization economies that once held these firms together within closer physical proximity. If firms substitute face-to-face interactions with IT, then they will be more likely to decentralize to suburban or exurban areas. Lower cost land and potentially better access to higher skilled labor are among the factors that may attract them to these outer areas. In contrast, many high tech firms are engaged in complex production processes that require close interaction with suppliers or customers. In these cases, localization economies will still drive firms to cluster together, in which case these firms are much less likely to decentralize to low density exurban locations. We defined high-technology employment at the two-digit SIC level following (Hecker, 2005). Using data from County Business Patterns, we define three separate variables: the percentage of firms that are classified as high-technology service firms, high-technology manufacturing, and wholesale trade. The second factor is occupational status, which is related to the former, but is also distinct. Certain literature, including the ideas of Richard Florida, assert that the new "creative class" is an exceptionally dynamic population, who may contribute to the demand for exurban land. Because there were substantial changes in occupation classifications between 1980 and 1990, we included only those that were constant in all time periods: percentage of the labor pool (adults greater than 16 years) that was employed in service occupations, and the percentage employed in farming, which relates to the strength of employment in the rural sector.

Policy Variations

Land-use policies are an important component of the factors that shape, and are shaped by, exurban land development. At the MSA level, we considered a measure of jurisdictional fragmentation, measured as the total number of jurisdictions (municipalities and other special jurisdictions) per land area.

Farmland Profitability

It is also important to control for the opportunity cost of agriculture in the demand for land in exurban areas. Therefore, we included several measures designed to capture the profitability of agriculture. These include farm profits per land area, derived from Regional Economic Information System. It is expected that the greater the farm profits per land area, the greater the opportunity cost of exurban development. We also included the percentage of the MSA in farmland, and the percentage in prime farmland (derived from soil type, by the STATSGO database).

Table 1 contains descriptive statistics of the 68 metropolitan statistical areas in our sample. Overall, there was significant variation across the MSAs. The January sunlight, July temperature and water variables derived and normalized to the US as a whole, so it appears that overall in the region, there is less January sunlight, about average July temperature, and more water area than in the nation as a whole. Average income across the study is fairly representative for the US as a whole, but there was significant variation in housing values within each MSA, indicating many potential submarkets for land. All variables were tested for normality. There was considerable skewness in the variables percent MSA in farmland, percent MSA in prime farmland, and nearest neighbor distance; correspondingly, the logged value of these variables was used in the analysis.

Regression Analysis

Two regression analyses were run. The first was a panel model for the years 1980-2000. Panel techniques can account for structural differences among observations, in this case, MSAs. These differences may or may not be constant over time. A random-effects formulation allows for the impact of temporally-varying changes to be distributed differently across space. Researchers may have clear theoretical expectation regarding the nature of structural differences in the data (i.e., fixed vs. random effects); yet in practice, data often require a particular correction that may not conform to theoretical expectations (Greene 2003). In this analysis, we attempted to capture those covariates that we hypothesized to have the strongest associations with exurban household density, but a Hausman test on regression residuals (comparing fixed vs. random effects) indicated that structural differences across MSAs did vary according to time. The regression residuals of each time period were tested for spatial autocorrelation across MSAs, but no evidence of spatial specification problems was evident. Because a few of the MSAs are contiguous, it is possible that commuters live within one MSA and travel to a neighboring MSA, but at the aggregate level, no such spillovers can be measured. A Durbin-Watson test for serial autocorrelation (i.e., temporal persistence) was also insignificant. The second regression formulation was an analysis of spatial pattern (patch density and patch shape index [LSI]) for the year 2000.

Structural Difference across Counties

While certain covariates are expected to exhibit similar associations across the range of counties in the study area, it may be that there are “high-growth” or “low-growth” counties in terms of the economic growth-exurban development link, and that the selected independent variables are insufficient for fully capturing these effects. Three aspects of potential structural differences across counties were evaluated: the size of the MSA (i.e., was exurbanization more likely in micropolitan areas than large cities), and percentage of economic growth, measured by changes in wages and changes in employment. Dummy variables were created to represent those counties in the 75% percentile and above for those three categories.

