WP 2011-18
October 13, 2011

Working Paper

Dyson School of Applied Economics and Management
Cornell University, Ithaca, New York 14853-7801 USA

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June, 2011

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ABSTRACT

Greenhouse/nursery production in the U.S. has been highly concentrated in metropolitan areas. This paper examines the emergent, complex relationship between urban agglomeration and greenhouse/nursery production in the Northeast, Southeast and Pacific regions of the U.S. We use spatial econometric models to examine the effect of urbanization, spatial concentrations of firms, and firm-internal factors on greenhouse/nursery production levels. The analysis distinguishes the attributes of agglomeration forces stemming from urbanization economies and localization economies. Results suggest that the greenhouse/nursery sector may benefit from clustering among firms within the same sector. Also, greenhouse/nursery production levels are positively associated with population growth and the direct market access to consumers. The economic vibrancy of greenhouse/nursery businesses in densely populated areas would depend upon the capacity to adjust to increased land competition in metropolitan areas, while exploiting marketing opportunities offered by proximity to urban consumers.

Key words: Greenhouse/nursery, agglomeration economies, urbanization, land competition

JEL: R11, Q10, C21.

1. INTRODUCTION

The U.S. greenhouse and nursery sector has realized relatively rapid growth over the past two decades, emerging as a significant, but sometimes underappreciated component of U.S. agriculture. The most recent 2007 Census of Agriculture showed that the market value of agricultural products sold by this sector was about $16.6 billion, which was comparable to the value other important agricultural products such as soybeans ($20.3 bil.) and fruits, tree nuts, and berries ($18.6 bil.) (USDA, 2010). Major greenhouse and nursery products include bedding/garden plants, cut flowers, nursery stock, sod, ornamentals, and other products associated with landscaping and home improvements. Also, the Census counts all food crops grown under cover, extending sector definition and measurement to high-value greenhouse fruit and berries, vegetables, fresh cut herbs, and mushrooms (USDA, 2010). Previous research, based on farm gate sales reported in the Census between 1949 and 2002, shows that greenhouse/nursery production has been highly concentrated in metropolitan areas for the last half century, especially in the Northeast, Southeast, and Pacific regions (Cheng et al., 2006). Farms in metropolitan counties have accounted for more than three-fourths of U.S. greenhouse/nursery sales since the late 1940s (Bills et al., 2006; Heimlich & Brooks, 1989).

These spatial arrangements are widely recognized by industry stakeholders and the research community (see Campbell et al., 2009; Cox et al., 1994a and 1994b; Hall and Palma, 2010; Hall et al., 2006) but little research has focused directly on the ways urban proximity plays into the economic vibrancy of the industry. This study addresses that void using von Thünen location theory, developed some 150 years ago for urban-rural relations in Northern Germany, as a point of departure. Agricultural markets were used to illustrate the importance of location and the resulting transport costs to a central city in determining land use and land rent. This theory has greatly influenced scholars studying the implications of urbanization on land use (Fujita et al. 1999; Krugman 1995). Von Thünen's idealized spatial model visualized an isolated population settlement supplied by farmers in the surrounding countryside. Within this framework, competition among farmers in commodity production determines a gradient of land rents, which confront each farmer with a trade-off between land rents and transportation costs. Differences in transportation costs and crop yields promote a pattern of concentric rings of production. High-rent land near the city is reserved for crops with high transportation costs and/or crops yielding high value per acre, and land farther from the city is used to grow land-intensive crops and/or crops with cheaper transportation costs.

These constructs have much currency today. Urbanization is one of the most important factors influencing agriculture and natural resources (Irwin et al., 2009; Partridge et al., 2007; Larson et al., 2001; Gardner, 1994; Lopez et al., 1988). A prevailing opinion is that urbanization has a negative impact on agriculture. However, a surprising story in the data is that the greenhouse/nursery production thrives in metropolitan areas (Bills et al., 2006; Heimlich & Brooks, 1989; Heimlich & Barnard, 1992) and represents one of the fast growing sectors in U.S. agriculture. This "green industry", greenhouse and nursery growers along with businesses closely allied with them, provide jobs and business opportunities to agricultural entrepreneurs displaced by the shrinking number of farms in traditional agriculture (Hall et al, 2006; Cox et al., 1994; Hall et al., 2009; Hodges et al., 2010). Some research has examined primarily optimal production and marketing systems (e.g. Stokes et al., 1997; Purcell et al., 1993; Hinson et al., 1995; Foltz et al., 1993). Relatively little academic research has accumulated around the factors affecting firm location and the structure of greenhouse/nursery sector in the agriculture's urban dimensions. Our study examines how economic geography may influence greenhouse/nursery production and explicitly addresses a key policy question for the sector: how does "proximity" matter for the competitiveness and productivity of greenhouse/nursery industries?

