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INTRA-REGIONAL DEVELOPMENT: AGRICULTURAL AND NODAL ADJUSTMENT IN OKLAHOMA'S SOUTHERN HIGH PLAINS

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Introduction

Family farms are located throughout the American countryside between rural towns. The economic linkages between family farms and rural towns constitute an integral part of the spatial economic plain of rural America. The interjacent economic linkage between farm populations and rural trade centers has been studied extensively and certain general relationships have been postulated.

The most fundamental proposition relates the density and size of family farms to the number of rural retail businesses and trade centers. A Minnesota time series study found the number of rural trade centers varied directly with the density of the surrounding farm population [14]. A cross-sectional California study of two rural towns and their adjacent hinterlands estimated the rural town surrounded by relatively smaller farms received $68 more retail trade per $100 of farm output than did the rural town surrounded by relatively larger farms [5].

Other researchers have related the dynamics of agricultural development to the growth and decline of rural communities. Based on time series research conducted on South Dakota rural trade centers, it was concluded that: as agricultural development occurred, the average size of a family farm increased; total farm population decreased; the number of rural retail businesses decreased; and some rural communities ceased to exist as the economic functions performed in them became obsolete [1, 3].

Farm structure, as represented by the number of farms, real per farm income, and the acreage base, continues to adjust to changes in technology, commodity markets, and farm policy [8]. The changes in farm structure directly change the spatial demand plain around rural communities [9]. Businesses located in rural communities servicing the farm demand respond to changes in farm demand by adjusting either the quantity or the location of the services offered. The objective of this paper is to show the locational choice of rural businesses offering services in towns of different sizes is directly affect ed by adjustments in farm structure and that the rural business locational response partially determines the relative number of communities per order in a rural central place hierarchy.

This study adds to the previous research in several important ways. The analysis explicitly relates the location decision of a rural business to community size and regional changes in the hinterland farm structure. The study distinguishes the effects of changes in farm population, farm income, and farm input usage, on the location of businesses across different sized communities. Finally, a procedure was developed that facilitated an estimate of an indirect central place effect between communities of different sizes as a result of regional changes in farm structure.

Farm Family-Rural Town Economic Linkages

The farm family demand function consists of two distinct sets of goods; producer goods for profit maximization and household consumption goods for utility maximization. Regardless of the level or variety of farm activities pursued, each farm operator has derived demand for inputs that cannot be produced internally on the farm at a reasonable cost. Once profit maximization is achieved, each farm family allocates its limited disposable income among the various economic goods and services contained within the family's utility function to maximize utility.

Given individual farm families demand both producer and consumer goods, businesses located in rural towns face a diverse set of aggregate demand curves. The size of any particular business community (i.e. rural town) is partially determined by the absolute size of the set of economic goods that are offered by the businesses located in it. The largest agglomeration of retail businesses will offer the greatest number of economic goods to the farm population and the smallest agglomeration of retail businesses will offer the least number of economic goods to the farm population.

Central Place Theory

Central place theory encompasses the economic principles of farm demand and rural business supply [2, 11, 15, 21]. The range of a good establishes the spatial aggregate demand for a good, i.e. the distance over which the aggregation of demand occurs for each rural business offering each good from every rural town. The threshold level of demand establishes a firm level spatial entry and exit condition by requiring the aggregate average revenue curve faced by each rural business be tangent to the average total cost of providing each good in the long run [2]. The two principles together establish the physical size of a rural market, how many farm families are serviced from the center, and the maximum number of businesses that can offer goods in the market.

Central place spatial market equilibrium and disequilibrium can be represented with a comparative statics monopolistic competition model by incorporating the short-run and long-run effects of an exogenous shift in farm demand on the firm's profit function. The long-run case, average total costs equal to average revenue, represents a stable equilibrium in which the firm has zero real economic profits and no incentive to relocate. The short-run cases represent unstable disequilibriums in which the firm is either incurring real negative or positive economic profits [6, 7, 12, 13, 24, 25, 26].