Results

Typologies of the Economic Growth-Exurbanization Link

We explored the overall association between total employment growth and exurban growth (as measured by exurban household density) over the time period 1980-2000 (See Figure 2). The MSAs were cross-tabulated according to which quartile it fell into with respect to the percentage change in employment and the percentage change in exurban household density. A χ^2-test indicated that this crosstabulation was not random; i.e., there was an overall statistical association between employment growth and exurbanization.

Those MSAs which were in the lowest quartiles of both economic growth and exurbanization were in large part agricultural MSAs, with declining industry, such as Anderson, IN; Danville, IL; Terre Haute, IN; Peoria, IL or Youngstown, OH. Conversely, those MSAs that had the greatest growth in both employment and exurbanization were MSAs who largely represented changes corresponding to the "new economy": Columbus, OH; Madison, WI; Minneapolis, MN. For example, Columbus, OH became a leading regional center in the insurance industry during this time period.

Random-Effects Model, Exurban Household Density 1980-2000

Table 2 presents the results of the random-effects model for the years 1980-2000. Model 1 presents the results without any dummy variables for structural change. Overall, the percent of the MSA in prime farmland was the strongest predictor of exurban density. It was anticipated that prime farmland would increase the opportunity cost of exurban development, but this effect is difficult to measure in practice because good agricultural soils also tend to be good for development. MSA road density was the second strongest positive association with exurban household density. The percentage of people occupied as farmers was negatively associated with exurban development, indicating that areas with relatively greater concentrations of farmers are associated with lower exurban household densities. In addition, the percentage of MSA area in farmland was negatively associated with exurban density. Farmland could compete directly with exurban land on the landscape. There is some evidence that there has been considerable abandonment of agricultural land in areas that are not prime farmland.

Three additional formulations of the random-effects model were constructed: one with a dummy variable for those counties in the first quartile in wage growth (percentage change in wages) from 1980 to 2000, those in the first quartile of employment growth, and those in the first quartile of total size (i.e., MSA area). The coefficient on the dummy variable for high wage-growth counties was large in magnitude, relative to other coefficients, but was not significant. It could be that wage growth is important, but there is relatively too much uncertainty in the overall signal. The dummy variable that represents high employment growth counties was positive and significant, indicating greater exurban household density in those counties, more so than any other factor. Lastly, the estimated relationship between MSA size and exurban was negative, but insignificant. The significance of the high-employment growth dummy indicates that there may be a functional relationship between employment growth and exurbanization, but that relationship is not uniform across MSAs.

The Pattern of Exurban Settlement, 2000

Table 3 reports the results of a second set of regression analyses conducted, with patch density and LSI as the dependent variables. Patch density of exurban population increases with exurban household density. In this formulation, the variable road density was not included, since road layers are used in the creation of the spatially explicit population dataset.

LSI is a good indicator of overall exurban fragmentation, as it measures the normalized ratio of edge to area: the higher the LSI, the greater the edge density. LSI was negatively correlated with percent of the population with a college degree, and with the percentage of high-technology service firms, indicating that exurban populations were more compact than fragmented with increasing values for those two variables. LSI was positively associated with greater variation in house values as well as the percentage of wholesale trading firms, indicating that exurban population tends to be fragmented in those areas with higher values in those two variables. Lastly, fragmentation was higher with a higher percentage of people in the MSA who are employed in service occupations.

Surprisingly, the measure of IT services, number of ISP service providers per MSA, had contradictory influences in the 2000 regression. It was highly significant compared to patch density, but with a negative sign (indicating an inverse relationship between the number of ISP providers and the number of patches of exurban development). To the extent that IT infrastructure may be related to clustering forces, this finding might provide some evidence of such processes. In the LSI formulation, it was not significant at all. Particularly because Sohn et al. (2002) found a significant relationship between IT and urban structure, more consideration of this factor is warranted. It could also be that there is a nonlinear relationship between ISP providers and exurban development that the regression is not capturing, or the scale of analysis is too aggregated to obtain a clear signal.