Economic geography has been the focus of a considerable amount of research. Many regional economists and scientists have examined the spatial dimensions of firms and households with the concept of agglomeration economies (Henderson & Thisse, 2004; Romer, 1986; Porter, 1990; Fujita et al., 1999). They argue that the concept of agglomeration economies (spatial clustering) provides a compelling explanation for industrial location, metropolitan expansion, productivity growth, technical efficiency, economic development, and entrepreneurship. Geographically and functionally, urban agglomeration economies can be categorized into urbanization economies and localization economies (Eriksson et al., 2009; Hoover, 1948; Isard, 1956). Urbanization economies generate externalities associated with co-presence of consumers and firms from diverse industries in an agglomeration, independent from individual industry structure (Jacobs, 1969; Quigley, 1998). Localization economies are industry-specific external effects realized locally by many producers in the same industry or in similar industries.

Urban agglomeration economies seem critical for the greenhouse/nursery production and location. Both the bulkiness and perishability of greenhouse/nursery products increase transport costs, making close proximity to markets an important consideration for greenhouse and nursery producers. Hence, production tends to be concentrated in locations with rapid population and suburban growth. The dynamics and proximity of urban areas open up marketing opportunities often not available to producers in more remote locations. In addition, metropolitan locations can generate production benefits such as ready access to production inputs, hired and contract labor, and off-farm employment options for the farm family. Urban agglomerations can also create an environment where ideas and knowledge are more rapidly diffused. Conversely, the U.S. greenhouse/nursery sector has experienced significant challenges from changing market structure, land competition, energy and input costs, and aggressive marketing by off-shore competitors (Hall et al., 2006; Hall et al., 2009; Uva & Richards, 2001; Shields & Willits, 2003). The present state of knowledge about the trajectory of this green industry is limited. The emergent, complex relationship between urban agglomeration economies and greenhouse/nursery production requires closer scrutiny.

As greenhouse/nursery production continues to concentrate in metropolitan areas, a salient research question arises around the economic externalities of agglomeration stemming from urbanization and spatial concentration of firms in the sector or related sectors. This study addresses those matters with a theoretical model. Then, we use spatial econometric models to analyze how urbanization economies, localization economies, and firm-specific factors affect county-level greenhouse/nursery production in the Northeast, Southeast, and Pacific regions. A concluding section discusses the implications of our analysis to better ascertain opportunities and threats for ensuring the performance of firms in densely populated metropolitan settings.

2. THEORETICAL MODEL

Theoretical and empirical overviews of modern concepts on spatial agglomeration economics are widely available (e.g. Fujita & Thisse, 2002; Henderson & Thisse, 2004). Urban agglomeration economies have been seen as the driving force behind the spatial concentration of population and economic activity within cities and regions. Further, the evidence suggests that spatial concentration is eventually limited by offsetting diseconomies, tracing to such factors as high land rents, wages, and congestion. Firms and households can relocate within the spatial range of some of the core location economies that still offer opportunities for higher profits and higher utility, but avoid most of the costs of congestion. The individual relocation decisions of firms and households appear to be the forces that gradually reshape the metropolitan landscape (Richardson, 1995). The basic characterization of urban agglomeration economies is the reduction in average costs (increasing returns to scale), arising out of the spatial concentration of firms in the same and similar industries (localization economies) and firms in different industries within an urban area (urbanization economies).

The distinction between localization economies and urbanization economies appears to be commonly accepted in the literature. Total population, employment levels, and the diversity of city's productive structure are often used to gauge the importance of urbanization economies (Richardson, 1995). Localization economies can be observed in industrial districts and science parks; examples would include Detroit's car industry, Silicon Valley's semiconductor industry, and Hollywood's motion picture industry. In these cases, localization economies are dominant in the process of inter-firm cooperation and industrial growth, although urbanization economies are also active. Localization economies usually take the form of externalities in which the productivity and growth of labor in a given sector in a given area is assumed to increase with total employment in that sector (Fujita & Thisse, 2002). Also, knowledge spillovers and economies of scale in industry-specific public services enhance the performance of each operation through lower transaction costs and improved diffusion of financial, production, and marketing information (Romer, 1986; Porter, 1990; Fujita & Thisse, 2002).

Evidence of positive agglomeration externalities in agriculture production was found in the U.S. hog sector (Roe et al., 2002) and in the Denmark hog sector (Larue et al., 2009). These previous studies demonstrated that agglomeration externalities may be sector specific (localization economies), i.e. the performance of one hog operation improves with higher concentration of hog operations in a given region, or they arise from general economic activity (urbanization economies), i.e. the performance of one pig farm improves when other firms are located nearby. Turning to the dairy sector, Isik (2004) developed a comprehensive behavioral model of location and production to analyze the spatial pattern of fluid milk production. The results emphasized the importance of localization economies that may be external to the individual firm but internal to the dairy industry. The performance of a dairy operation would improve by the easy access of industry infrastructures and services. Isik (2004) further stated that agglomeration economies can also arise because the interdependencies in the sector often generate internal scale economies.