The spatial entry condition occurs when the average total costs to a business supplying any good i is below the aggregate spatial market demand within the range of good i. In the long-run, the positive economic profits are expected to induce other rural businesses to enter the particular market until the real profit level is zero. The firm level exit condition occurs when the average total costs to a rural business of supplying good i is above the spatial market demand within the range of good i. In the long-run the negative real profits are expected to induce marginal rural businesses to exit the market until real profits are zero.

Spatial Residual Demand

The exiting of the last marginal business from a geographical market results in spatial residual demand that is no longer being serviced by any rural business in that particular market [6]. The spatial residual demand is the amount of aggregate demand below the threshold level of any remaining firm for any good i. The remaining rural consumers constituting the residual spatial demand must travel to some other spatial market to procure the good that is no longer offered locally. The spatial demand transfer between community markets will occur whether the residual demand is for a consumption good or farm production good. The residual demand transfers within the community hierarchy is the positive indirect central place effect of an exogenous regional decrease in farm family demand.

Direct and Indirect Effects

Given a regional decline in farm demand some businesses are expected to experience both a direct negative and an indirect positive effect on the level of aggregate demand they face. If any business receives more residual demand transfers from businesses located in other communities than it loses in its own local market it is expected to incur an increase in total demand. Ceteris paribus, the net direction of the demand shift for a business located in a community receiving a

demand transfer is determined by the interaction of the direct negative and indirect positive effects. Businesses located in those communities where the positive indirect transfer is greater than the negative direct losses from a decline in farm demand are expected to realize an increase in total demand even though they experience a loss in local demand.

The Empirical Model

The empirical model uses the number of businesses and real sales per community as dependent variables representing the supply of goods at each community order. The number of farms and real per farm income are independent variables representing farm family consumption demand shifters. Total planted acres is an independent variable that is highly correlated to the farm usage of seed, fertilizer, and equipment and represents a farm input demand shifter. Variables representing other sources of real nonfarm basic income and transportation are included to control for other exogenous sources of demand shifts that are extraneous to the farm structure-rural business market relationship.

Model Specification and Data

The statistical model is a cross-sectional (26 communities) time series (1968-1984) OLS regression equation with dummy variables to explicitly incorporate a central place hierarchy of three different community sizes in the Oklahoma panhandle. The estimated coefficients on the independent variables are the partial derivatives of the independent variables with respect to the dependent variables and are consistent with the theoretical comparative statics framework. The dummy variables allow for different regression intercepts and different slopes by central place order for the independent farm variables [10, 27].

The model allows the number of farms (FN), real per farm income (RPFY), and total planted acres (PA) to vary across the community hierarchy while constraining real basic nonfarm income (RBNFY) and the mobility factor (TRAN) to a regional (Oklahoma panhandle) homogeneity condition. Allowing the farm-related variables to vary across community size while holding the two regional demand shifters constant facilitates a more efficient estimation of the farm-induced demand shift across communities of different sizes. Equation specification (excluding the intercept term) is as follows with variable definitions and data sources given in Table 1:

$$(1)\quad RS = f(D_1, D_2, X_i, D_1X_i, D_2X_i, X_j)$$

(2) $BUS = f(D_1, D_2, X_i, D_1X_i, D_2X_i, X_j)$

where

RS = 1 x 402 vector of observations on real sales per community.

BUS = 1 x 402 vector of observations on the number of businesses per community.

D_1 = 1 x 304 vector that has a value of 1 if the annual community observation contained less than 48 reported businesses and 0 otherwise (22 communities).

D_2 = 1 x 51 vector that has a value of 1 if the annual community observation contained more than 48 but less than 100 businesses and 0 otherwise (3 communities).

X_i = 3 x 402 vector of observations on FN, RPFY, and PA.

D_1X_i = 3 x 334 vector of observations on the interaction of D_1 with FN, RPFY, and PA.

D_2X_i = 3 x 51 vector of observations on the interaction of D_2 with FN, RPFY, and PA.

X_j = 2 x 402 vector of observations on RBNFY and TRAN.