Discussion

What exactly are the drivers of exurban residential land uses? This analysis has indicated that some of the variation in exurban household density relates to agricultural profitability, especially the percentage of the MSA in farmland, and percentage of the population occupied as farmers. The strongest associates of exurban household density in the panel model were July temperature, water, prime farmland (though with the opposite sign as expected), road density, and the deviation in house values. The greater the deviation in house values at the MSA level, the more exurbanization there is to be expected. This finding is consistent with Munroe and York (2003) who found that accounting for the spread of house values in a region increases the overall explanation of land-use patterns. None of the factors that were included to account for regional variations in economic structure were significant. However, for the 2000 spatially-explicit formulation, more such factors were significant. Specifically, the pattern of exurban development is more complex (i.e., less compact with more edge to area) when there was a greater percentage of wholesale trade firms, and when there were more people employed in service occupations. Moreover, the overall level of exurbanization differed significantly for high employment growth counties, a finding that merits further study.

In any analysis of regional-local processes, scale can be a confounding problem. First, there is a problem defining the proper extent, i.e., the actual commutershed for an urbanized area. We chose to use the 2000 MSAs and urbanized area boundaries throughout the study period to keep geography consistent. Moreover, working backwards from the 2000 urban-exurban relationships allows the examination of how those areas came to be. However, it might be preferable to represent the true functional relationship between urban core and effective commutershed at each time step, but it would be hard to have reliable data for each time step, and problems of inconsistent geography over time would be considerable. Lastly, there may be substantial aggregation bias in examining these problems at a metropolitan scale; aggregation may obscure important relationships. However, for the purposes of this study, our choice of units seems appropriate, since the purpose was to examine what relationships, if any, were observable between metropolitan structure and the associated exurban pattern. Future research would include developing explicitly multilevel models, i.e., to capture more finer-scale relationships than were possible here.

Our economic growth-exurbanization typology largely conformed to theoretical expectations, and indicated an interesting picture of this overall relationship. Overall, growth did certainly correspond to exurbanization, though there was greater variation in the upper half of each distribution than in the lower halves. There appears to be some evidence that those MSAs with the highest growth in exurban household density also were those with high employment growth. There were no cases of high-growth exurbanization in the presence of low employment growth, or vice versa, though there were some interesting variations in between. Chicago, IL had high exurbanization, but lower than median percentage change in employment. Chicago has greatly increased in extent, but that time period was also associated with significant economic restructuring in Chicago and the decentralization of the manufacturing industry. Lafayette, IN had significant employment growth, but relatively little exurbanization. Cleveland, OH had low employment growth, but strong exurbanization. Some analyses of Cleveland have indicated that inner city dynamics have pushed land development outward (Bier and Howe, 1998). It is clear that such a bivariate analysis cannot capture all the possible dynamics, especially relating to jurisdictional variations and inconsistent MSA land policy, which have a large influence.

Lastly, more work needs to be done examining how local residential land conversion could feed back into regional economic change. Boarnet (1994) made the important contribution to regional analyses of rural/urban relationships by recognizing that city labor market areas are larger than the municipality that contains the bulk of the labor force. By extension, it can then be argued that the same is likely true for land markets. It is clear that urban spatial structure and regional economic growth are interdependent and so exurban development may be an important factor in fostering or hindering regional economic growth. Economic development policies that seek to promote economic growth require an understanding of how urban spatial structure affects economic growth and vice versa, how urban form is affected by economic growth. An understanding of how regional economic growth affects exurbanization and how the local context mediates these effects can provide insights into the more general relationship between urban spatial structure and economic growth. On the other hand, management of urban growth requires an understanding of how economic growth contributes to urban expansion. Effective regional land use policies may have to balance divergent growth management and economic development objectives.

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Table 1. Descriptive Statistics