Modifying the theoretical model by Isik (2004), we develop a model of firm location and production to examine the effects of urban agglomeration externalities on greenhouse/nursery production. Assume that firm i produces output Q_i using inputs M_{i1} ..., M_{ij} from input market j and supplies output to a consumption center. The output Q_i is specified by a stochastic quasi-concave production function

(1) $$Q_i = f(M_{i1}, \ldots , M_{ij}, \xi_i, \varepsilon_i)$$

where ξ_i is the firm-specific factors such as technology adoption and ε_i is the stochastic variable.

Assume that firm i's location is given by Cartesian coordinates (x_i, y_i). Denote h_{ik} as the distance between the firm i's location and the output market k and s_{ij} as the distance from firm i to the input market j. Define b as the transport cost per unit distance on the output Q_i, and r_j is the transport cost per unit distance on the jth input M_{ij}. The profit of each competitive firm i is

(2) $$\pi_i\big(M, P, w, c_i \big| (x_i, y_i)\big) = (P - bh_{ik})Q_i - \left(\textstyle\sum_{j=1}^{J}(w_j + r_j\, s_{ij})M_{ij}\right) - c_i$$

where π_i is the profit, M is a vector of inputs, w is a vector of input prices, P is the output price,

w_j is the input price, and c_i is firm i's fixed cost. The firm is assumed to have a von Neumann–Morgenstern utility function, $U(W)$ defined on wealth W with $U_W > 0$ and $U_{WW} < 0$, where a subscript denotes partial differentiation. The wealth is the sum of the initial wealth (W_0) and the profit given in (2). The objective of each firm i is to maximize the expected utility

(3) $$EU(W_0 + \pi_i(M, P, w, c_i | (x_i, y_i))),$$

where E is the expectation operator. The choice variables in (3) are the firm's input levels M_{ij}, which can be characterized by the first-order condition in (4), where $f_{M_{ij}}$ is the partial derivative of output Q_i with respect to the input M_{ij}.

(4) $$\frac{\partial EU}{\partial M_{ij}} = EU_w\left[(P - bh_{ik})f_{M_{ij}} - (w_j + r_j s_{ij})\right] = 0.$$

The optimal input use is then solved as

(5) $$M^*_{ij} = M^*_{ij}(P, b, h_{ik}, w_j, r_j, s_{ij}, U \mid (x_i, y_i)).$$

Given the optimal input levels in (5) and production function in (1), the optimal output level is then defined as

(6) $$Q^*_i = f(M^*_{i1}, \ldots, M^*_{ij}, \xi_i, \varepsilon_i \mid (x_i, y_i)) = f(P, b, h_{ik}, w_j, r_j, s_{ij}, U, \xi_i, , \varepsilon_i \mid (x_i, y_i)).$$

The optimal production level will expand as the relative output price increases, as technology favoring production improves, as input prices drop, and as local sector and industry infrastructure improves. Several categories of the variables affecting the optimal output may include: (i) firm-specific factors ξ_i that feature firm productivity and specialization, (ii) localization economies δ_i that are related to w_i, r_j, and s_{ij}, (iii) urbanization economies φ_i that may be related to P, h_{ik}, b, r_j, w_i, (iv) local socioeconomic and biophysical conditions θ_i that impact P, w_i, and U. Thus, equation (6) is formalized as

(7) $$Q^*_i = f(\xi_i, \delta_i, \varphi_i, \theta_{i,}, \varepsilon_i \mid (x_i, y_i)).$$

Note that localization economies δ_i include the spatial interaction of greenhouse/nursery production among firms (i.e., $\delta_i = \delta_i\,(Q^*_l)$, ∀ firm $i \neq$ firm l). Each firm i's optimal output (Q^*_i) depends on agglomeration effect of its neighboring firms' optimal output levels ($\delta_i = \delta_i\,(Q^*_l)$).

3. ECONOMETRIC MODEL

The empirical application of the theoretical model uses county-level agricultural and economic data obtained from the 2007 U.S. Census of Agriculture to examine the factors affecting greenhouse/nursery production at the county level. The focus is on using county-level greenhouse/nursery product sales in understanding how the industry agglomeration factors ($\delta_i\,(Q^*_l)$), as well as urbanization factors, shape the spatial distribution of the industry.