A three tiered central place dummy matrix was constructed based on each community's relative position in the study area's central place hierarchy and the dependent variables variances within the three groups. Within central place theory the order of a community is based on the variety of economic functions performed at each community [2]. It is assumed the number of economic functions performed at a community is highly correlated to the number of businesses at each community [12]. The lowest order contained the 22 communities that reported less than 48 businesses per year. The middle order contained three communities that reported between 49 and 100 businesses per year and the highest order contained the one community that reported more than 100 businesses per year.

Inherent within the central place matrix is a control for community population. The lowest ordered communities have, a priori, a smaller resident population than the higher ordered communities [20]. Community population is treated as exogenous to the farm structure-community business relationship and is controlled for with the hierarchy matrix.

Theoretically, mutual attraction is the drawing power of a more diverse set of economic goods on farm families by businesses located within any given community [4, 7]. Mutual attraction is assumed to vary directly with the order of a community [7]. The community hierarchy matrix controls for the effects of mutual attraction as the higher the order

of a community the more economic goods its businesses offer and the greater its businesses attraction power.

Changes in the continuous independent farm variables are expected to affect the dependent community variables through both a direct local effect and the indirect central place effect. The direct local effects of a change in the independent farm variables are expected to be positively related to the dependent community variables. Ceteris paribus, increases (decreases) in local farm demand are expected to cause increases (decreases) in the number of businesses and real sales per community. The indirect central place effects of a change in the farm variables are expected to be inversely related to the dependent community variables.

Ceteris paribus, the relative strength of the direct and indirect effects will determine the estimated coefficient's sign for each independent farm variable across the community sizes. If the direct effect is stronger than the indirect effect, the expected sign of the partial derivative is positive. If the indirect effects are stronger than the direct effect, the expected sign of the partial derivative is negative.

The comparative statics regression framework facilitates an empirical analysis of the locational response of rural businesses given an exogenous change in the independent farm variables. *Ceteris paribus*, whether firms are entering or exiting a community market is determined by the sign on the farm parameter. Firm entry is expected to occur when the estimated sign on the farm parameter is positive, and firms are expected to exit when the estimated sign on the farm parameter is negative.

Interpretation of Model Results

The important result of the empirical model is the direction of change in the dependent community variables given a change in the independent farm variables across the central place hierarchy. The estimated sign for each coefficient is the sign of the partial derivative of each farm variable with respect to the number of businesses and their real sales by community order within the hierarchy [27]. *Ceteris paribus*, the partial derivative indicates the direction each firm's demand curve shifts given a change in the farm variable. The direction the demand curve shift determines each firm's profit level and influences its location decision [25, 26].

The firm's location decision determines which order of community is gaining or losing businesses across the central place hierarchy. The growth or decline of business activity within individual communities determines the relative number of communities within each order of the

central place hierarchy. The model generates estimates that reflect how changes in the regional farm structure induce dynamic adjustments in the region's central place hierarchy.

Table 2 shows the estimated partial derivatives and their statistical significance level for each farm variable by community order for both dependent community variables. The estimated parameters and other statistical properties of the regressions are reported in the appendix. All the partial derivatives are statistically significant at the one percent probability level in the community real sales model. Several of the partial derivatives are statistically insignificant in the number of businesses per community model, although all but one are of the same sign as the statistically significant partial derivatives in the real sales per community model.

Farm Population Effect

The statistically significant positive derivative of the number of farms with respect to real sales indicates the effect the decrease in farm numbers was to decrease real sales in both the smallest and largest communities. The estimated farm number's coefficient on the number of businesses coincides with the real sales estimates for the lowest and highest community orders. The estimated inverse relationship between the number of farms and the independent variables for the middle ordered communities indicates the exiting of rural businesses from the other communities has increased the entry of rural businesses in the more centrally located middle sized communities.

The results confirm the previous finding that a decline in farm population causes a direct negative effect on economic activity in a community [1, 3, 9, 14, 24]. The estimated inverse relationship between the centrally located middle ordered communities and farm population adds to the previous estimates the element of spatial demand transfers, indicating the negative population effect is more than compensated by a positive indirect effect in at least one size of community. The positive indirect effect adds an element of dynamics to the community hierarchy adjustment process that had been previously missing.

