1975

Population, land use, and income in a central place region

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Population, land use, and income in a central place region

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CHAPTER I. INTRODUCTION

Interest in the economic implications of space has a rather long-standing tradition, but this concern has been, for the most part, outside of the Anglo-American school. Where much of this literature can be classified as explicit spatial consideration of the questions of land use and location, recent interests are more difficult to categorize. Developments since the Second World War have been in both the discovery of the older works and the application of new economic tools to regional problems, whether or not the spatial element is expressed or merely implied by the use of small and open economies.

This investigation is intended to integrate several recent formulations of regional economies into a model which describes a region's response to exogenous forces given the available land resources. In particular, the economic base model of regional response to national demand for the region's export goods, the intraregional dependencies of the Beckmann formulation of the central place structure, and the Alonso interpretation of the von Thunen land use model form the basic building blocks for the regional structure of population, land use, and income. It should be noted at this time, however, that the following analysis does not attempt to deal with the location of central places and, therefore, touches on only one aspect of central place theory.

A discussion of the three lines of economic literature is contained in Chapter II. The basic approach is to present the model as originally formulated, a recent specification most useful to this research, and a discussion of the intended function each model will play in the proposed model.

Chapter III contains the development of the model of population, land use, and income in which regional variables are driven in an economic base fashion, constrained by the available land through an Alonso-like structure, and allocated among subregions in a central place framework.

The problems of testing the model presented in Chapter III result from the type and the detail of available data. These difficulties are discussed in Chapter IV along with the specification of the sample regions and their characteristics.

In light of the sample selected, an empirical model is developed which allows for some of the attributes of the theoretical model to be tested. This model and the results of the statistical estimation are presented in Chapter V. Finally, Chapter VI summarizes the results of this study.

CHAPTER II. REVIEW OF LITERATURE

This chapter is a review of three types of regional economic models. Each focuses primarily upon one aspect of the regional economy and attempts to highlight particular regional characteristics. The regional economic base model is a Keynesian-type model applied to an open economy. Such a model is regional in nature because the economy is subject to major influences from outside its geographic boundaries, but it has no spatial consideration. However, economic base models emphasize the regional dependency upon national levels of demand for export goods.

Central place models deal explicitly with some of the spatial elements of a region. These elements include the partitioning of the regional landscape into market areas and the location of cities. In addition, the economic links among cities within a region form a hierarchical structure which will be shown to be a disaggregation of the economic base model. It is this aspect which will be employed in the model formulation of Chapter III.

Finally, land use models will be discussed. Although central place models introduce a spatial consideration by way of the location of places within a region, these places are themselves still dimensionless. They can be thought of simply as points on the regional plain. Land use models, on the other hand, are directly concerned with the necessary dimensions of economic activity. Thus in discussing the competition among various sectors for the limited supply of land, shape and form are added to the regional landscape.

Regional economic base models

The regional economic base concept is an application of the Keynesian model to open economies. In its simplest form, the economic base is comparable to a one-nation-rest-of-world model in which repercussions are assumed to be negligible. In more sophisticated versions, multiple regions and feedbacks are considered. Discussions of the simple economic base can be found in Hoyt (27), Andrews (3), and Sirkin (50). A description of the more general formulation is provided by Metzler (36), and comparisons of both are given by Isard (29) and Richardson (49).

The principle characteristics of simple economic base models are the assumptions that regional exports are set exogenously and that the ratio of production for domestic consumption to production for export remains constant. Thus, it is possible to forecast regional income and regional production for local consumption given an estimate of the level of exports, or, as if often the case, to estimate total regional population and non-basic employment given and estimate of basic (i.e., export) employment.

The following model illustrates the basic structure of economic base theory and the assumptions necessary to derive the constant ratio of non-basic to basic employment.

Let Y = regional income;

D = the part of the area's output (value added) which is absorbed by the area, i.e., the domestic activities;

E = the part of the area's value added which is exported;

F = net factor payments from outside the area;

T = net transfer payments to the area from outside.

Let the income be defined as

$$Y = D + E + F + T,$$

so that Y represents the disposable income of the region.

For simplicity, define

$$X = E + F + T$$

so that

$$Y = D + X .$$

In addition, define

M = value of imports of the area,

B = external balance on current account

$= X - M$.

Finally, assume that D, M, and B are functions of income such that

$$D = dY,$$

$$M = mY, \text{ and}$$

$$B = bY;$$

and that X, F, and T are independent of the level of regional income.

The ratio of nonbasic output (D) to the economic base (X) is the "base ratio". From the balance on current account relationship, the base ratio must be

$$\frac{D}{X} = \frac{D}{M + B},$$

so that the domestic activity may be stated as

$$D = \frac{D}{M + B} X .$$

Again from the current account equation

$$X = M + B .$$

Using the marginal propensities from the functions for M and B yields

$$X = mY + bY,$$

or

$$Y = \frac{1}{m + b} X .$$

It is now possible to show the impact of an exogenous change in X and the applicability of the base ratio. Let the base increase by ΔX; income will rise by

$$\Delta Y = \frac{1}{m + b} \Delta X .$$

Consequently, the increase in domestic activity will be

$$\Delta D = d\Delta Y = \frac{d}{m + b} \Delta X .$$

Dividing this equation by the equation for domestic activity gives

$$\frac{\Delta D}{D} = \frac{d}{m + b} \; \frac{M + B}{D} \frac{\Delta X}{X} ,$$

and by substitution for M, B, and D

$$\frac{\Delta D}{D} = \frac{\Delta X}{X} .$$

Thus

$$\Delta D = \frac{D}{X} \Delta X,$$

and the change in domestic activity becomes readily estimable given a forecast of the change in basic activity and knowledge of the base ratio.

The base ratio estimation of the change in the nonbasic employment is appropriate in this example by construction. The crucial definitions are the functional forms for D, M, and B. For the economic base model to hold the average propensity must equal the marginal propensity in domestic consumption, in imported consumption, and in lending.

Although this analysis has been in value terms, the transition to employment and population is easily made under the assumptions of constant ratios of employment to output and population to employees. Let

NBE/D = the ratio of nonbasic employment to domestic output,

BE/X = the ratio of basic employment to basic output, and

P/TE = the ratio of total regional population to total employment.

Then the change in domestic activity can be rewritten

$$\frac{\Delta NBE}{NBE} = \frac{\Delta BE}{BE} ,$$

or

$$\Delta NBE = \frac{NBE}{BE} \Delta BE.$$

The change in total employment becomes

$$\Delta TE = \frac{NBE}{BE} \Delta BE + \Delta BE,$$

and the population becomes

$$\Delta P = P/TE \ \Delta TE.$$

Both formulations of the economic base model rest heavily upon rather strong assumptions. However, it seems reasonable that for spatially small or less populated regions the export demand should more closely approximate the dominant role attributed to it. In addition, it also seems probable that the repercussions are indeed negligible for small regions. Equality between the marginal and average propensities remains in question.

Central place models

The foundation of the central place literature is found in the works of two authors. The first is that of Christaller (18) and the second is that of Losch (34). Both works are attempts to discover the principles which govern the location of economic activity in a complex system of interdependencies. Although the work of Christaller predates and is less comprehensive than that of Losch, the hierarchical considerations of Christaller make it convenient to discuss this work last.

Losch constructs a system of production and marketing places upon a homogeneous plain having a rural population arranged in a triangular lattice pattern. Each farm site is a potential production or marketing center. Production will be undertaken if there exists a market area about a farm site in which demand is great enough to induce production. Let d in Figure 1 be an individual demand curve for a typical product. If OP is the price of the product at the production site, a consumer at the production site would buy PQ of the good. Consumers at locations away from the production site would incur an effective price of OP plus freight costs, so that quantity demanded drops as one moves further from the production site. At a freight cost of PF quantity demanded is zero. This sets the limit to the market area for the good sold at a price of OP. The total quantity demanded in this market area is equal to the volume of the cone that would result from rotating the triangle PQF on PQ as an axis (see Figure 2) multiplied by a population density factor.

This procedure yields a single point on the total demand curve facing the potential producer. A repeated calculation for every possible price will give a total demand curve, D in Figure 3. Production of the