Variable	Minimum	Maximum	Mean	Std. Deviation
January sunlight	-1.79	0.01	-0.91	0.44
July temperature	-0.80	0.89	0.06	0.40
Water	-1.46	2.18	0.42	0.82
% over 25 with college degree, 2000	18.20	54.14	27.91	6.96
% unemployment 2000	2.64	7.86	5.26	1.23
Average income 2000; $1,000	24.67	42.12	32.24	3.78
Est. st. dev in house value, 2000; $1,000	46.13	158.62	83.13	21.34
Distance to nearest neighbor, km	28.20	258.10	65.27	39.57
% high tech service firms, 2000	1.19	6.52	3.65	0.92
% wholesale firms, 2000	3.38	22.82	11.52	2.88
% high tech mfg firms, 2000	0.57	8.78	3.09	1.56
Road density for MSA, 2000	14.61	87.49	43.08	11.61
Percent Caucasian, 2000	66.85	97.41	87.00	6.53
Farm profits per MSA km2, 1997	-3.09	24.53	5.28	6.38
Total Juris.* 100 per MSA area, 1997	0.35	5.85	1.93	1.05
% Farmland in MSA, 1997	5.81	92.23	54.99	19.54
% with service occupation, 2000	8.64	25.39	16.86	3.46
% with occupation as farmer, 2000	0.12	1.43	0.50	0.32
Exurban household density, 2000	2.73	31.38	15.04	6.34
% MSA in prime farmland	0.66	76.12	21.27	30.71
Patch density, Fragstats	0.00	0.09	0.05	0.02
Landscape Shape Index, Fragstats	2.48	12.56	5.80	2.48
N	68			

Table 2. Random-Effects Panel Analysis of Exurban Household Density, 1980 – 2000

	No subgroups – Model 1			High Wage Growth			High Employment Growth			Size		
	Coeff.	Std.Err.	P-value	Coeff.	Std.Err.	P-value	Coeff.	Std.Err.	P-value	Coeff.	Std.Err.	P-value
Constant	5.7897	9.3847	0.54	5.8289	9.3038	0.53	4.9744	9.0222	0.58	3.5840	9.1674	0.70
January sunlight	-1.4115	0.8436	0.09	-1.3983	0.8667	0.11	-1.1517	0.8327	0.17	-1.1487	0.8570	0.18
July temperature	2.0345	1.0740	0.06	2.3300*	1.1126	0.04	2.5731*	1.0619	0.02	2.7133*	1.1176	0.02
Water	-0.7603	0.4221	0.07	-0.7110	0.4189	0.09	-0.8616*	0.3962	0.03	-0.8375*	0.4098	0.04
% college degree	-0.0499	0.0519	0.34	-0.0629	0.0514	0.22	-0.0741	0.0505	0.14	-0.0699	0.0517	0.18
% unemployment	-0.0615	0.2741	0.82	-0.0686	0.2812	0.81	-0.1291	0.2732	0.64	0.0316	0.2706	0.91
Household income	-0.0056	0.1248	0.96	0.0245	0.1223	0.84	0.0342	0.1205	0.78	0.0246	0.1228	0.84
St. dev in house values	0.3358*	0.1752	0.06	0.4167*	0.1776	0.02	0.4805**	0.1774	0.01	0.3995*	0.1782	0.02
% high-tech service firms	-0.4748	0.3516	0.18	-0.5327	0.3456	0.12	-0.5541	0.3404	0.10	-0.5088	0.3534	0.15
% of wholesale trade firms	0.0881	0.1357	0.52	-0.0059	0.1355	0.97	0.0199	0.1338	0.88	0.0014	0.1410	0.99
% high-tech mf firms	0.0410	0.1937	0.83	0.1379	0.1912	0.47	0.1208	0.1823	0.51	0.0758	0.1862	0.68
MSA road density	0.2731**	0.0358	0.00	0.2630**	0.0355	0.00	0.2639**	0.0346	0.00	0.2680**	0.0363	0.00
% Caucasian	0.0093	0.0607	0.88	-0.0046	0.0634	0.94	0.0005	0.0592	0.99	0.0216	0.0599	0.72
MSA farm profits	0.0462	0.0458	0.31	0.0540	0.0439	0.22	0.0455	0.0435	0.30	0.0537	0.0440	0.22
Jurisdictions per area	0.4198	0.3168	0.19	0.3864	0.3399	0.26	0.1958	0.3354	0.56	0.5473	0.3151	0.08
% of MSA in farmland	-0.0483*	0.0238	0.04	-0.0453	0.0241	0.06	-0.0395	0.0236	0.09	-0.0506*	0.0239	0.03
% occupied in service	0.0219	0.0376	0.56	0.0201	0.0391	0.61	0.0271	0.0387	0.48	0.0178	0.0392	0.65
% occupied as farmers	-0.1999*	0.0966	0.04	-0.1510	0.0998	0.13	-0.1586	0.0952	0.10	-0.1836	0.0969	0.06
Nearest neighbor distance	-0.7231	0.7212	0.32	-0.6998	0.7061	0.32	-0.7277	0.6903	0.29	-0.5724	0.7060	0.42
% MSA in prime farmland	0.5994*	0.2764	0.03	0.5825*	0.2660	0.03	0.6613**	0.2635	0.01	0.5795*	0.2748	0.03
High wage growth MSAs				0.8820	0.7412	0.23						
High employment growth							1.6117**	0.6133	0.01			
Large MSAs										-0.1252	0.6696	0.85
Log-likelihood	-498.04			-494.56			-491.27			-495.62		
R^2	0.76			0.77			0.78			0.77		
Akaike Info. Criteria	5.108			5.094			5.074			5.102		