The theoretical model addresses the spatial dependence among greenhouse/nursery production units that stems from the hypothesized intra-sector agglomeration externalities. Including the spatial interactions among the county-level production may violate the assumption of independent observations and uncorrelated error terms in the traditional statistical methods (Anselin & Bera, 1998; Anselin, 2002). Following the approach by Isik (2004) and Roe et al. (2002), our study uses spatial lag models to relax the assumption of independent decision-making in production across counties. That is, the regression models included an endogenous spatial lag variable (Wy) to capture localization economies within the greenhouse/nursery sector. The explicit spatial interaction among dependent variables is given by

(8) $$y = \rho Wy + X\beta + \varepsilon$$

where y is the N x 1 vector of the dependent variable, W is the N x N spatial weight matrix defining the "neighborhood" structure among counties, ρ is a scalar autocorrelation parameter to be estimated, X is the N x K matrix of exogenous explanatory variables, β is the K x 1 vector of parameters to be estimated, and ε is the N x 1 vector of random disturbance terms.

The spatial lag model in equation (8) extends a standard linear regression by adding a spatial lag operator *Wy*. The spatial weight matrix (*W*) contains information on the "neighborhood" structure between all pairs of counties. The elements of *W* are the spatial weights (ω_{ij}), which specify the spatial relationship between county *i* and county *j*. Based on the geographic arrangement of counties, the spatial weights (ω_{ij}) are non-zero when two counties are neighbors that share a common physical boundary, or are within a designated distance of each other. The spatial weight matrix (*W*) averages the greenhouse/nursery production levels of nearby counties for any given county. Thus, the spatial lag variable (*Wy*) is the weighted average of production levels at neighboring locations. Its estimated coefficient ρ reflects the spatial autocorrelation among county-level greenhouse/nursery production units.

3.1. Study Regions

Our analysis encompasses three major greenhouse/nursery production regions: the Northeast, the Southeast, and the Pacific. These three multistate regions accounted for nearly two-thirds of U.S. greenhouse/nursery sales reported in the 2007 U.S. Census of Agriculture. By law, the Census cannot disclose information on individual farm businesses. To avoid disclosure, the USDA suppresses information on some variables to avoid disclosing information on individual farms. We excluded counties for which nursery/greenhouse sales were not reported. Therefore, in our analysis the Northeast region includes 194 counties in 11 states —Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; the Southeast region covers 199 counties in four states — Alabama, Florida, Georgia, and South Carolina; and the Pacific region encompasses 96 counties of three states — California, Oregon, and Washington[1].

When estimating a spatial lag model, there are various methods to define the spatial weight matrix, *W*. In this study, an inverse distance function is used to assign the weights in the spatial weight matrix so that $\omega_{ij=}$ $1/d_{ij}$, where d_{ij} is equal to the centroid-to-centroid distance in miles between counties *i* and *j*. A series of critical distances are tested to detect the best model performance in terms of the smallest value of Akaike's Information Criterion (AIC) statistic. As a result, the model is estimated based on the critical distance that roughly corresponds the minimum distance necessary for all the counties to have at least one neighbor. The spatial weight matrix used in model estimation is created by d_{ij} equal to 75, 75, and 100 miles for the Northeast, Pacific, and Southeast regions, respectively.

4. DATA AND VARIABLE CONSTRUCTION

Our selected variables distinguish among firm-specific factors, localization economies, urbanization economies, and socioeconomic and biophysical factors. The county-level agricultural and economic data were assembled from the 2007 U.S. Census of Agriculture and from the U.S. Census Bureau (Table 1).

[Insert Table 1 here]

The model takes the form

$$(9) \quad y = \beta_0 + \rho Wy + \beta_1 Intersector + \beta_2 Labor + \beta_3 Glass$$
$$+ \beta_4 Pop + \beta_5 Popgrowth + \beta_6 LandVal + \beta_7 Directmkt + \beta_8 Housing + \beta_9 Tax$$
$$+ \beta_{10} Land + \beta_{11} Income + \beta_{12} Nonfarmocc + \beta_{13} Soil + \varepsilon,$$

where total sales of greenhouse/nursery products in a county were used as a proxy for the optimal output Q^*_i of representative firm *i* in county *i* in equation (7). The dependent variable *y* (*Greenhouse*) is the natural logarithm of total sales of greenhouse and nursery products[2]. Regression models described in (9) involve the following explanatory variables.

4.1. Firm-Specific Variables

Greenhouse/nursery production is a highly intensive enterprise that requires substantial labor and capital inputs. Internal economies of scale and scope for the firm can be a driving force in consolidation and concentration of greenhouse/nursery production. We use two variables to take into account firm internal factors: average farm payroll expenses per hired worker at the county level (*Labor*) and the area of greenhouse/nursery production under glass or other protection (*Glass*). The Census does not report sector-level data on farm expenses for each county. Similarly, there are no available data for labor costs specific to the greenhouse/nursery production. As a surrogate measure, we consider average payroll expenses reported for all farms in each county to capture variation on the relative labor cost by county. The variable *Labor* is a proxy for labor competition or availability, since many production methods in the greenhouse/nursery sector are very labor intensive and must compete well with seasonal farm work due to higher wages and more year-round production seasons. Also, greenhouse/nursery operations often produce in a controlled greenhouse environment with automatic irrigation, fertilization, heating/cooling air, and lighting systems. We include the variable *Glass* as a proxy for the technology used and its contribution to increased productivity.