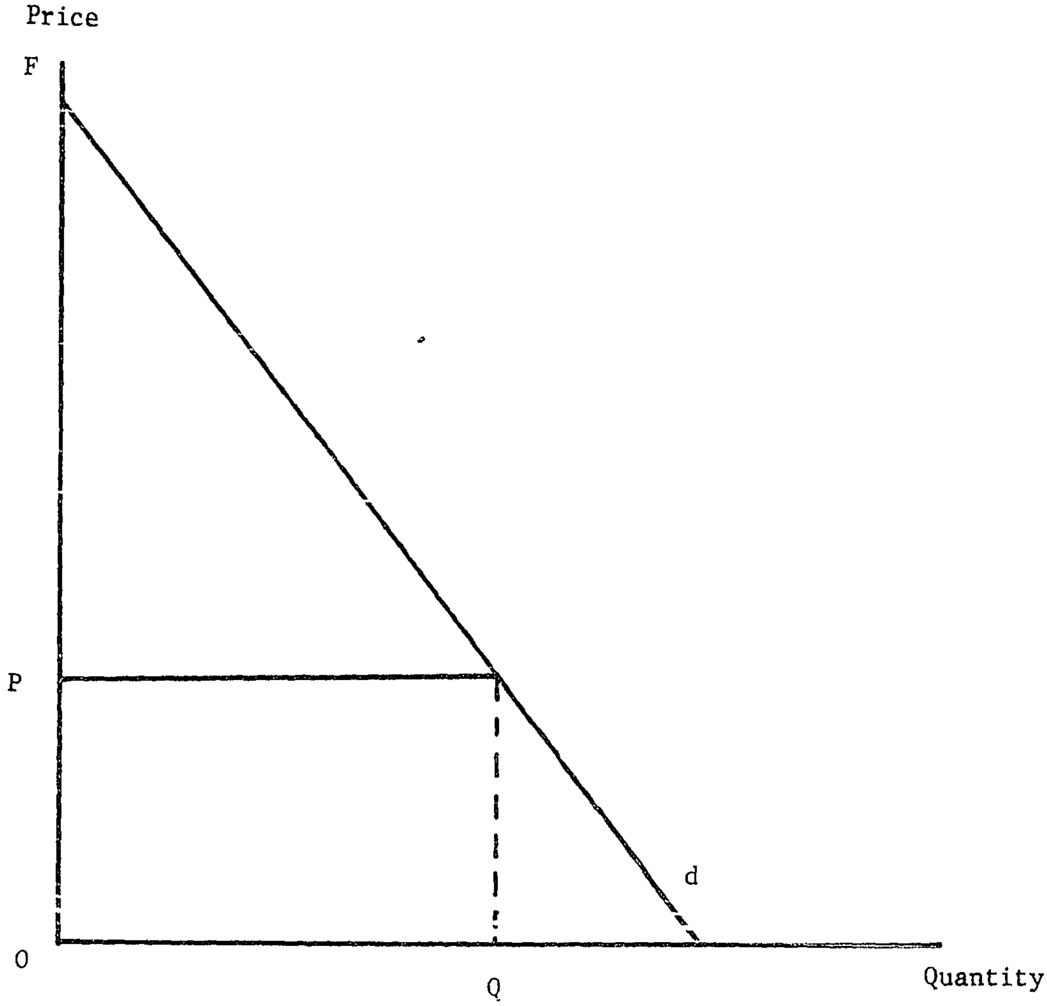


Figure 1. Commodity demand curve

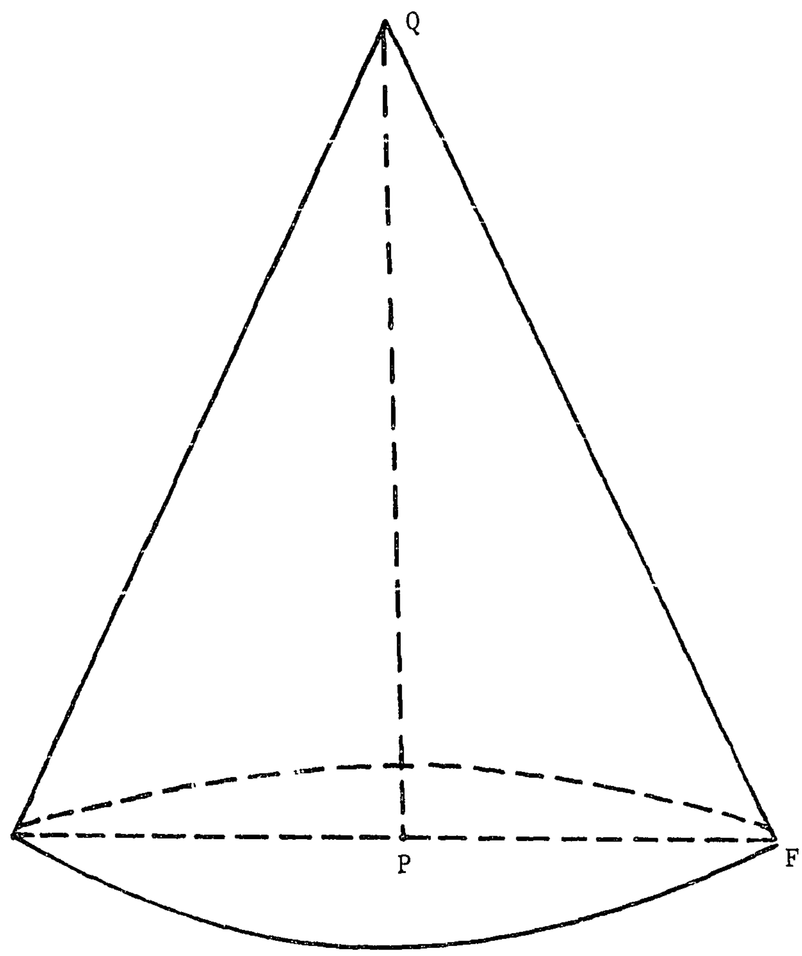


Figure 2. Market area demand cone

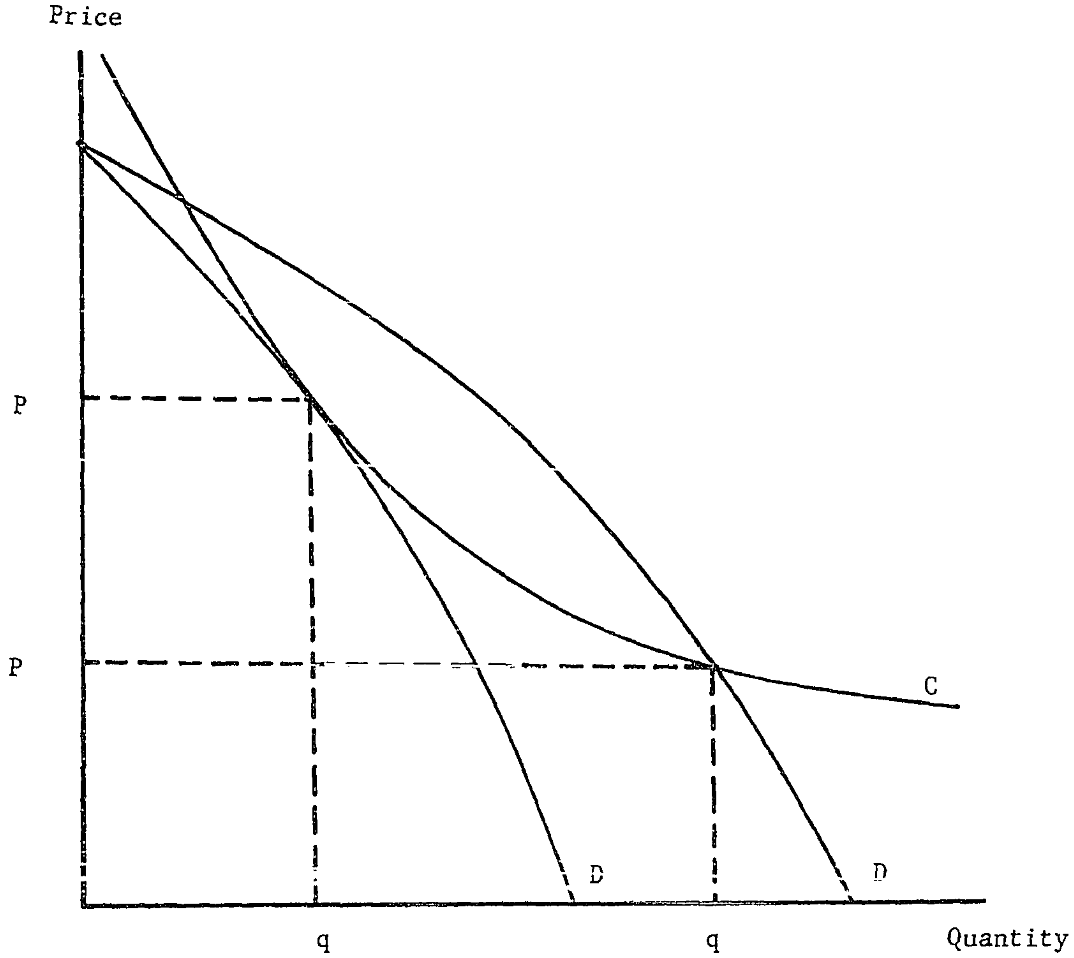
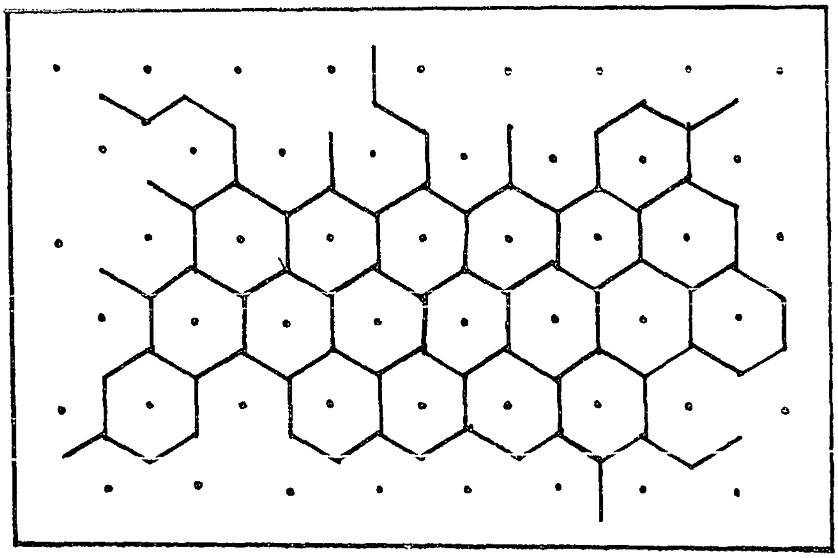


Figure 3. Demand and cost relationships

commodity will take place only if the long run average cost curve, C, intersects or is tangent to D, in this example at an output of q.

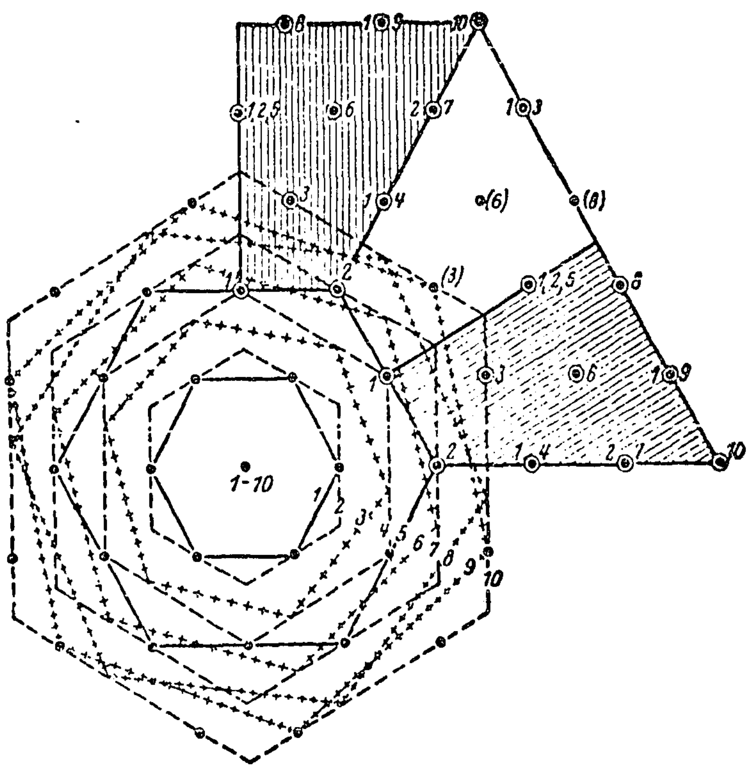
Losch makes two further assumptions which will modify the circular market area developed for the single producer above. Such circular areas are not capable of covering the economic plain without overlapping. Competition among multiple producers to service the entire population will lead to market areas having a hexagonal form. Secondly, if each market area is larger than the minimum necessary to induce production and if the sum of all such excesses would admit another production site to enter profitably, such a site will develop. Thus the hexagonal market areas will be as small as economically possible and the pattern of market areas will look like the honeycomb pattern of Figure 4. The minimization of market areas also minimizes the total demand so that a typical producer would face the total demand curve D' in Figure 3 and produce an output of q .

If multiple goods are provided to a region, the pattern of distribution sites can be determined by generalizing the approach taken above. Figure 5 indicates the distribution of the regional population. Each point equals one household, and the hexagons represent the various market areas. If a point lies within the hexagon, it is served only by the central point of the market area. If, on the other hand, a point lies on the market area boundary between two centers, it is served equally by both centers. Points which fall at the corners of the hexagons are served equally by three centers.



• Household location
___ Market area boundary

Figure 4. Hexagonal market areas



Simple points indicate original settlements. Market centers are enclosed in circles and the level of the good provided indicated by the figures. Alternative market centers are in parentheses.

Figure 5. Ten smallest market areas (34, p. 118)

The various sizes of possible market areas can now be determined by using the central point, noted 1-10, as a reference. These market areas correspond to the order of the good. The good which can be provided in the smallest area is the lowest order good. Larger areas imply higher order goods. Thus, the central point provides goods of orders 1 through 10.

The smallest area which the central point can serve is shown by the 1-boundary. In addition to serving itself, this point serves six other households. However, each of these households purchases only one-third of its total expenditures from the point 1-10 so that the effective market population is one-third of six plus one, or three.

The next largest area is shown by the 2-boundary. Again six households lie on the boundary, but in this case each household buys one-half of its total purchases from the point 1-10. The market area population is therefore one-half of six plus one, or four.

Order three goods are provided to the area within the 3-boundary. Here all households lie inside the boundary so that each household buys only at the central point. Thus the market size is six plus one, or seven. Continual progression upward yields market area populations for the 4 through 10 boundaries of 9, 12, 13, 16, 19, 21, and 25.

The pattern of distribution sites developed for the 10 smallest market areas shows no clear hierarchical system. The central reference point does provide a full range of goods of orders 1 through 10, but other provision sites need not. Figure 5 indicates the other sites providing goods and the orders of the goods provided by the figures next to the points. These centers provide discontinuous ranges of goods. Thus a site which provides a good of order 5 need not provide all goods of lower orders.

Christaller's system of central places differs from Losch's in two ways. Where Losch begins with the smallest market area and builds upward, Christaller starts with the largest market area and proceeds downward. Where Losch assumes that the smallest possible market area will result from competition, Christaller's regions are more planned than competitive. The resulting structure is by construction hierarchical and a city which provides a good of order n will also provide all goods of orders less than n (18; 34).

Christaller considers several systems of central places. These differ with the intent of the planner; only that based on the marketing principle will be discussed here. Assume again a homogeneous plain with uniform agricultural population. The marketing principle seeks that structure of central places which will completely service the rural population with a full range of commodities and employing the fewest number of sites. As in the Loschian system, each good has a unique market area. However, unlike Losch, the effective market area need not be the smallest possible but rather may range from the area which will just allow profitable provision to the market area so large that consumers beyond the market boundary would not pay to purchase the good at any price at the central place. The actual shape that the market areas assume is again the hexagonal form described above.

The pattern of central places thus developed is shown in Figure 6. By way of definition, the G-place provides a G-good and is a higher order place than the B-place because the G-region is larger than the B-region. Correspondingly, the G-good is a higher order good for the same reason.

Unlike the Losch system, the system of central places under the marketing principle has a clear hierarchical form. A higher order place provides all of the goods provided by a lower place plus the additional higher order good. In fact, the order of a place is defined by the highest order good which it provides.