Total Planted Acres Effect

The interpretation of the partial derivatives of total planted acres with respect to real sales and the number of businesses per community order is the same as the farm population explanation. The direct effects of a decline in total planted acres were stronger than the indirect residual input demand transfers for the lowest and highest ordered communities.

The positive indirect farm input demand transfers were greater to the middle ordered communities than the negative direct effects in their own markets. The estimates imply the exiting of agri-input businesses from the other rural communities has tended to increase the entry of agri-input businesses in the middle ordered communities.

An analysis of the effect of a change in farm input usage on rural community business by community size is almost absent from the literature. This analysis indicates that decreases in the level of input usage adversely affects two sizes of rural communities. The analysis suggests a decrease in farm input usage would cause a further shift in farm input demand from the smallest communities to the centrally located middle sized communities.

Real Per Farm Income Effects

The statistically significant positive derivatives of real per farm income with respect to the community variables for the highest ordered community implies the direct effect of an increase in farm income was stronger than the indirect farm income transfers for a community of this size. The statistically significant negative derivatives for the lower ordered groups implies the effects of the indirect income transfers were greater than the direct effects of the increase in farm income for the two smaller community sizes. The analysis implies the historical trend of increasing real per farm income has tended to increase the exiting of businesses from the two smaller community sizes and the entry of businesses into the largest community.

These results are as expected and consistent with previous findings in the Great Plains and Mexico [9, 13]. The results imply an increase in farm income, particularly in sparsely populated areas, significantly contributes to the spatial consolidation of business activity into a regional growth center. The analysis, by controlling for the transportation and other income effects, provides a direct estimate of the farm income effect on this regional process.

Implications

The statistical analysis supports the postulate of a changing farm structure affecting the location of rural business activity within a rural central place hierarchy. The relative farm effect on the community hierarchy was the greatest in the two smaller community groups where the indirect transfers were stronger than the direct effects of changes in the farm structure. The analysis indicates the farm spatial demand flows have tended to shift rural business revenues upward through the

community hierarchy from the lowest ordered communities to the larger communities.

The statistically significant diametrically signed farm parameters at the different community levels implies that community level impacts that are derived from county level estimates are statistically unstable. The results imply county level farm coefficients cannot be applied to specific communities within a county without accounting for the communities relative position in the central place hierarchy and the indirect spatial flows within a county. Traditional county level models completely disregard the spatial demand flows that occur within the community hierarchy and attribute this community growth and decline element to some other factor.

The estimates of the indirect effects from changes in farm structure for the smaller communities add an element of dynamics that had been missing from the literature. The indirect demand transfers applied to all three of the farm variables and help explain the dynamics of rural central place hierarchies as a function of adjustments in the farm economic base. The absolute magnitude of the effects is still an empirical question, as they will theoretically vary through time and across regions.

The model implies the structure of different sized communities' retail sector has changed as the community hierarchy has adapted to an adjusting farm structure. The derivatives imply both consumer and farm input retail activities have been decreasing in the smallest rural towns. The negative farm income and planted acres derivatives for the middle ordered communities implies consumer-related businesses have been declining and agri-businesses have been increasing for this size community. The positive farm income and planted acres derivatives for the highest ordered community implies consumer-related businesses have been increasing and farm input-related businesses have been decreasing for this size community.

The estimates from the model have direct implications for rural policy in agriculturally dependent areas. The estimates confirm that any farm policy that affects the number of farms, real per farm income, or the acreage base will directly affect the structure of the community hierarchy and the composition of private services offered at communities of different sizes. Farm policy, when implemented in agriculturally dependent areas should be coordinated with rural development policies so that community governments and businesses can plan for the changes in local economic bases that will occur as a result of changes in the regional farm structure.