4.2. Localization Economies Variables

Along with firm-internal economies of scale and scope, there exist economies of scale that are external to the firms but internal to the greenhouse/nursery sector. Existence of such localization economies at the intra-sector level implies that the performance of a greenhouse/nursery operation will improve when other greenhouse/nursery operations are located nearby. We capture localization economies within the greenhouse/nursery sector by constructing a spatial lag variable (*Spacelag*), i.e., *Wy* in equation (8). The variable *Spacelag* equals the weighted average sales of greenhouse/nursery in neighboring counties within a designated concentric distance from the county of interest.

In addition, localization economies can also arise from the presence of infrastructure that facilitates all crop production. Such benefits may arise because many related sectors locate near to one another. They can often draw from the same pool of workers, technicians and service suppliers whose skills are specific to the entire crop production industry. Thus, county sales of all commodities except greenhouse/nursery products are used as a proxy for inter-sector localization economies (*Intersector*).

4.3. Urbanization Variables

The existence and size of cities are typically explained by positive external benefits that are generated by the spatial concentration of businesses and households within a local economy. These externalities, known as urbanization economies, bring pressure on farmers to adapt and also offer them opportunities. We use county population estimates for 2007 (*Pop*) and the rate of county's population growth between 2002 and 2007 (*Popgrowth*) from the U.S. Census Bureau as proxies of this urbanization effect. Population in a county is not only an indicator of urbanization, but also an indicator of market size for marketing greenhouse/nursery products.

Direct market access to urban consumers may also affect the prevalence of greenhouse/nursery production in metropolitan areas. We include the number of farms that sold agricultural products directly to individuals for human consumption (*Directmkt*) in the regression. To gauge the specific effect of land conversion in urbanization economies, we include U.S. Census Bureau estimates of the change in housing units per capita between 2000 and 2007 (*Housing*), along with Census of Agriculture data on the per-acre value of the land and buildings (*Landval*), and a proxy measure of effective property tax rates on farm real estate

(*Taxes*).

4.4. Socioeconomic and Biophysical Variables

Local socioeconomic and biophysical conditions may affect the extent of greenhouse/nursery production in a given county. Average personal income for all residents in each county (*Income*) is included to account for the impacts of local economic conditions. We also consider the average participation by the principal farm operator in non-farm occupations (*Nonfarmocc*). As a farm-based population becomes more involved in nonfarm occupations, the opportunity cost of farm operators' labor and management probably increases. We hypothesize that management of large-scale greenhouse/nursery operations becomes less likely in counties with large proportions of farmers working off farm.

Physiographic factors such as soil and climate can influence greenhouse/nursery sales but measurement at county level is problematic. The geographic footprint of the sector is relatively small and many growers produce under cover in tightly controlled environments. Other growers take advantage of microclimates or pockets of unique soils or topography for certain specialty crops. However, despite this diversity, other things equal, one expects that operations located in counties with favorable soils and climate may have lower production costs than their counterparts located in less advantaged counties. A detailed assessment of these physiographic conditions at county level is beyond the scope of this study and beyond the reach of available data. Instead, we use the reported Census yield of the most prevalent crops as a proxy for varying physiographic factors as a surrogate measure to control for county to county differences in production outcomes. The indicator selected was the average tons of forage crops per acre (*Soil).* Forage crops are the most ubiquitous crops in the US. Thus, average per acre forage crop yields, calculated after aggregating the harvested amount of all forages, can be determined for virtually all counties included in our sample. Finally, it may be easier to locate a large-scale facility in a larger county merely because there may be more tracts of land available for added nursery/greenhouse production. Hence, we include a measure of a county's total land mass (*Land*).

5. ECONOMETRIC RESULTS

Table 2 shows descriptive statistics of variables used for spatial modeling. Table 3 shows the results of estimated spatial lag models. The variables population (*Pop*) and property tax rates on farm real estate (*Taxes*) were dropped from the sample due to their high level of collinearity with certain explanatory variables. These estimated models fit the data reasonably well. The pseudo-R-squared, the degree of correlation between the predicted and observed greenhouse/nursery sales, is 0.76 for the Northeast, 0.77 for the Pacific, and 0.49 for the Southeast. Also, the estimated models show little evidence of spatial dependence in residuals of all three regions, as indicated by the Lagrange Multiplier test.