Both of the central place models discussed have assumed that the regional populations are constant and that the market area boundaries are variable. Added insight may be provided by assuming the reverse. Let the regional boundary for an order one city be fixed and allow the regional population to be variable.

The minimum population necessary for the introduction of the order one good can be seen by specifying the supply and demand relationships operational in the region. Assume that all residents have identical and linear demand functions and that the transportation costs to the central city are zero. Let one of these demand functions be

$$p = s - tq'$$

where p = the price of the order one good, and

q' = the quantity of the order one good.

If the total regional population is n, the market demand and average revenue function is

$$AR = p = s - (t/n)q$$

$$q = nq'.$$

Thus the total revenue is

$$TR = pq = sq - (t/n)q^2,$$

and marginal revenue is

$$MR = \frac{dTR}{dq} = s - 2(t/n)q.$$

The supply relationships must be based on some assumption about the cost of providing the good. The Beckmann (5) interpretation of Christaller's model assumes an initial fixed cost and constant marginal costs. Let the total cost function be

$$TC = a + bq,$$

so that average cost is

$$AC = \frac{TC}{q} = \frac{a}{q} + b, \text{ and}$$

marginal cost is

$$MC = \frac{dTC}{dq} = b.$$

Since the good will not be introduced until the providing firm is at least able to cover costs, the minimum population and the introductory quantity of the good can be determined as follows. Profit maximization requires that the firm produce at the quantity where MC = MR, or

$$b = s - 2(t/n)q.$$

The point at which costs are first covered is where AC = AR, or

$$\frac{a}{q} + b = s - \frac{t}{n}q.$$

These two equations are sufficient to solve for the minimum population and the introductory quantity. A simple rearrangement of terms in each equation yields

$$(b-s)/2 = -(t/n)q,$$

and $$a/q + b-s = -(t/n)q.$$

Substituting for the $-(t/n)q$ term gives

$$(b-s)/2 = a/q + b-s,$$

and solving for q yields the introductory quantity, q_I,

$$q_I = 2a/(s-b).$$

A further substitution of the introductory quantity into the MC = MR equality allows for the determination of the minimum regional population, n_{mim}, needed for local provision of the good. Thus

$$b = s-2(t/n)\frac{2a}{s-b}$$

so that

$$n_{min} = 4at/(s-b)^2 .$$

The minimum market area population is therefore a function of the supply and demand parameters for the particular commodity.

The price at which the good will be sold is also determinable. Substitution of the introductory quantity and the minimum population into the demand equations gives

$$\begin{aligned} P_I &= s-\left[\frac{t}{4at/(s-b)^2}\right] \cdot \frac{2a}{s-b} \\ &= s- (s-b)/2 \\ &= (s+b)/2. \end{aligned}$$

This price lies midway between the demand curve intercept and the marginal cost.

Figure 7 presents the minimum requirements in graphical form. $D_{N=1}$ is an individual demand curve, and $D_{N=min}$ is the lowest level of market demand which can induce production. The introductory price and quantity are determined by the point of tangency of $D_{N=min}$ and the average cost curve, AC.

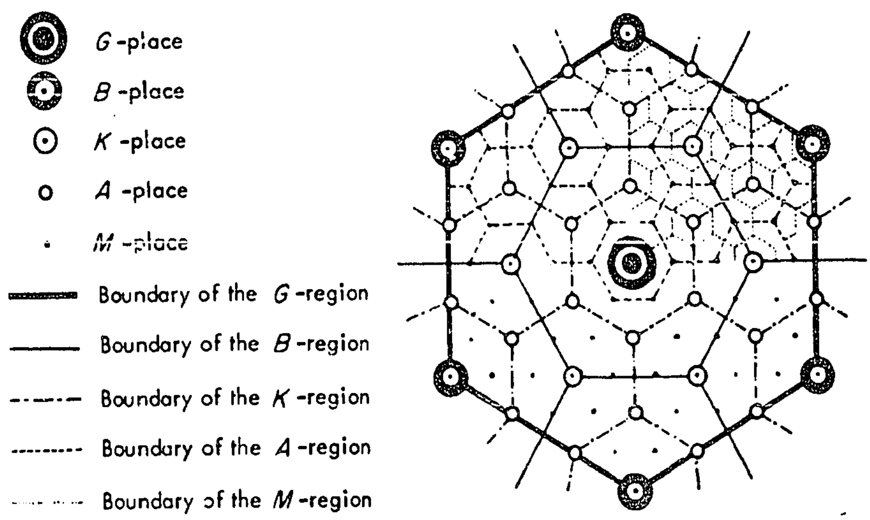


Figure 6. Market areas under the marketing principle (18, p. 66)

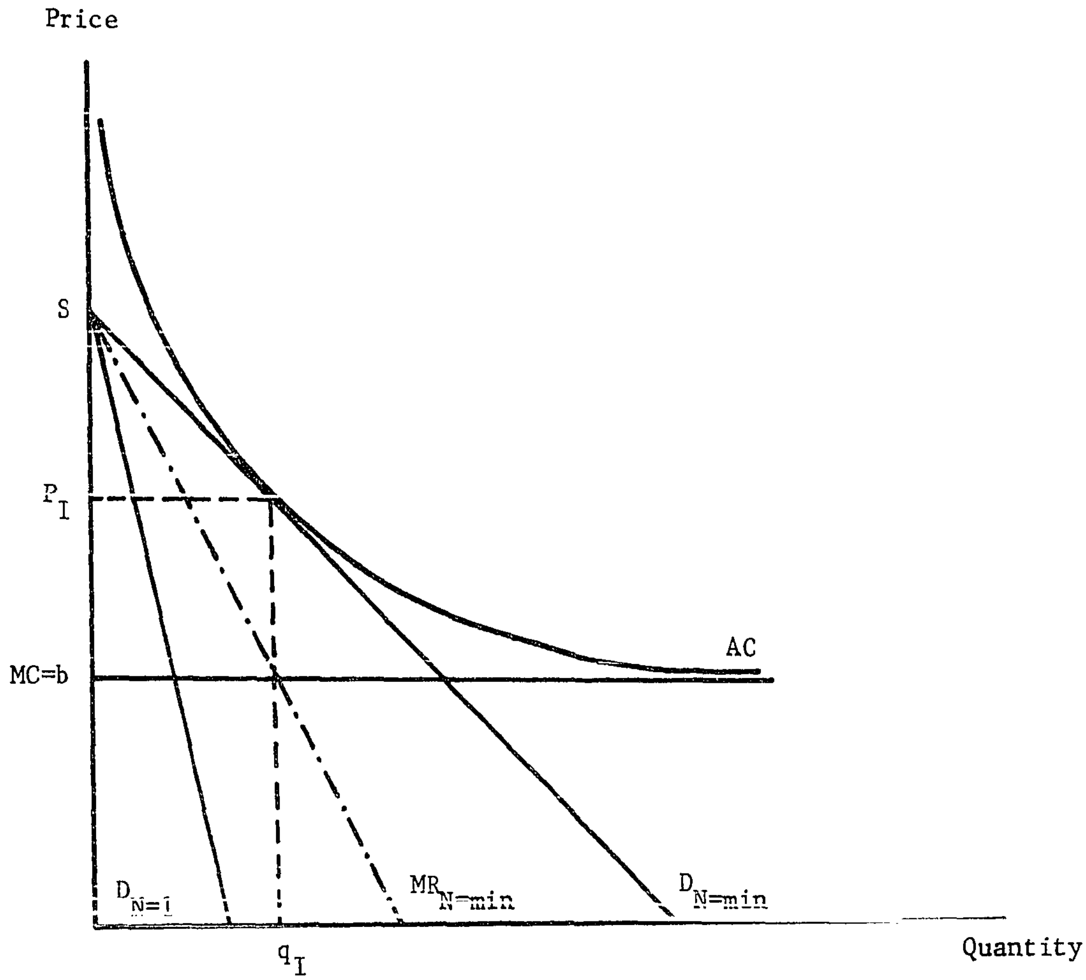


Figure 7. Supply and demand relationships for the introduction of a commodity

A 1958 article by Beckmann (5) looked specifically at the hierarchical system of Christaller in an attempt to provide a theoretical foundation for the empirical relationship known as the rank size rule. Criticism of Beckmann's interpretation of the Christaller model by Dacey (19) and, especially, Parr (44) led to a reformulation by Beckmann and McPherson (6).

The basic hierarchical structure of the reformulated model is quite simple. Assuming a uniformly distributed rural population, the lowest order city will provide the lowest order good to a market area having r rural residents. If the service mix and technology are the same for all low order places, k_1 persons are required in each central place to service each person in the market area. Let c_1 denote the city size. Since the city must provide the good to itself as well as the rural area, the city size will be

$$c_1 = k_1(r+c_1) \text{ , or}$$

$$c_1 = \left(\frac{k_1}{1-k_1}\right)r.$$

Higher order places provide higher order goods to increasingly larger market areas. For a representative city of order n, the city population will provide n order goods to a region having s_n population, composed of both rural and lower order city populations. It will also provide goods of order n-1 through 1 to market areas having populations of s_{n-1} through s_1 (where $s_1 = r$). Thus the city size will be

$$c_n = \sum_{i=1}^{n} k_i(c_n+s_i), \text{ or}$$

$$c_n = \sum_{i=1}^{n} \left(\frac{k_i}{1- \sum_{i=1}^{n} k_j} \right) s_i \ .$$

With slight modification, it is easy to show that the Beckmann-McPherson model is a spatial disaggregation of the export base model presented earlier. For the region composed of the lowest order place and surrounding rural population, it is clear that given a base employment of r, the ratio $k_1/(1-k_1)$ is equivalent to the base ratio of nonbasic employment to base employment.

In order to show this relationship for regions having more than a single place, it is convenient to assume the nonspatial aspects of the export base theory. Hence c should be interpreted as service or nonbasic population and r as basic population. If the region under consideration is of order n, goods of order 1 through n will be provided by service populations somewhere in the region. Let c^i be the service population necessary to provide a good of order i and r^t be the total regional base population. Then within the region as a whole

$$c^i = k_i(r^t + c^1 + c^2 + \ldots + c^i + \ldots + c^n).$$

The total regional service population is the sum of populations providing each order of goods,

$$c^t = c^1 + \ldots + c^n = (k_i + \ldots + k_n)(r^t + c^1 + \ldots + c^n)$$

$$= (k_1 + \ldots k_n)(r^t + c^t)$$

$$= \frac{k_1 + \ldots + k_n}{1-k_1- \ldots -k_n} r^t = \sum_{i=1}^{n} k_i/(1- \sum_{i=1}^{n} k_i)\ r^t.$$

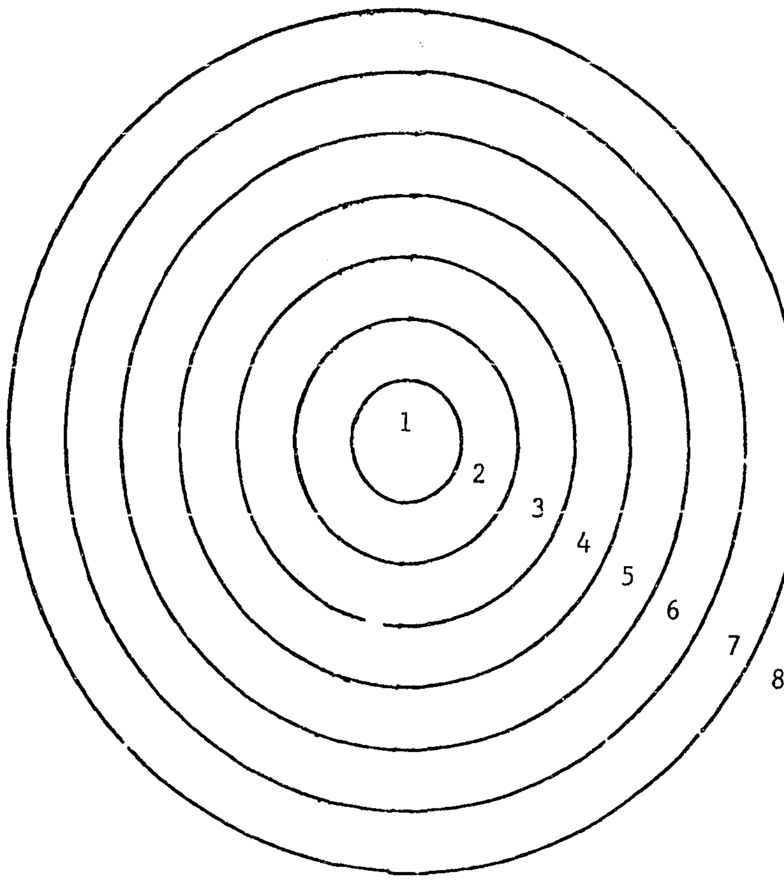
Again, it should be clear that this last ratio is equivalent to the base ratio for the region as a whole. The Beckmann-McPherson interpretation of Christaller's hierarchies is therefore completely consistent with the simple export base models. Later analysis will build on this area of comparability.