Table 3. Ordinary Least Squares Regression, 2000; Dependent Variable is Patch Density and Landscape Shape Index

	Patch Density			Landscape Shape Index		
	Coeff.	Std.Err.	P-value	Coeff.	Std.Err.	P-value
Constant	-0.0016	0.0685	0.98	-0.8121	1.2432	0.52
January sunlight	-0.0074	0.0065	0.25	-0.2075	0.1172	0.08
July temperature	0.0040	0.0085	0.64	0.1708	0.1535	0.27
Water	0.0023	0.0033	0.50	-0.0115	0.0605	0.85
% college degree	-0.0017**	0.0004	0.00	-0.0227**	0.0076	0.00
% unemployment	0.0007	0.0020	0.74	-0.0053	0.0364	0.89
St. dev in house values	0.0042**	0.0015	0.01	0.1213**	0.0271	0.00
Household income	0.0034**	0.0010	0.00	0.0084	0.0179	0.64
# of ISP providers	-0.0001**	0.0000	0.00	0.0000	0.0002	0.98
% high-tech service firms	-0.0023	0.0028	0.41	-0.1134*	0.0510	0.03
% of wholesale trade firms	0.0006	0.0010	0.56	0.0851**	0.0190	0.00
% high-tech mf firms	-0.0011	0.0016	0.49	-0.0338	0.0285	0.24
% Caucasian	-0.0007	0.0004	0.08	0.0030	0.0072	0.67
MSA farm profits	-0.0001	0.0003	0.86	0.0098	0.0060	0.11
Jurisdictions per area	0.0035	0.0023	0.14	-0.0338	0.0423	0.43
% of MSA in farmland	-0.0001	0.0002	0.53	0.0012	0.0031	0.71
% occupied in service	0.0020**	0.0007	0.00	0.0253*	0.0120	0.04
% occupied as farmers	-0.0046	0.0075	0.54	-0.1447	0.1355	0.29
Nearest neighbor distance	-0.0038	0.0049	0.44	0.1328	0.0883	0.14
Adjusted R^2	0.5865			0.6922		