[Insert Tables 2-3 here]

The results indicate that localization economies are important in the Northeast and the Pacific. The estimated coefficient of the spatial lag variable (*Spacelag*) was positive and statistically significant in the models for the Northeast and Pacific regions. The production level of the greenhouse/nursery sector is positively correlated across counties in these two regions, but not in the Southeast. The spatial concentrations of greenhouse/nursery production in the Northeast and Pacific regions might facilitate a local, sector-specific infrastructure. Intra-sector infrastructure may enhance the economic performance of the firm through lower transaction costs, the diffusion of production and marketing information, as well as the availability of specific production inputs, labor, and technical services. The results also suggest that the greenhouse/nursery industry in the Northeast might benefit from localization economies arising from a general inter-sector infrastructure of other related crop enterprises (*Intersector*).

Urbanization has both positive and negative consequences for agriculture. The net effects of urbanization on agricultural land use may depend on the type of agricultural commodity produced. Greenhouse/nursery production generally requires less land than most agricultural activities, and products have high transportation costs and high perishability. Those attributes, one can argue, give greenhouse/nursery firms the incentive to locate around metro areas. However, a counter argument is that some farm inputs and product transactions costs are relatively high in metro areas. The concentration of agriculture activities in rural areas can create economies of scale and scope that are not available in metro areas where nonagricultural activities congest the infrastructure for input delivery and bulk output marketing. Although greenhouse/nursery production is largely situated in metropolitan areas, the effects of land use and land rents around urban areas on production levels are not clear. The models estimated here allow one to consider several dimensions of this phenomenon. Some insights do emerge from our estimated models.

Population growth (*Popgrowth*) has a significant, positive effect on greenhouse/nursery production in the Pacific and Southeast. A growing population may open up marketing opportunities for supplying greenhouse/nursery products with quality and service in these regions. The effect of population growth (*Popgrowth*) however, was not significant in the Northeast. This is not surprising because the Northeast is the most densely populated region in the U.S, with the lowest average of population growth rate between 2002 and 2007 among the three regions. In addition to the increasing demand of urban consumers for the greenhouse/

nursery products, growing population may provide opportunities to grow new crops and market them in new ways. Direct market access to consumers *(Directmkt)* is positive and highly significant in the three regional models. Various innovative direct marketing strategies have been recognized as a key to successful small and medium scale farm business. Proximity and premium product quality could be more important to these smaller-sized buyers than a low price.

Greenhouse and nursery operations have blossomed in the past several decades in metro settings with, seemingly, a home improvement store or a garden center just about every mile. Residential and commercial property development has created new demand for plants, flowers, shrubs, trees, and other landscaping components. However, new development to support growing populations competes with farm businesses in the land market, increasing land prices. *Ceteris paribus*, change in housing units (*Housing*) could have significantly negative impacts on the greenhouse/nursery production in the Pacific. Note that greenhouse and nursery production tends to be highly concentrated in the most urbanized areas of California around coastal counties from San Mateo in the north to San Diego in the south. Thus, the estimated effect of *Housing* implied that expansion of urban growth boundaries could threaten the long-term health of the greenhouse/nursery sector in the Pacific.

While producers in the Pacific and the Southeast have larger average sales, their sales per acre of total production area are smaller than for producers in the Northeast. We found that counties with higher land value (*Landval*) seem to have larger greenhouse/nursery production in the Northeast. Greenhouse/nursery production in the Northeast has been persistently concentrated among the coastal metro counties along the Washington, D.C. to Boston corridor, where farmland value, as well as farm's equity position, is relatively high. This could suggest that greenhouse/nursery operations might better compete with urban-oriented land uses.

Additionally, greenhouse/nursery production in the Southeast is presently concentrated in counties with relatively large land area (*Land*). This might imply that urban advantages for the production in the Southeast could be as important as locating a large-scale facility in a larger or rural county because there may be more land available for purchase. On the other hand, the heterogeneity of this sector means that the product mix of some operations may generate benefits attributable to a larger land base and lower population densities.

With regard to input variables to account for the firm-internal economies of scale, Average payroll per worker (*Labor*), capturing relative cost of labor by county, is positively associated with the greenhouse/nursery production level in the three regions. This result is expected because greenhouse/nursery production depends heavily on a relatively more costly but reliable and skilled work force. Furthermore, the estimated coefficient of *Glass* is positively significant in the three regions. Thus, the production levels are higher when counties have larger specialized operation areas under glass or other protection (*Glass*). The effect of *Glass* in the Northeast was the largest among the three regions. Operations in the colder States of the Northeast utilize greenhouses for crop production to a greater extent than in the Pacific and Southeast.