Land use models

The locational aspect of central place theory provides a framework of nodal points upon the otherwise homogeneous landscape. Von Thunen (69), on the other hand, was concerned with the uses to which the area about a nodal point should be allocated. Although this work was first presented in 1826, the basic approach has proved applicable in modern formulations.

The basic model of Von Thunen assumes an agricultural region isolated from the rest of the world. This region is centered on a single city which services the rural area with manufactured goods and which acts as the only market place for the trading of agricultural commodities. The problem is to allocate the uniformly fertile land among various agricultural commodities in a "rational" fashion. Von Thunen's answer is to allocate such that the costs of overcoming the friction of space are minimized. Given two crops of equal value per acre of land, that crop which is "heavier" and, therefore, more expensive to transport to the city market should locate nearer the city. A generalization of this principle leads to a series of concentric rings of land uses, as in Figure 8 below.

Although Von Thunen (69) considers the commodity price and land rent implications of his model, it is perhaps easier to handle these matters in a more recent formulation. Muth (39) and Alonso (1) present Von Thunen



Zone	Utilization
1	Town
2	Gardens
3	Forestry
4	Intensive arable
5	Less intensive arable
6	Least intensive arable
7	Animal husbandry
8	Wilderness

Figure 8. Von Thunen's land utilization zones (30, p. 119)

systems in which the urban sector is also conceived to function in a fashion similar to the agricultural sectors of the initial model. A more extensive application is found in Alonso (2) from which the following discussion is adapted.

The allocation of land in the Alonso model to various competing uses is accomplished by means of bidding for both site and quantity. Of course, possession of a particular parcel goes to the highest bidder. Alonso develops bid-rent functions for each bidder. These functions specify the maximum rent each use would be willing to pay per unit of land at any distance from the focal point of the region given a constant level of utility or profits. The derivation of the residential bid-rent function for an individual is based on traditional utility maximization within a limited budget.

If utility of an individual is fixed at u_0 and the location of land is predetermined at t_0, the utility function for this individual is

$$u_0 = u(z,q,t_0),$$

where z = the amount of all nonland purchases, and

q = the quantity of land purchased.

The budget equation is

$$y = p_z z + p_0 q + k(t_0),$$

where p_0 = the price of land at distance t_0, and

$k(t_0)$ = the commuting costs from t_0.

Differentiating the utility function and the budget equation yields

$$du_0 = 0 = u_z dz + u_q dq, \text{ and}$$

$$dy = 0 = p_z dz + p_0 dq.$$

These two equations give

$$u_q/u_z = p_0/p_z.$$

The first two equations and the last provide three equations with which the three unknowns (z, q, p_0) can be determined. The price p_0 is the price an individual would be willing to pay for a unit of land at t_0, given constant utility of u_0. This price is one point on the residential bid-rent function. If instead of fixing distance, it is allowed to vary, a parametric solution for price can be found in terms of distance, and this becomes the residential bid-rent function. The particular function specified is itself only one of a family of such functions, where any one is determined by the level of utility. Alonso further shows that these bid-rent functions are single-valued, imply higher utility by lower curves, and do not cross for any one individual.

Comparable bid-rent functions can be constructed for the agricultural and business sectors. However, constant profits, rather than utility, specify the altitude of the curves. In the case of agriculture, let

$p_a(t_0)$ = the price per unit of land at distance t_0 from the regional focal point,

N_a = the number of units of a crop produced per unit of land,

P_a = the price of the crop at the market place,

C_a = the cost of producing one unit of the crop, and

$k_a(t_0)$ = the cost of transporting one unit of the product a distance t_0 to the market.

Calculating rent as a residual yields a bid-rent function of

$$p_a(t) = N_a(P_a - C_a - k_a(t)).$$

The derivation of bid-rent functions for a business firm is complicated by the number of assumptions possible about the type of market in which a firm may operate. Two types of firms are considered in the following analysis: firms producing for export and firms providing the local market and operating under constant returns to scale.

For business firms which produce for export and operate in a competitive national market, a bid-rent function identical to that for agriculture is appropriate. Such firms would find a locational advantage only in the reduction of transportation costs outside of the region and would bid up the price of land to the point where all economic profits are zero. Let this bid-rent function be

$$p_m(t) = N_m(P_m - C_m - k_m(t)).$$

Firms which supply the local market with goods and services may incur economic profits by virtue of their local monopoly position. If, unlike Alonso, output per unit of land is held constant and the total effects of location are included in the transportation costs, as might be the case for a firm which accepted the commodity price and paid for delivery to the customer's home, the firm's profits can be stated as

$$R = V_s - O_s - K_s(t_0) - p_s(t_0)$$

where R = profits per unit of land,

V_s = revenue per unit of land,

O_s = operating expenses per unit of land,

$K_s(t_0)$ = transportation costs from a unit of land at distance t_0, and

$p_s(t_0)$ = rent per unit of land at t_0.

Solving for the rent as a function of distance, holding profits constant at R_0, yields a service firm bid-rent function of

$$p_s(t) = V_s - O_s - R_0 - K_s(t).$$

The equilibrium allocation of land is most readily seen in a region having two sectors bidding for land. Figure 9 shows the bid-rent functions of aggregated agricultural and residential sectors. Point 0 is the focal point of the region. If the only sector bidding for land in the region were the agricultural sector, farm land would extend from 0 to t_a and beyond t_a the land would lie idle.

The introduction of a residential population requires a division of the land between uses. If, as is shown, the residential bid-rent function has a steeper slope than the agricultural, land nearest the center will be allocated to nonfarm uses. The slopes, therefore, are a measure of the weight of the product and, in this case, people are "heavier" than the agricultural product.

The mechanism by which land is bid away from farm to nonfarm use is by increasing the maximum rent the residential sector is willing to pay until the residential function exceeds or equals the agricultural function over the required residential land. Thus, if the amount of land necessary for urban residents is Ot_r, the residential bid-rent function would have to have a price intercept of p_r . The intercept, however,

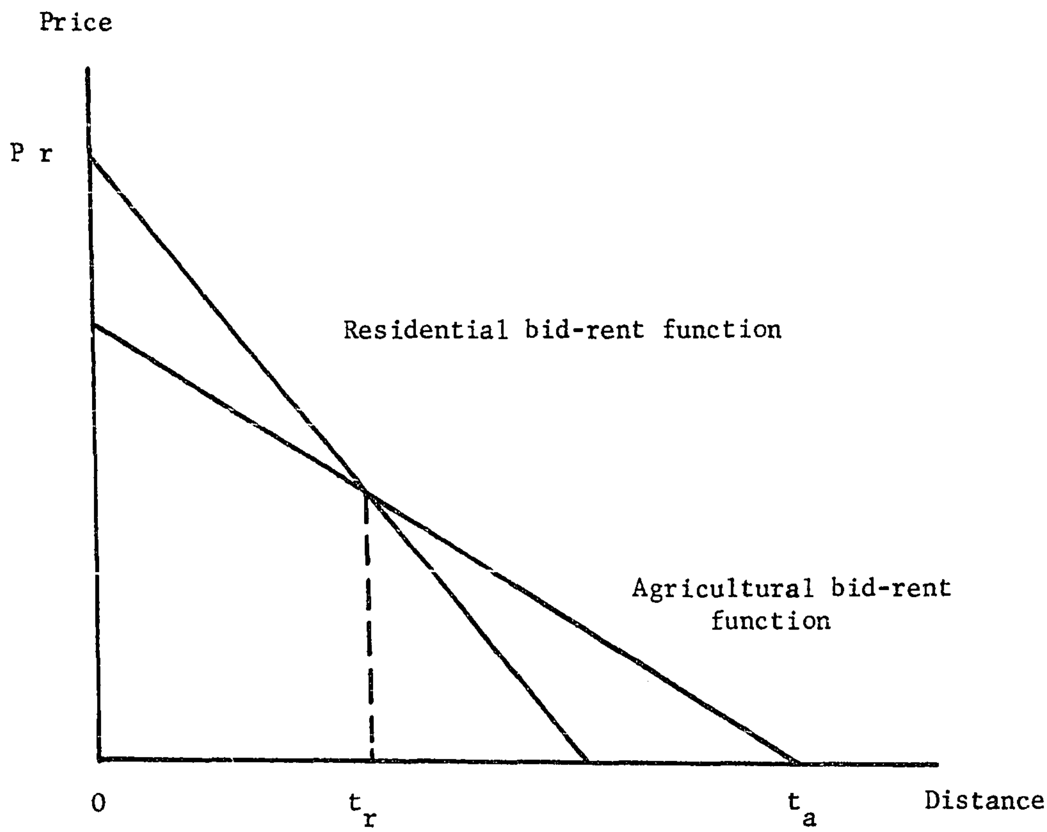


Figure 9. Allocation of land between two sectors

would be no higher than p_r because any higher bid-rent function would give residents lower utility.

Addition of more sectors would further subdivide the available land with each use ranked in terms of the steepness of their bid-rent functions and the steepest function bidding away the land nearest the regional center. Viewing the regional plain from above would yield a pattern of concentric rings centered on the regional focal point. This pattern, of course, is that developed by von Thunen.

Regional land use models provide dimensions not accounted for in either the export base or the central place models. The next chapter will demonstrate how land use can augment the first two models in explaining regional population and income.

Summary

The general features of three types of regional models have been discussed above. The next chapter presents a regional model for non-metropolitan areas which incorporates aspects of each. However, it should be noted that whereas the export base and central place models are consistent with respect to the urban or base multipliers, the locational implications of the central place theory are not consistent with land use models. Although the problem will not be pursued on the assumption that the distortions are minor in a spatially small and less populated region, it can be quickly stated: in the locational pattern presented by Christaller (18), not all central places of a given order are equidistant from central places of two or more orders higher. Thus, based on land use models, the closer places enjoy a locational advantage which will be reflected in a different pattern of bid-rent functions and of land use. A discussion of this point can be found in Isard (28) and Henderson (25).

CHAPTER III. POPULATION, LAND USE, AND INCOME IN A CENTRAL PLACE REGION

The purpose of the following discussion is to develop a model of the response of nonmetropolitan regions to exogenous changes in the demands for the regions' export commodities. In particular, the impact of the exogenous demands upon regional land use, population, population distribution, and income will be derived for a simplified central place region. This analysis draws heavily upon the concepts embodied in economic base models, central place models, and land use models.

The regions to be investigated are nonmetropolitan regions in which the largest city has a population of less than 50,000 people. It is assumed that within these regions three orders of urban places exists and that the regions conform to the central place hierarchical structure. Thus the following model deals explicitly with only three orders of cities.

In a central place system, each city, regardless of order, can be considered to be surrounded by a given sized subregion to which the city supplies goods and services of order one. Goods and services of order two are supplied from cities of order two or greater to that subregion immediately about the city and to the order one subregions nearest the city. In a similar fashion, order three goods are provided from third order or higher cities to an even larger market area. Since each region of concern here has been defined as having the largest city of order three, each region is a market area of order three. A stylized diagram of such a region is given in Figure 10.