Endnote

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Table 1
Variables, Acronyms, Definitions, and Data Sources

Variable Name	Variable Definition	Data Source
	Dependent Variables	
RS	1 x 402 vector of observations on real (deflated) sales by community	Oklahoma Sales Tax Commission 1968-1984
BUS	1 x 402 vector of observations on the number of businesses by community	Oklahoma Sales Tax Commission 1968-1984
	Independent Variables	
FN	1 x 402 vector of observations of the number of farms by county	Census of Agriculture 1968-1984
RPFY	1 x 402 vector of observations on real per farm income by county	Bureau of Economic Analysis 1968-1984
PA	1 x 402 vector of observations on total planted acres by county	Oklahoma Dept. of Agriculture 1968-1984
RBNFY	1 x 402 vector of observations on real manufacturing, mineral, and government income by region	Bureau of Economic Analysis 1968-1984
TRAN	1 x 402 vector of observations on real state transfers of road funds by region	Oklahoma Sales Tax Commission 1968-1984

Table 2
Estimated Partial Derivatives

Independent Variable	Dependent Variables	
	Real Sales Per Community	No. of Businesses Per Community@
	Sign of Partial Derivative	Sign of Partial Derivative
Number of Farms		
Large Community	> 0*	< 0
Middle Community	< 0*	< 0
Small Community	> 0*	> 0
Planted Acres		
Large Community	> 0*	> 0*
Middle Community	< 0*	< 0*
Small Community	> 0*	> 0*
Real Per Farm Income		
Large Community	> 0*	> 0*
Middle Community	< 0*	< 0*
Small Community	< 0*	< 0*

* = significant at 1% level
@ = corrected for first order autocorrelation

Table 3
Farm Structure Community Estimates
for the Number of Businesses

Variables	Number of Businesses*	Dummy Coefficient	Mean Elasticity
Intercept	191.25275	191.25275	
	(.0001)		
D_2 Intercept	-96.39647	94.39647	
	(.0001)		
D_3 Intercept	-196.58770	-5.33495	
	(.0001)		
Farm Income ($)	.00007	.00007	.01441
	(.0001)		
D_2 Farm Income ($)	-.00016	-.00009	-.05483
	(.0006)		
D_3 Farm Income ($)	-.00014	-.00007	-.46306
	(.0001)		
Farm Numbers (#)	-.00017	-.00017	-.00061
	(.9751)		
D_2 Farm Numbers (#)	-.00075	-.00767	-.09159
	(.2979)		
D_3 Farm Numbers (#)	.00183	.00200	.22888
	(.5999)		
Planted Acres (per acre)	.00003	.00003	.05928
	(.0212)		
D_2 Planted Acres (per acre)	-.00008	-.00005	-.33136
	(.0001)		
D_3 Planted Acres (per acre)	-.00001	.00002	1.27019
	(.3278)		
Nonfarm Basic Income ($)	2.53272E-07		
	(.0172)		
Transportation ($)	-.000002		
	(.3585)		
R^2	.9673		
D. W.	2.3407		

* = corrected for first order autocorrelation with a statistically significant coefficient.
Significance level in parentheses is a probability level of the coefficient not equal to zero.

Table 4
Farm Structure Comunity Estimates for Real Sales

Variables	Real Sales	Dummy Coefficient	Mean Elasticity
Intercept	24,762,308.00000 (.0001)	24,762,308.3	
D_2 Intercept	-22,174,314.39647 (.0001)	2,587,994.3	
D_3 Intercept	-33,904,795.58770 (.0001)	-9,142,486.9	
Farm Income	12.37704 (.0004)	12.37704	.01249
D_2 Farm Income	-26.71512 (.0196)	-14.33808	-.08759
D_3 Farm Income	-22.97892 (.0059)	-10.60188	-.91183
Farm Numbers	4300.21800 (.0035)	4300.21800	.07504
D_2 Farm Numbers	-4619.85600 (.0093)	-319.63800	-.03378
D_3 Farm Numbers	-4102.04400 (.0002)	198.17400	.29486
Planted Acres	16.53312 (.0001)	16.53312	.16012
D_2 Planted Acres	-17.89032 (.0001)	-1.35720	-.07961
D_3 Planted Acres	-8.97744 (.0054)	7.55568	6.23883
Nonfarm Basic Income	-.00199 (.9428)		
Transportation	2.56126 (.0001)		
R^2	.9550		
D. W.	2.0473		

Significance level in parentheses is a probability level of the coefficient not equal to zero.