Other local factors considered may contribute to the historical patterns of production levels. Income levels of residents (*Income*) in a county have significantly positive influence on the greenhouse/nursery production of the Northeast. Income levels can be a proxy of local consumer demand for greenhouse/nursery products. The strong local economy may imply more household spending on greenhouse/nursery goods and services and thus fuel local growers to produce more for profitable niche markets. A lower proportion of farmers declaring a nonfarm occupation as their primary livelihood (*Nonfarmocc*) is associated to higher greenhouse/nursery production in the Pacific. One may expect that management of large-scale greenhouse/nursery operation becomes less likely as farm operators in nonfarm occupations increase. Conversely, the positive coefficient of *Nonfarmocc* is identified in the model of the Northeast is compatible with the smaller size of operations and the higher level of off-farm employment in this region. The surrogate measure of soil quality (*Soil*) is not significant for all three regions. One may argue that many high-valued greenhouse/nursery products are grown in protected environments-either undercover or underground. Under these conditions, soils and climate exert relatively little influence over production outcomes.

6. CONCLUSIONS

The econometric models developed here hold promise for examining the impacts of localization economies, urbanization economies, and firm-internal scale of economies in determining county-level greenhouse/nursery production in the major production regions of the U.S. The results imply that urban agglomeration economies are important for the spatial structure of greenhouse/nursery production in some but not all multistate regions. First, production of these high-value commodities may benefit from spatial clustering of firms at the both intra-sector and inter-sector levels in the Northeast, and at the intra-sector in the Pacific. However, we found no evidence of benefits accruing to agglomeration economies in the Southeast. This suggests that county and state public policies aimed at encouraging spatial concentrations of high-valued agricultural production (i.e. local tax incentives, or investments to develop local human capital) would enhance the positive externalities created by localization economies in some situations, particularly in the Northeast and in the Pacific regions.

Another important focus of the models is on determining the urbanization factors affecting the greenhouse/nursery production. The study shows that higher levels of population growth are associated with higher greenhouse/nursery production levels in the Pacific and Southeast. In addition, direct market access to consumers may play an important role in county-level production in the three regions. These findings indicate that increased demand and greater participation in direct market channels may contribute to growth in the greenhouse/ nursery sector. However, the results also help illustrate the subtleties of urban development pressure on farming operations. Traditionally, such pressure was brought to play out in terms of higher land prices and subsequent increases in production costs. For example, the findings suggest higher land values are associated with higher greenhouse/nursery production in the Northeast, while change in numbers of housing units is negatively associated with the production level in the Pacific. Thus, the econometric results demonstrate that a critical element in assuring the continued economic vibrancy of greenhouse/nursery businesses in the Northeast and the Pacific is the capacity to adjust to increased competition for land in metropolitan areas, while exploiting the marketing opportunities offered by proximity to urban consumers.

The three regions differ in climate, land use, marketing options, and socioeconomic situation in terms of their distinct comparative/competitive advantage in agriculture and commodity specialization. We consider the regional setting presented in this analysis as an appropriate scale for policy-relevant spatial analysis. However, consolidation trends in the greenhouse/nursery sector pose limitations to the use of data from the U.S. Census of Agriculture. In this study, for example, the spatial analysis for the Southeast is inferior to its Northeast and Pacific counterparts, due to the relatively large number of missing observations - counties with suppressed sales reports to avoid information disclosure. This may explain why the variables that characterize localization economies and urban development pressure were not statistically significant in the Southeast model. Future research should focus on devising robust strategies to impute missing data in the Agricultural Census. In addition, future research can employ the model to examine urban agglomeration economies in greenhouse/nursery production at a more disaggregated geographic unit of analysis (e.g. census tracts) and limiting the scope of the analysis (e.g. a small number of metropolitan areas). Such study is likely to involve substantial data collection efforts. Finally, future research can replicate this analysis in a dynamic framework, employing panel data methods to capture within-country changes over time for critical urbanization and localization variables.

Overall, dealing with spatial relationships and devising methods to accurately measure them are not settled issues. Results obtained in this study pave the way for additional efforts to account for such relationships. Doing so will better inform policy decisions on public support for metropolitan agriculture and the steps needed to ensure its vibrancy in the years ahead.

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Table 1. Variable name, definition and data source