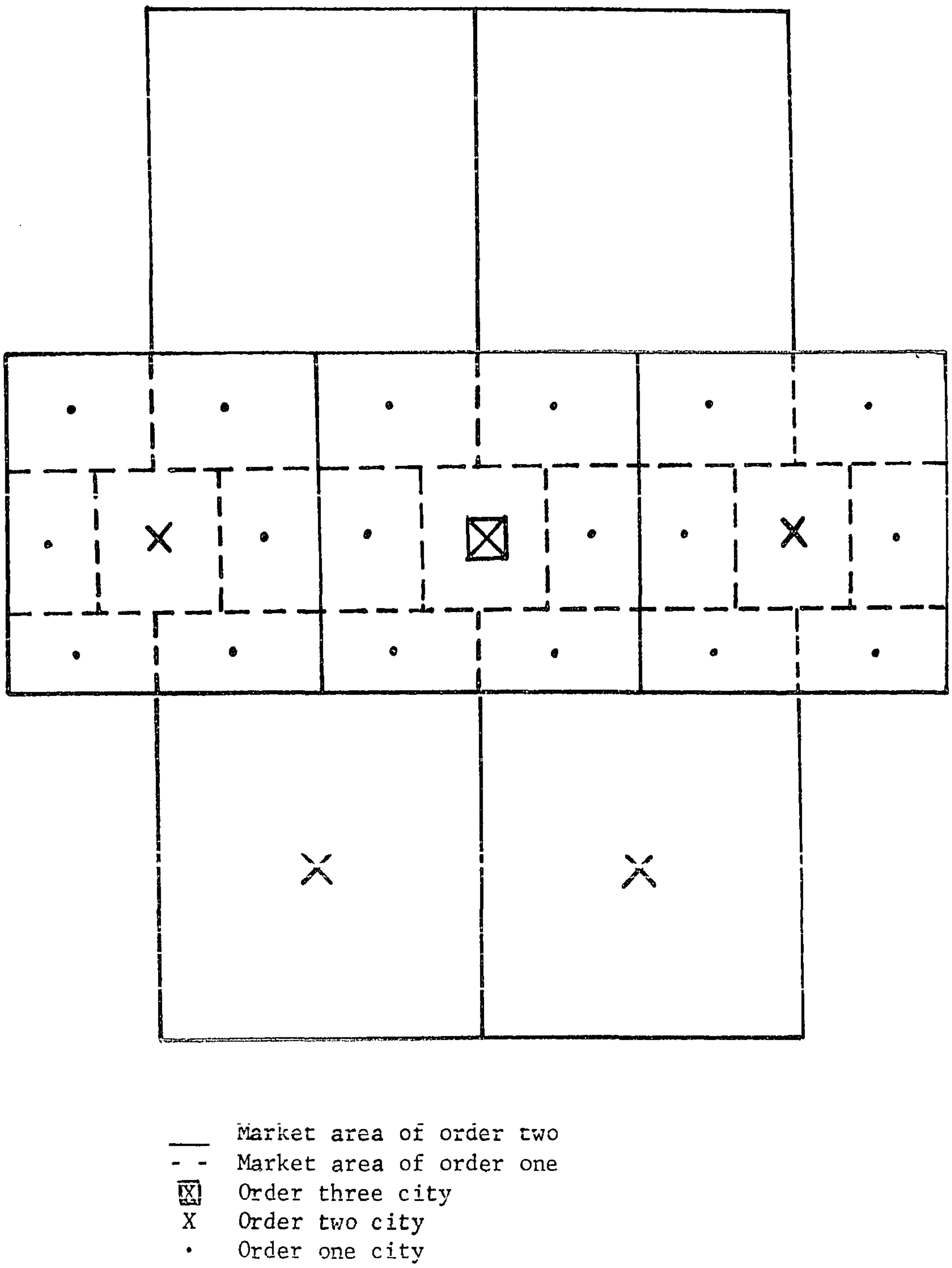


Figure 10. A stylized central place region

Although the term order is applied to both cities and commodities, the concept being employed here relates to the commodity. The order of a city is not defined by its population but by the highest order commodity which it provides, although it is expected that cities which provide higher order goods will also have larger populations.

Low order goods are those which can be provided profitably to a small market area. This may be because the cost of provision is relatively low, or the demand is relatively high with frequent purchases, or a combination of the two factors. Typical examples would be groceries or gasoline which are often provided in even the smallest towns. At the other extreme are the high order goods which require large market areas because the cost of provision is high or there is infrequent demand for the good from any particular household. Examples here might be cultural events associated with the major metropolitan centers. This is the sense of the term order used throughout the following discussion.

The order one city

The service function of the cities is such that, given the basic population in the market area, service population and regional land use can be determined. Analysis of an order one city will serve to point out the salient features of the urban dependency upon the basic population. Let a typical urban place have a market area of given size populated by a basic agricultural population of A and a basic manufacturing population of M. Then, if the demand and production relationships are such that there exists a constant ratio, h, representing the population necessary to serve one regional resident with order one goods, the service sector population will be

$$S = h\ (M + A + S)$$

$$= k\ (M + A),\ \text{where}\ k = h/1\text{-}h.$$

The urban population becomes

$$U = (1 + k)\ M + kA,$$

and the total subregional population is

$$T = (1 + k)(M + A).$$

This assumes that the agricultural population resides at the work site and the manufacturing population resides within the urban boundaries.

As was discussed in the previous chapter, the ratio h/(1-h) is equivalent to the base ratio. Hence, this isolated region can be viewed either in the contexts of a central place model or an export base model. Each of these models is driven by an exogenously determined variable which can be taken as a measure of export demand. However, even though the basic population and the export product can be linked by a production function, neither variable best fits the requirements for an exogenous variable. Instead, it will be more useful to assume that export prices are competitively set in national markets and are then taken as given by regional producers. Output and input levels are decisions to be made by the regional producers in light of the national prices.

In order to estimate the produce and input decisions, it is necessary to make some assumptions about the production functions of the basic industries and the cost of inputs to the industries. Assume that the agricultural and manufacturing industries each produce a homogeneous product using linear production functions such that the ratios for any two inputs are constant at all levels of output. Let land be the only factor in fixed supply in the region and, therefore, the constraining input. With respect to factor costs, assume all input prices are determined competitively in national markets except for that on land. Let the rent on land be determined as the residual after all other factor payments have been deducted from revenue.

If the constancy of the labor-land ratio holds for all regional sectors, i.e. service, residential, manufacturing, and agriculture, specification of the regional land use will summarize the production and population variables also. The process by which the regional land is allocated to the various sectors is seen most easily if the region is again an order one subregion.

A cross section of the region is depicted in Figure 11. The point 0 is the urban center and OL is the distance from the urban center to the regional limit. Given the price on the agriculture output and the price of agricultural labor and assuming only land and labor enter the production function, the maximum rent to be paid for agricultural land will be

$$Ax = Va - (wag)a$$

where Va = agricultural revenue per unit of land

wag = agricultural wage bill per worker

a = agricultural workers per unit of land.

If there is no advantage to central location in agricultural production, Ax is the bid-rent function for agricultural land.

The agricultural population will generate a local service sector and a resulting need for service land; and the service employees, in turn, will generate a demand for residential land. In order for land to be shifted from agricultural use to service or residential use, the bid-rent

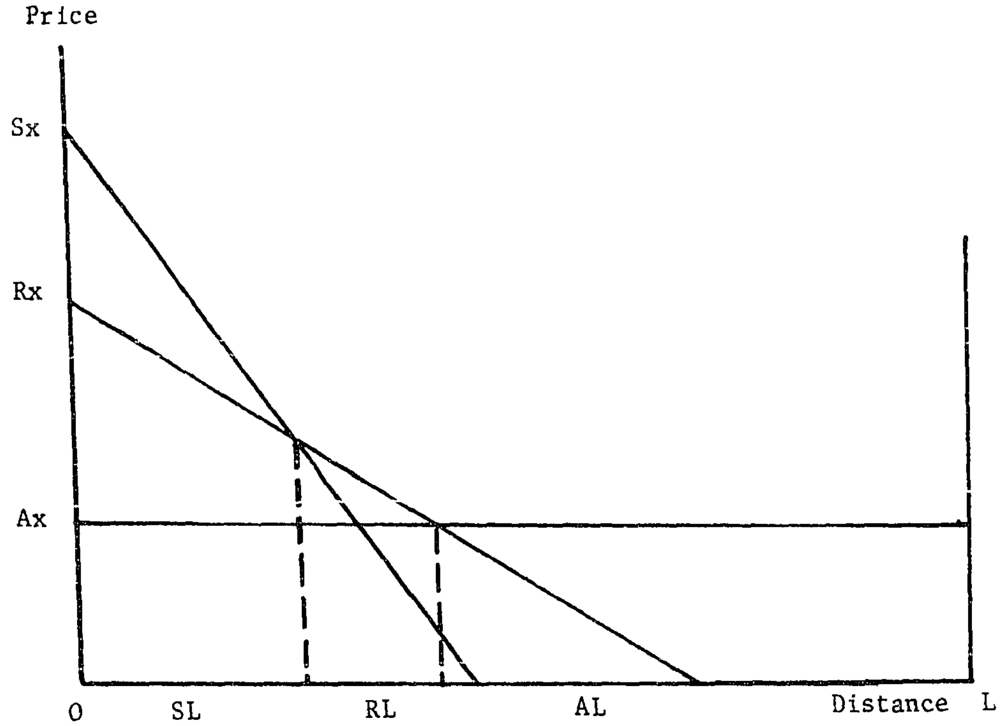


Figure 11. Allocation of land among three sectors

functions for the latter sectors must exceed that for agriculture over the required land area. These bid-rent functions are shown in Figure 11, where the service sector and the residential functions have intercepts of Sx and Rx respectively. The slopes attached to these bid-rent functions result from assumed positive advantages to central locations which must be compensated for at noncentral locations.

The region is in equilibrium if the intercepts on the urban bid-rent functions are high enough to bid away the required land from agricultural use. This requires that the service and residential functions be flexible with respect to their intercepts. On the other hand, profit maximization in the service sector and utility maximization for urban residents would require that the rents paid on land be as low as possible. Thus the urban bid-rent functions will have intercepts no higher than those required to bid away the necessary land.

The land requirements for the above situation can be determined as follows. Let

ka = the service sector multiplier for agricultural workers

a = the labor-land ratio in agriculture

s = the labor-land ratio in service

r = the resident-land ratio in the residential sector

A = the agricultural population.

Then the total service population, given a predetermined agricultural population, is

$$S = (ka)A$$

and the service land required is

$$SL = (1/s)S.$$

If the total residential population is

$$R = S,$$

total residential land use will be

$$RL = (1/r)R.$$

However, the agricultural population is not predetermined but is a function of the amount of land area not converted to urban use. It is necessary, therefore, to solve for regional populations and land uses simultaneously. To close this model add the following equations:

$$A = (a)AL$$

$$AL = L - SL - RL$$

where AL = the agricultural land area

L = the given regional total area.

The introduction of a local manufacturing sector as a second basic industry requires a treatment similar to that given the agricultural sector. Like the agricultural sector, manufacturing is assumed to be operating in a competitive national market which fixes the price of output and all factor prices except that on land. The maximum land rent, Mx, is given as a residual. However, like the urban sectors, manufacturing is assumed to incur disadvantages from noncentral location, and thus the manufacturing bid-rent function will have a negative slope. Graphically, the regional land use will appear as in Figure 12 if the maximum rent is sufficient to extend the urban limit beyond that which would exist with only the agricultural sector.