Figure 1. Study Area

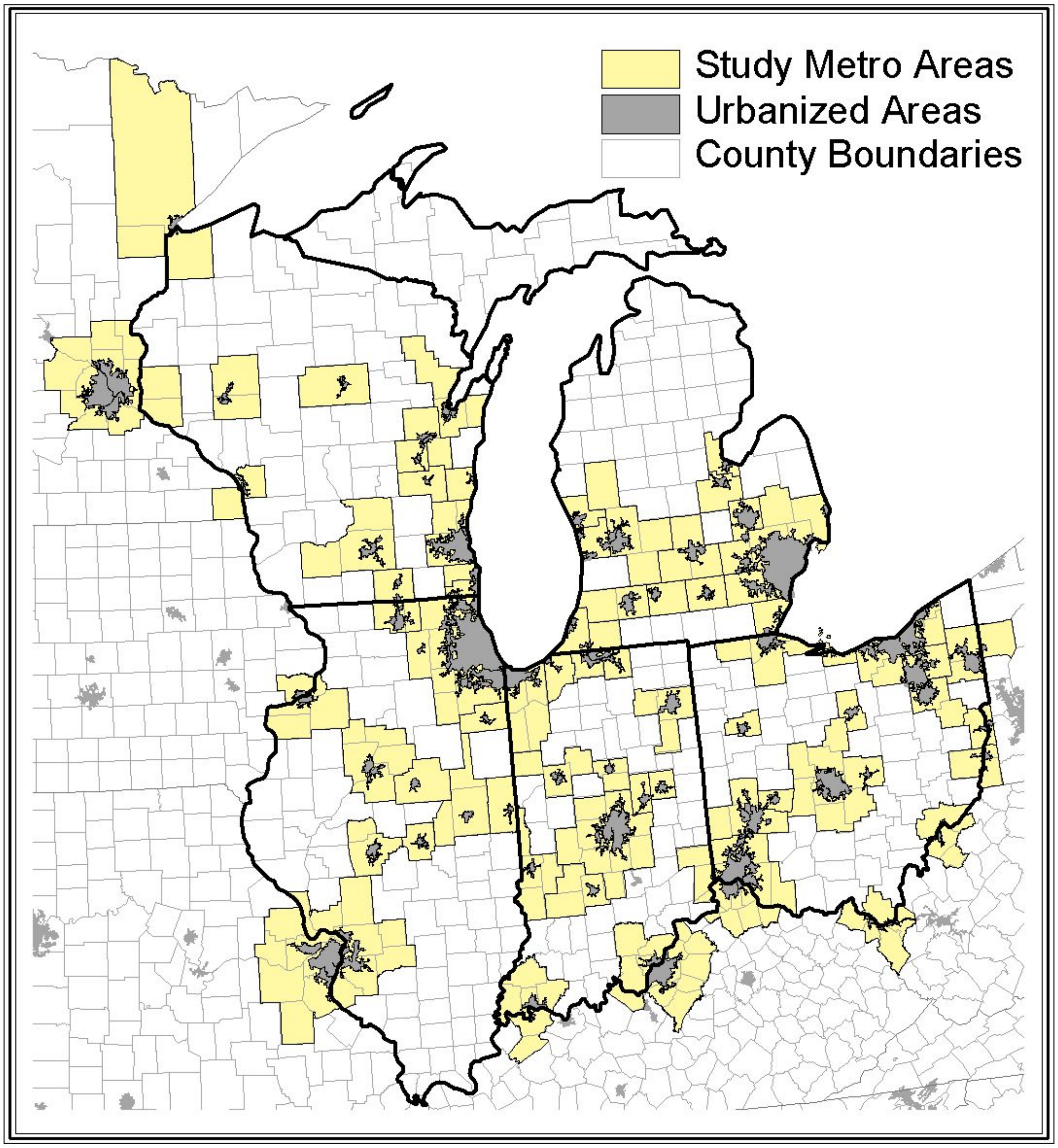

Figure 2. Economic Growth-Exurbanization Typologies, Cross Tabulations by Quartile of Percentage Change in Employment and Exurbanization 1980-2000

Quartiles of % Exurban Growth	Quartiles of % Employment Growth			
	1st	2nd	3rd	4th
1st	Anderson, IN Danville, IL Davenport, IA Decatur, IL Duluth, MN Niles, MI Peoria, IL Terre Haute, IN Weirton, OH Youngstown, OH	Battle Creek, MI Bay City, MI Champaign, IL Kankakee, IL Muncie, IN Saginaw, MI		
2nd	Huntington, WV Mansfield, OH Parkersburg, WV	Canton, OH Dayton, OH Jackson, MI Kokomo, IN Lima, OH Michigan City, IN Sandusky, OH Springfield, OH	Evansville, IN Fond du Lac, WI Sheboygan, WI Toledo, OH	Lafayette, IN Monroe, MI
3rd	Cleveland, OH Flint, MI Racine, WI	Akron, OH Muskegon, MI	Fort Wayne, IN Janesville, WI Kalamazoo, MI Lansing, MI South Bend, IN Springfield, IL	Appleton, WI Bloomington, IN Bloomington, IL Eau Claire, WI La Crosse, WI Wausau, WI
4th		Chicago, IL	Ann Arbor, MI Cincinnati, OH Detroit, MI Louisville, KY Milwaukee, WI Rockford, IL St. Louis,	Columbus, OH Elkhart, IN Grand Rapids, MI Green Bay, WI Holland, MI Indianapolis, IN Madison, WI Minneapolis, MN Oshkosh, WI