Variable	Definition	Data Source
Greenhouse	Natural logarithm of sales of greenhouse and nursery products in 2007($1,000)	2007 Census of Agriculture
Spacelag	Weighted average of the natural logarithm of *Greenhouse* of neighbor counties [a]	2007 Census of Agriculture
Intersector	Natural logarithm of sales of other crops ($1,000)	2007 Census of Agriculture
Labor	Natural logarithm of average payroll per worker, 2007 ($)	2007 Census of Agriculture
Glass	Natural logarithm of greenhouse/nursery production under glass or other protection (square feet)	2007 Census of Agriculture
Pop	Natural logarithm of population in 2007 (persons)	U.S. Census Bureau
Popgrowth	Percent population growth, 2000-2007	U.S. Census Bureau
Housing	Change in housing units per capita 2000-2007*1,000	U.S. Census Bureau
Directmkt	Natural logarithm of the number of farms selling agricultural products directly to individuals	2007 Census of Agriculture
Landval	Per-acre estimated market value of land and buildings ($)	2007 Census of Agriculture
Tax	Property taxes per thousand dollars land and building value, 2007	2007 Census of Agriculture
Income	Natural logarithm of personal income per capita in 2007 ($1,000)	Bureau of Economic Analysis
Nonfarmocc	Percent farm operators in nonfarm occupation	2007 Census of Agriculture
Land	Natural logarithm of county land area (acres)	2007 Census of Agriculture
Soil	Tons of forage crops per acre- average	2007 Census of Agriculture

[a] 'Neighbor' counties with centroids located within the 75-mile (100-mile) radius of the focal county in the Northeast and Southeast (Pacific).

Table 2. Summary statistics of variables used for spatial modeling

	Northeast (N=194)		Pacific (N=96)		Southeast(N=199)	
	Mean	S.D.[a]	Mean	S.D.	Mean	S.D.
Greenhouse	8.12	1.62	7.96	4.32	6.00	4.67
Spacelag	8.16	1.01	11.00	1.16	6.17	2.16
Intersector	9.16	1.12	10.49	2.30	8.39	1.93
Labor	8.94	.77	8.84	1.05	8.35	2.00
Glass	12.50	2.84	7.89	8.88	2.57	9.58
Popgrowth	2.41	5.03	7.19	8.22	10.03	13.31
Housing	38.26	98.53	40.63	21.93	51.81	48.35
Directmkt	4.48	.68	4.62	1.14	2.75	1.85
Landval	7.15	6.45	7.19	5.43	4.30	2.97
Income	3.58	.25	3.52	.26	3.33	.21
Nonfarmocc	51.95	6.86	51.64	8.18	58.53	5.93
Land	12.86	.57	13.82	.83	12.71	.55
Soil	2.30	.58	3.33	1.85	2.20	.82

[a] S.D. = Standard Deviation

Table 3. Spatial lag models for the three regions (the dependent variable is the logarithm of county-level greenhouse/nursery sales in 2007)

	Northeast		Pacific		Southeast	
Variable	Coefficient	S.E.[a]	Coefficient	S.E.	Coefficient	S.E.
Constant	-12.220 ***	2.222	-13.260 **	6.345	-10.345	7.788
Localization Economies						
Spacelag	0.486 ***	0.073	0.393 ***	0.091	-0.214	0.146
Intersector	0.440 ***	0.072	-0.011	0.148	0.019	0.183
Urbanization						
Popgrowth	-0.001	0.013	0.197 ***	0.055	0.053 *	0.031
Housing	0.001	0.001	-0.045 ***	0.017	0.001	0.008
Directmkt	0.271 **	0.131	1.543 ***	0.370	0.963 ***	0.157
LandVal	0.028 *	0.015	0.049	0.053	0.130	0.098
Firm-Specific						
Labor	0.233 ***	0.083	0.889 ***	0.231	0.708 ***	0.127
Glass	0.191 ***	0.025	0.084 **	0.034	0.092 ***	0.030
Socioeconomic Conditions						
Income	1.081 ***	0.316	1.448	1.105	-0.507	1.397
Nonfarmocc	0.017 *	0.010	-0.077 **	0.036	-0.053	0.043
Land	0.145	0.134	0.134	0.335	0.973 *	0.568
Soil	-0.059	0.133	-0.162	0.167	-0.016	0.361
Model Diagnostics						
Number of Observations	194		96		199	
R-squared	0.76		0.77		0.49	
Akaike (AIC)	491.8		471.3		1069.7	
LaGrange Multiplier Test Statistic	0.26		1.24		0.11	
p-Value LM test	0.604		0.265		0.737	

*, **, *** denote statistical significance at the ten, five, and one percent levels, respectively.
[a] S.E. = Standard Error.

Endnotes

[1] Suppressed Census data to preserve confidentiality pose a growing obstacle to spatial analyses because of continuing structural change in the U.S. farm sector. The problem is endemic but especially acute in the nursery/greenhouse sector. We have missing sales data of 36 counties or 15.7 percent in the Northeast, 35 counties or 26.7 percent in the Pacific, and 134 counties or 40.2 percent in the Southeast. Unfortunately, there is no systematic way to impute the missing data. We experimented with naïve imputations using the percentage distribution of farms reporting nursery/greenhouse sales and we examined the reporting history in these counties for previous Census years. However, the imputations were deemed not useful enough to improve the study results.

[2] Some variables have a value of zero; we added "0.001" to the variable in those cases before taking the natural log.

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