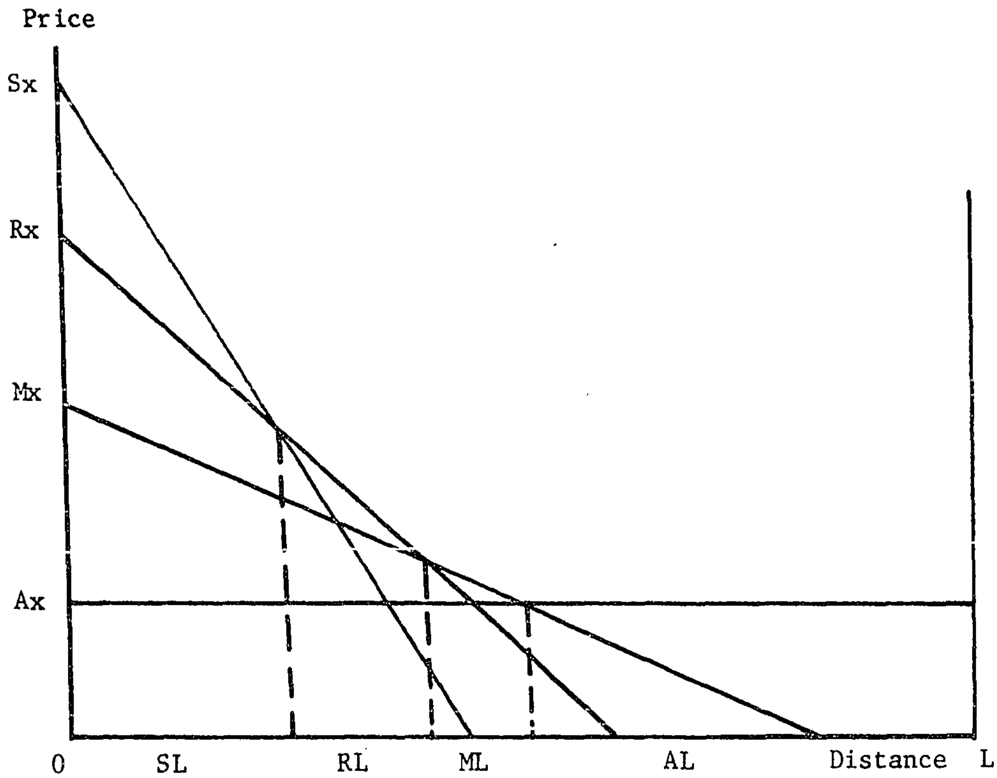


Figure 12. Allocation of land among four sectors

Manufacturing employment will generate the need for additional urban service and residential land. This influence can be taken into account by augmenting the previous specification in the following fashion. The service population will be the sum of the requirements for the agricultural and the manufacturing populations.

$$S = (ka)A + (km)M \quad (1)$$

where km = the service sector multiplier for manufacturing workers

M = manufacturing employment.

The service sector land use is as above

$$SL = (1/s)S. \quad (2)$$

The urban residential population is the sum of the service and manufacturing populations

$$R = S + M. \quad (3)$$

Residential land use remains

$$RL = (1/r)R. \quad (4)$$

The agricultural population is

$$A = (a)AL, \quad (5)$$

and the manufacturing population is determined similarly by

$$M = (m)ML. \quad (6)$$

The land use in each of the basic sectors requires a more complex determination. Without the manufacturing sector, the basic land use could be taken as a residual. If manufacturing is introduced with an exogenously set maximum rent, the manufacturing bid-rent function will specify the total urban land use. Let this bid-rent function be

$$MR = Mx - (e_m)d \quad (7)$$

where Mx = maximum manufacturing rent

e_m = cost of noncentral location per unit of distance

d = distance from the urban center.

Since the rural bid-rent function is assumed constant at Ax, rural land will be converted to manufacturing use whenever the manufacturing rent exceeds Ax. Thus the urban limit must be

$$Mx - (e_m)d = Ax$$

$$d = (1/e_m)(Mx-Ax). \qquad (8)$$

The total urban land use will be some function of the urban limit d. For convenience, let that function be

$$U = d, \qquad (9)$$

where U = urban land use.

This assumption is accurate if the region under consideration exists on a line. However, if the region is defined in two dimensions, the proper expression would be

$$U = \pi d^2.$$

It follows, therefore, that the agricultural land use can be expressed as

$$AL = L - U, \qquad (10)$$

and that the manufacturing land use can be stated as the residual

$$ML = U - SL - RL. \qquad (11)$$

Equations 1-11 are sufficient to establish the impact of exogenous shifts in demand for the regional output through the changes in Ax and Mx. It remains to be shown that the economic base variables can also be restated in terms of the same exogenous demands. In order to do this, let the income identity be

$$Y = SY + RY + MY + AY. \qquad (12)$$

where SY = service sector income

RY = residential sector income

MY = manufacturing sector income

AY = agricultural sector income;

and $SY + RY$ = domestic or nonbasic income

and $MY + AY$ = export or basic income.

The basic sectors' incomes are easily determined. The national demands which establish the output prices give gross revenue per land unit. Thus the product of gross revenue per land unit and area gives total income.

$$MY = (Vm)ML \tag{13}$$

and

$$AY = (Va)AL, \tag{14}$$

where Vm = gross revenue per land unit in manufacturing

and Va = gross revenue per land unit in agriculture.

An equivalent measure of total value in the service and residential sectors is not as readily available since the returns to land in these sectors must be set within the system. Let the bid-rent function for service be

$$SR = Sx - (e_s)d$$

and for the residential land be

$$RR = Rx - (e_r)d.$$

Recalling that the function for manufacturing is

$$MR = Mx - (e_m)d,$$

where Mx is fixed but Sx and Rx are flexible, allows Rx to be determined based on Mx and Sx to be set based on Rx. At the point where residential land changes to manufacturing, it must be true that

$$Rx - (e_r)d = Mx - (e_m)d.$$

If the distance measure is identical to land use,

$$Rx = Mx + (e_r - e_m)(RL + SL). \tag{15}$$

At the service-residential border

$$Sx - (e_s)d = Rx - (e_r)d,$$

so that

$$Sx = Rx + (e_s - e_r)SL. \tag{16}$$

If the service sector is competitive so that price equals cost, with two factors of production, the value of output per land unit will be

$$Vs = Sx + (wser)s \tag{17}$$

where Sx accounts for the entire locational costs, including the cost necessary to overcome the disadvantages of noncentral location and wser is the wage rate in the service sector.

Of course, a rental rate of Sx will occur only at the urban center and rents actually paid at any site removed from the center will be lower. The amount of the discount in the rental value for noncentral locations is equal to the transportation expense necessary to compensate for the disadvantages of noncentrality. Thus applying a value of Sx for each unit of service land will account for all locational costs associated with service provision, i.e., site and transportation costs. In addition, the value of Vs is a measure of the local region's price level.

The service wage rate, in turn, may be a function of the manufacturing wage rate so that

$$wser = p(wmfg). \tag{18}$$

Total service sector income is therefore

$$SY = (Vs)SL. \tag{19}$$

If the residential value per land unit is found in a similar fashion, but the labor input is assumed to be zero, residential value per unit of land will be

$$Vr = Rx. \quad (20.$$

Like the term Sx, Rx includes all of the locational costs associated with each unit of residential land. Unlike Sx, Rx is never an effective rent since, by assumption, the service function usurps the central site. However, it is the price that would be paid for central residential land if a resident could acquire a central site. Residential income will be

$$RY = (Vr)RL. \tag{21}$$

Equations 1-21 specify regional land use, population, income, and price level given the national prices for manufactured and agricultural goods and for labor for the order one city. The modifications necessary to apply this formulation to higher order places is presented below.

The order two city

An order two city provides all of the services of an order one city to its own subregion and, in addition, provides goods and services of order two to the larger market area composed of its immediate subregion and the surrounding order one subregions. This enlarged service function requires an expanded definition of the functional relationship of the service sector to the basic employment. The local basic population will generate a service sector for order one goods as in the order one city. The basic populations in the immediate subregion and the surrounding order one subregions increase the service sector by their demand for goods of order two. Thus the total service employment in the i th order two city is

$$S_{2i} = (ka_1 + ka_2)A_{2i} + (km_1 + km_2)M_{2i}$$

$$+ \sum_{j=1}^{N_1} (ka_2 A_{1ij} + km_2 M_{1ij}) \qquad (1.1)$$

where the notation on the "k" urban multipliers index the order of the good being demanded. The subscripts on the employment variables index the order of the subregion of residence, the particular order two subregion and the particular order one subregion of residence so that

A_{1ij} is the agricultural employment in the j th order one subregion in the i th order two market area, and

M_{2i} is the manufacturing employment in the i th order two subregion.

Let there be N_1 order one subregions in the market area. If the labor-land ratio for the provision of goods and services of order two is equal to that in the provision of order one goods, the system of equations given for the order one city can be applied intact to the order two city with only the substitution of equation 1.1 for equation 1.

The order three city

The land use, population, and income specification in and about an order three city is as for the order one and order two cities except for the necessary adjustment for the service population. Since the service function of this city is broader than that for lower levels, the service employment determination must be expanded again. This center provides order one goods and services to its own basic population, order two goods and services to its own and the immediately surrounding order one subregions, and order three goods and services to the entire regional basic population. Thus the service employment can be stated as

$$S_3 = (ka_1+ka_2+ka_3)A_3 + (km_1+km_2+km_3)M_3$$
$$+ \sum_{j=1}^{N_1} \left[(ka_2+ka_3)A_{10j} + (km_2+km_3)M_{10j}\right]$$
$$+ \sum_{i=1}^{N_2} \left[ka_3A_{2i} + km_3M_{2i} + \sum_{j=1}^{N_1} (ka_3A_{1ij} + km_3M_{1ij})\right] \qquad (1.2)$$

where the notation is as above. Let i=0 indicate that the one level city does not lie in an order two market area of any order two city but rather is provided by the order three city. Also, let N_2 be the number of order two cities in the market area. The subregional variables for the order three city are found by substituting equation 1.2 for equation 1 in the system given for the order one city.

Implications of the land constraint on the regional populations

The implications of the regional land constraint upon the populations within a region can be seen by solving for the various populations in terms of the exogenous variables. This requires a simultaneous solution for the urban sector which is easier to interpret if the populations are stated in terms of the urban area and the agricultural population. These solutions are found below.

For the order one subregion, equations 7 through 10 specify the regional division of land between the rural and the urban sectors. Substituting 8 into 9 gives the urban land area as

$$U = (1/e_m)(Mx-Ax),$$

and the rural area becomes

$$AL = L - (1/e_m)(Mx-Ax).$$

Thus the total land area, L, is allocated based on the differences in maximum rents which result from the external demands for the export products and upon the production functions and labor costs in the two sectors. As would be expected, the land allocated to each sector is directly related to the maximum rent for the respective sector. In addition urban land is positively and rural land is negatively related to changes in the slope of the manufacturing bid-rent function, which reflects changing sensitivity to central location on the part of the manufacturing sector. The agricultural population is determined from equation 5 and is a direct function of the rural land area

$$A = (a)\ AL.$$

Once the urban area and the rural population have been determined, the urban land uses and populations can be found by solving equations 1, 2, 3, 4, 6, and 11 simultaneously. The resulting expression for the service population is

$$S = \frac{1+m/r}{1+(km)m/s + m/r + (km)m/r}(ka)A + \frac{(km)m}{1+(km)m/s + m/r + (km)m/r}U,$$

and for the service land use

$$SL = (1/s)S.$$

The second term in the service population function gives the number of service employees which would exist in an urban place of size U if there were no rural hinterland. In such an isolated city, given fixed land to employee ratios, there is only one equilibrium allocation of land, and hence a unique population distribution, consistent with the urban size. This second term reflects that relationship.

The first term picks up the impact on the service sector arising from the agricultural population. With no land constraint, the added service employment would be (ka)A. However, the net addition to the urban service sector over that occurring in an isolated city is necessarily less than the unconstrained number. This is a result of the model construction which interprets the service sector as the primary urban function and the manufacturing sector as a residual land use. Thus that portion of the urban area which is allocated to supporting the hinterland is effectively deducted from the urban area U before the manufacturing use is determined. On the other hand, the net addition to the service population must be positive since, by contradiction, if it were negative there would be a larger land area allocated to manufacturing with a larger manufacturing population and therefore a larger supporting service sector.

The Beckmann and McPherson (6) model ignores this interplay among the regional populations by assuming one basic sector and no land constraint. It therefore may be taken as a statement of regional equilibrium, but it is devoid of any mechanism which would describe how the equilibrium is to be attained.

The residential population and land area have similar solutions:

$$R = \frac{1-m/s}{1+(km)m/s + m/r + (km)m/r}(ka)A + \frac{m + (km)m}{1+(km)m/s + m/r + (km)m/r}U$$

and

$$RL = (1/r)R.$$

Again, the second term reflects the residential population of an isolated city and the first term is the net addition resulting from the increased service employment necessary to service the agricultural hinterland. However, the net addition need not be positive in this case, for, if the manufacturing sector has a higher employee to land ratio than the service sector, allocation of land from manufacturing use to service use will decrease the urban population.

Finally, the manufacturing employment and land area are

$$M = \frac{-(m/s + m/r)}{1+(km)m/s + m/r + (km)m/r}(ka)A + \frac{m}{1+(km)m/s + m/r + (km)m/r}U$$

and

$$ML = (1/m)M,$$

where the first term in the population expression accounts for the reduction in manufacturing employment necessary to provide the land needed to service the rural population.

The solutions for higher order places are found in a similar fashion. However, higher order places must allocate a portion of their urban land to the provision of services to lower order places. Consequently, the lower order populations are taken as predetermined to a particular city and enter into the urban population solutions with the same coefficient as the city's immediate rural population.

The model estimation

The estimation model for the variables in the entire region is presented under the assumption that observations are available on each variable. Unfortunately, this is not the case, and the model to be estimated adjusts for the data insufficiency.

In a typical region there will be one order three city and subregion, N_2 order two cities and subregions, and $N_1(N_2+1)$ order one cities and subregions. Let i denote the region and j subscript the order of the city. The observation on the second order cities is an average over the N_2 cities in each region, and the observation for the first order city is an average over the $N_1(N_2+1)$ cities in each region. Equations 22 to 36 include the equations and identities necessary to estimate the model presented above.

$$\begin{aligned} S_{ij} = {} & ka_1A_{ij} + km_1M_{ij} + (x_1)ka_2(N_1A_{i1} + A_{ij}) \\ & + (x_1)km_2(N_1M_{i1} + M_{ij}) \\ & + (x_2)ka_3(N_2A_{i2} + N_1(N_2+1)A_{i1} + A_{ij}) \\ & + (x_2)km_3(N_2M_{i2} + N_1(N_2+1)M_{i1} + M_{ij}) + u_{1ij} \end{aligned} \tag{22}$$

where
$x_1 = 0$, if $j = 1$,
$x_1 = 1$, if $j > 1$,
$x_2 = 0$, if $j < 3$,
$x_2 = 1$, if $j = 3$.

$$SL_{ij} = (1/s)S_{ij} + u_{2ij} \tag{23}$$

$$R_{ij} = S_{ij} + M_{ij} \tag{24}$$

$$RL_{ij} = (1/r)R_{ij} + u_{3ij} \tag{25}$$

$$A_{ij} = aAL_{ij} + u_{4ij} \tag{26}$$

$$M_{ij} = mML_{ij} + u_{5ij} \tag{27}$$

$$U_{ij} = (1/e_m)(Mx_{ij}-Ax_{ij}) + u_{6ij} \tag{28}$$

$$AL_{ij} = L_{ij} - U_{ij} \tag{29}$$

$$ML_{ij} = U_{ij} - SL_{ij} - RL_{ij} \tag{30}$$

$$Rx_{ij} = Mx_{ij} + (e_r-e_m)(RL_{ij}+SL_{ij}) + u_{7ij} \tag{31}$$

$$Sx_{ij} = Rx_{ij} + (e_s-e_r)SL_{ij} + u_{8ij} \tag{32}$$

$$Wser_{ij} = p(Wmfg_{ij}) + u_{9ij} \tag{33}$$

$$Vs_{ij} = Sx_{ij} + s(Wser_{ij}) \tag{34}$$

$$Vr_{ij} = Rx_{ij} \tag{35}$$

$$Y_{ij} = Vs_{ij}SL_{ij} + Vr_{ij}RL_{ij} + Vm_{ij}ML_{ij} + Va_{ij}AL_{ij} \tag{36}$$

where the observed variables are in upper case and the parameters to be estimated are in lower case, the u variables are normally distributed error terms, and

$$i = 1 \ldots n$$

$$j = 1, 2, 3.$$

The exogenous variables are L_{ij}, Mx_{ij}, $Wmfg_{ij}$, Vm_{ij} and Va_{ij}.

The next chapter describes the selection of the sample regions and the availability of data for these regions. Since the empirical model must be constructed in light of the type of data available, the description of the model to be tested is postponed until Chapter V.

CHAPTER IV. CHARACTERISTICS OF THE SAMPLE

This chapter discusses the criteria used in the selection of sample regions and the major characteristics of the regions incorporated in the study. In addition, a review of the quantity and quality of the data is included in order to lay the ground work for building the empirical model.

Regional definition

The sample regions used in the following analysis were selected from the delineation of Functional Economic Areas (FEA's) of Berry, et al., (12). The concept of an FEA was proposed by Fox as an unified system of regional delineation which could be applied to incorporate a large portion of the United States population and which would more accurately reflect the sphere of economic influence of central places than existing statistical regionalizations.

Fox and Kumar (24) discuss the application of FEA's to the state of Iowa. The first approximation to a state regionalization defined regions about the existing Standard Metropolitan Statistical Areas (SMSA's) by constructing a boundary having a 50 mile "radius" centered on the central city. The 50 mile limit was selected as the maximum practical commuting range for working and shopping. Given the grid pattern of the Iowa road system, the regions assumed the form of a square. The application of a 50 mile regional limit to the current SMSA's increased the population which, statistically, fell within an urban region. However, since cities which do not reach the required levels for SMSA central city status may still play an important function to their surrounding hinterlands, the FEA regionalization was extended to smaller urban places.

Berry, et al. (12), applied the FEA regionalization to the United States based upon the commuting data of the 1960 Census of Population. In all 305 regions are defined, with total regional populations ranging from 17 million to 13 thousand. Whereas regionalizations based on the SMSA criteria includes 2/3 of the 1960 population, applying the FEA concept to SMSA central cities incorporates 87 percent of the population, and extending the regionalization to smaller central cities adds another 9 percent. Thus only 4 percent of the 1960 U.S. population is outside of a FEA.

Sample selection

The initial selection of sample FEA's attempted to eliminate those regions defined by Berry which were either metropolitan in character or too small to provide the necessary levels of central places. In keeping with the first goal, all regions centered on an SMSA or which had central city and contiguous urban places having a total population in excess of 60,000 were eliminated. The second goal led to the establishment of 15,000 as the lower limit on a central city size. Eighty-one of the 305 FEA's fell between the above requirements.

Further evaluation led to the dropping of 35 of the 81 regions for one of the following reasons: the region has no places which could be considered to be of order two, the region has a noncentral city larger than or nearly equal to the central city population, the central city does not provide a substantial service function to the surrounding region,[1] or data was not available for one of the variables specified in the empirical model. A list of the remaining 46 regions and details of the counties included in each region is contained in Appendix A. Figure 13 shows the location of the 46 regions of the sample.

The regional hierarchy

The 46 regions included in this study are by assumption market areas of order three. In order to investigate the central place dependencies within the region, it was necessary to define three orders of urban places. Although any such definition admittedly must be arbitrary, some guide lines can be drawn from the sales functions performed by various sizes of cities. Borchert and Adams (15) classified cities by their retail and wholesale functions as follows: minimum convenience centers, typically places having less than 1,000 people; full convenience centers, places between 1,000 and 2,500 people; partial shopping centers, places between 2,500 and 5,000; complete shopping centers, populations from 5,000 to 25,000; secondary wholesale-retail centers, places from 25,000 to 50,000; and finally primary wholesale-retail centers, places in excess of 50,000. A summary of this classification is presented in Figure 14 detailing the number of services provided at each level and a supplemental criterion of dollar volume of sales.

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[1]The Rand-McNally City Rating Guide (47) was used for this criterion. Thus only cities which were classified as business centers or trading centers were included in the sample.

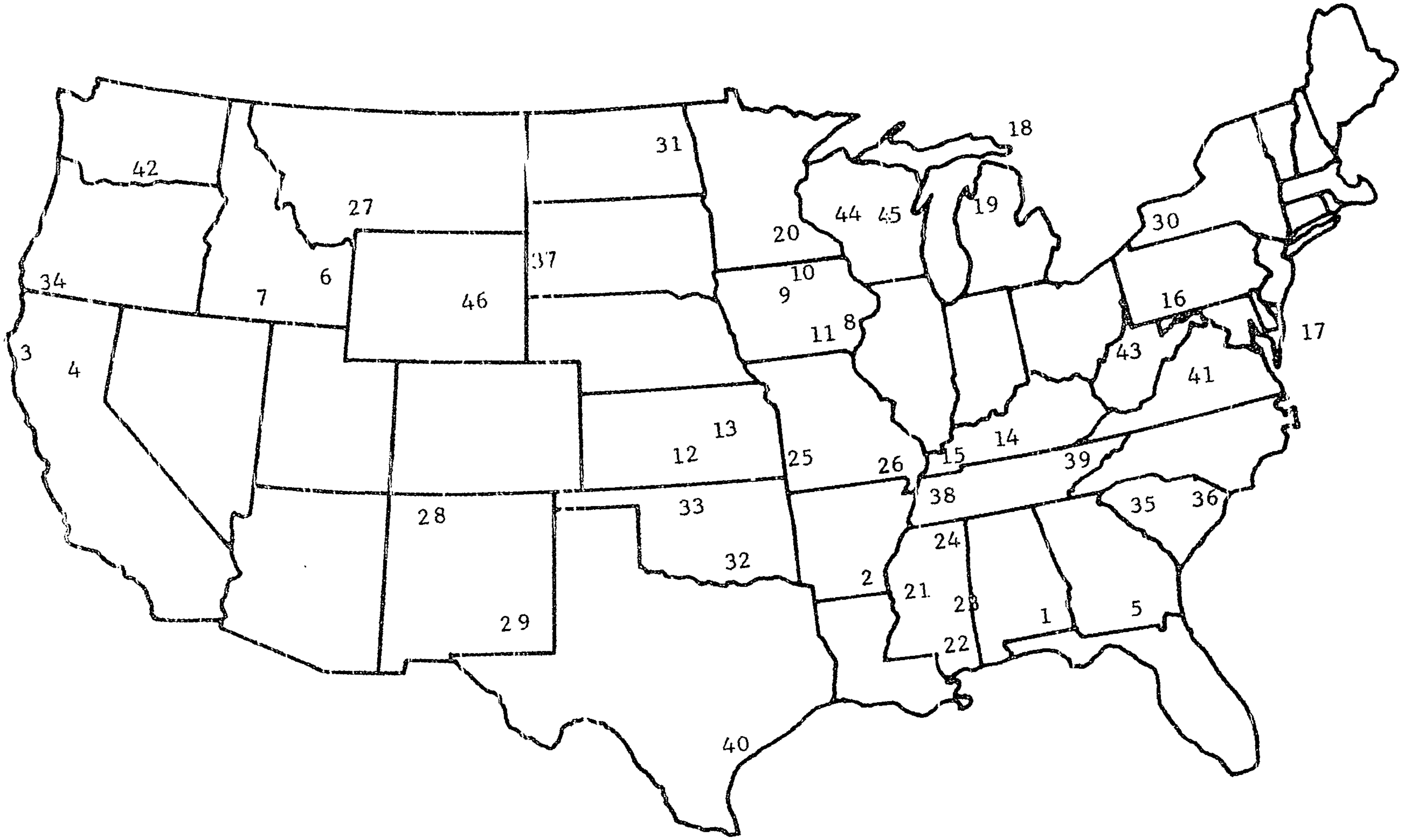
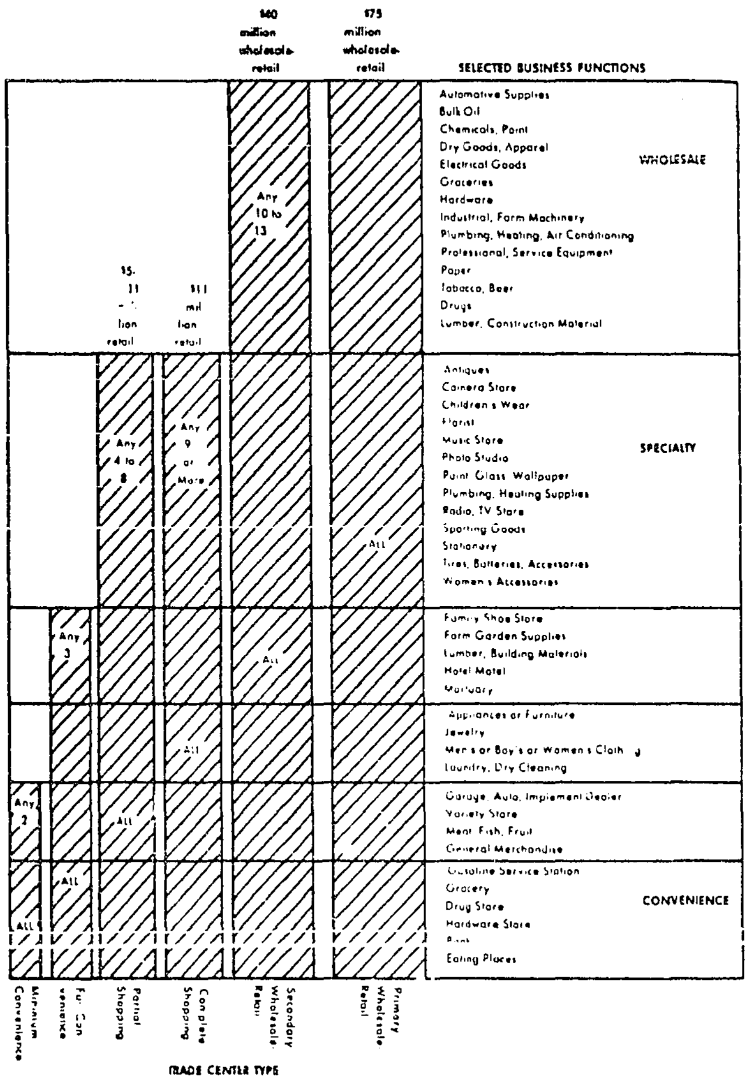


Figure 13. Location of sample FEA's



Graphic summary of characteristics of six levels in the Trade Center hierarchy. Type of center is indicated at base of each bar. Types of business are listed in right-hand column. Businesses which were required and optional in defining each type of Trade Center are indicated by markings on each bar. Width of bar is proportional to dollar volume as indicated for Partial Shopping Center, and above.

Figure 14. Hierarchy of service centers (14, p. 4)

The central cities of the sample FEA's are assumed to be of order three. Thirty-six of these meet the population and sales criteria for secondary wholesale-retail centers and the remaining ten, while having populations below 25,000, easily exceed the sales criterion.

Cities which meet both the size and sales requirements for complete shopping centers are defined as order two cities. In addition, in ten FEA's cities with less than 5,000 people, but more than 2,500 people, are defined as second order if they meet the sales criterion and the sizes of the central city or the other second order cities are low enough to warrant inclusion.

All other places in the region are defined as first, or lowest, order cities. From a practical point of view, individual series of data are not readily available for many of these places. Therefore observations for the first order cities are calculated as residuals from the regional totals after deducting for the higher order places and the rural farm sector. A listing of second and third order places is included in Appendix A.

Data collection

The availability of disaggregated regional data led to the definition of three sub-sectors in each region. The farm sector includes farm residents in all of the counties in each region. Thus there are 46 observations on each variable in this sector. The urban sector includes the second and third order cities. This sector has 92 observations on each variable, 46 for the total over all second order cities within a region and 46 for the third order city. Finally, the rural sector includes the first order places and the nonfarm rural residents. Again, this data was generated as a residual after the above two sectors had been deducted from the regional totals.

The model discussed in Chapter III is based largely upon land use requirements. Thus many of the relationships are in terms of land. Unfortunately, consistent series of land use data for nonfarm uses are not available. Therefore, data collection was an attempt to approximate the general nature of the model. The resulting variables are total figures for the various subsectors. Appendix B contains a list of the variables, the sources of the data and explanations of any adjustments made to the published figures.

Characteristics of the sample

The average population of the sample regions is 147.6 thousand. A percent breakdown by sectors yields 11.6 percent in the farm sector, 48.6 percent in the nonfarm rural area plus first order cities, 16.8 percent in the order two cities, and 23.1 percent in the third order places. The rather large rural population may be a result of some unavoidable misclassification. Although every effort was made to include contiguous places as a single city, it was often impossible for relatively small "suburbs" because of a lack of reported data. In addition, strictly rural nonfarm residents can not be readily allocated to any urban place. Therefore, residents in either of these two situations are grouped in the lowest order. Table 1 contains comparative statistics on the population distribution.

A review of the distribution of the manufacturing employment yields similar results (see Table 2). Perhaps the most noticeable point is that an even larger percent of the manufacturing employees live in the lowest order places than is evidenced by the population in general: 66.2 percent to 54.9 percent. Compare this to the decline in the central city, where 26.1 percent of the nonfarm population but only 17.7 percent of the manufacturing employees reside. On the other hand, the distribution of service employees, shown in Table 3, indicates the reverse, a decline in the percent residing in the lower order places and increases in the higher order places, especially the central city.

The lower level of concentration among the manufacturing employees may reflect either a correspondingly lower level of concentration among manufacturing firms or a greater willingness upon the part of manufacturing employees to commute relatively long distances to the work place. If there is a dispersal of manufacturing, it is interesting to note the relative distribution of the wage bill (Table 4) implies a lower wage rate for the employees in the low order places since the wage bill is less than would be expected based upon the distribution of employees. Whether this is a cause of the dispersal or a result of the types of firms which are less affected by centrality is beyong the present investigation.

The greater concentration in the service employee distribution reflects a sensitivity to central location. This, of course, is consistent with the marketing principle of central places. An even higher level of concentration is shown in the service sales figures (see Table 5). Here, the central place assumes the dominant position by selling nearly twice what would be expected based on its own resident population and the second order cities also sell in excess of expectations. Taking the employee distribution and the sales distribution both into consideration seems to indicate that the higher order cities are providing a service function to residents beyond their own boundaries. In addition, a comparison of the sales to the employee distribution indicates that the services offered at each level varies, with the larger places providing a higher valued (i.e. higher order) commodity.

There is also a difference among incomes at the three nonfarm levels. Comparing the distribution of total income, shown in Table 6, to the distribution of population indicates a potential ordering of incomes such that lower order places tend to have lower incomes.

In addition to the differences across the levels of nonfarm places, there appears to be some regional variation among the geographic areas of the country. This variation is most pronounced at the lowest level places in the south and at the second level in the west. These variations, shown in Table 7, lead to the use of regional dummy variables for several of the equations.

Table 1. Distribution of the regional population

	Average population total class (in thousands)	Percent of regional total	Percent of nonfarm population	Average population per city (in thousands)
Third order places	34.1 (10.4)[a]	23.1	26.1	34.1 (10.4)
Second order places	24.7 (16.7)	16.8	18.9	6.4 (3.0)
First order places	71.6 (39.5	48.6	54.9	
Nonfarm total	130.5			
Farm	17.1 (11.6)	11.6		
Total	147.6			

[a]Standard deviations in this and the following five tables are shown in parentheses.

Table 2. Distribution of the regional manufacturing employment

	Average Mfg. employment total class (in thousands)	Percent of regional total	Average Mfg. employment per city (in thousands)
Third order places	2.4 (1.5)	17.7	2.4 (1.5)
Second order places	2.2 (1.9)	16.2	0.5 (0.4)
First order places	9.0 (10.2)	66.2	
Total	13.6		

Table 3. Distribution of the regional service employment

	Average Service employment-total class (in thousands)	Percent of regional total	Average Service employment per city (in thousands)
Third order places	10.2 (3.2)	30.7	10.2 (3.2)
Second order places	7.0 (4.7)	21.1	1.8 (0.8)
First order places	16.0 (8.0)	48.2	
Total	33.2		

Table 4. Distribution of the regional manufacturing wage bill

	Average Wage Bill total class (in millions)	Percent of regional	Average Wage Bill per city (in millions)
Third order places	12.6 (9.9)	24.9	12.6 (9.9)
Second order places	11.4 (7.3)	22.5	3.4 (2.4)
First order places	26.7 (26.5)	52.7	
Total	50.7		

Table 5. Distribution of the regional service sales

	Average Service sales-total class (in millions)	Percent of regional	Average Service sales per city (in millions)
Third order places	174.7 (66.1)	42.2	174.7 (66.1)
Second order places	105.0 (77.9)	25.4	26.6 (12.5)
First order places	134.4 (86.0)	32.5	
Total	414.1		

Table 6. Distribution of the regional income

	Average income total class (in millions)	Percent of regional	Average income per city (in millions)
Third order places	96.0 (31.1)	30.1	96.0 (31.1)
Second order places	64.7 (46.9)	20.3	6.7 (8.5)
First order places	158.6 (85.9)	49.7	
Total	319.3		

Table 7. Geographic variations in the average populations

	Average Total population (thousands)	Average service population (thousands)	Average Mfg. population (thousands)
Third order places			
South	33.9	10.0	2.8
North	33.5	9.8	3.3
West	33.5	10.7	1.5
Second order places			
South	28.1	7.6	3.0
North	29.0	8.1	3.0
West	18.1	5.6	0.8
First order places			
South	102.4	20.0	13.3
North	59.0	16.1	10.4
West	49.7	11.4	2.7

CHAPTER V. THE EMPIRICAL MODEL AND RESULTS

The empirical model

The following model is constructed in an attempt to test the regional mechanism discussed in Chapter III while recognizing the limited amount of data available for small places. This respecification is not without major compromises. In particular, the lack of land use data makes it impossible to determine the maximum manufacturing rent (MR) which reflected the nationally established demand for manufacturing exports. The original model hypothesized that the region responded to the MR and endogenously determined the total value of the export good to be produced by allowing the manufacturing sector to bid land away from the agricultural sector. Without an estimate of MR, total manufacturing sales can be used as a surrogate measure but only at the expense of taking the allocation of land between urban and farm use as predetermined.

Without a disaggregation of urban land by sectors, it is not possible to estimate either directly or, as will be seen, indirectly, the employee-land ratios. The lack of this data makes it impossible to test the service and residential sector income equations.

Three features of the original model remain subject to estimation. The first is the dependency of the regional economy, in income and employment, upon the basic sectors. The second is the intra-regional distribution of the service employment, and the third is the total urban land required to support the service and manufacturing functions. This last relationship can only be estimated for the higher order places since generally not even total urban land statistics are available for the first order places.

The degree to which it is possible to disaggregate the regional variables also affects the structure of the model. Ideally, it would be advantageous to partition each region into subregions, following, as much as possible, a Christaller hierarchy; in practice, such a partitioning is impossible. Instead, the farm sector is handled on a total basis, as are the nonfarm sectors. However, since there are fewer series of data available for the first order places, the nonfarm sectors are grouped into two classes: the rural sector, composed of the nonfarm rural and the first order places, and the urban sector, composed of the second and third order cities.

Three equations estimate farm employment and income, given the quantity of agricultural land within the region. These equations are

F1. $$Ea_i = a_{10} + a_{11}Ls_i + a_{12}Ln_i + a_{13}Lw_i + a_{14}S_i + a_{15}N_i + a_{16}F_i + u_i$$

F2. $$Pa_i = a_{20} + a_{21}Eas_i + a_{22}Ean_i + a_{23}Eaw_i + u_i$$

F3. $$Ya_i = a_{30} + a_{31}A_i + u_i$$

where Ea = agricultural employment, and Eas, Ean, and Eaw differ from Ea in that they have been dummied by geographic regions, i.e., South, North, and West;

Ls, Ln, Lw = agricultural land areas in the South, North and West;

Pa = total farm population;

Ya = total farm income from all sources;

S = 1 if the region is in the South and zero otherwise;

N = 1 if the region is in the North and zero otherwise;

F = farm value per acre; and

A = total agricultural sales;

u = the error terms; and

i indexes the regions, 1 ..., 46.

Equation F1 estimates the agricultural employment based on the rural land area. The use of geographic dummy variables on both the intercept and the slope coefficients is an attempt to account for regional differences in agriculture among regions. The farm value per acre variable is introduced to proxy for land productivity.

The model in Chapter III defines a region's population as being equal to the regional employment. Equation F2 corrects for this abstraction by estimating the total regional farm population as a function of farm employment. Equation F3 estimates total regional farm income based on total regional farm sales.

The rural sector includes a rather wide range of places extending at one extreme from places of 5000 people to the other extreme of one household. This variation is a result of the fashion in which the regional statistics are reported. For the purposes of this research, it is not possible to further disaggregate the data. However, because of the extreme variability, it was not considered reasonable to include the rural sector with the other nonfarm places. Nonetheless, this sector provides substantial service functions which, in total, will be considered as first order.

Five equations specify the relationships in the rural sector. The primary exogenous variables are manufacturing value added, assumed to be exogenous to the entire region, and agricultural employment, endogenous to the region but predetermined to the nonfarm sectors. The five equations are

R1. $Mr_i = b_{10} + b_{11}V_i + b_{12}F_i + b_{13}D_i + b_{14}W_i + u_i$

R2. $Sr_i = b_{20} + b_{21}(Mr'_i + Ea_i) + b_{22}S_i + b_{23}N_i + u_i$

R3. $Pr_i = b_{30} + b_{31}(Mr'_i + Sr_i) + u_i$

R4. $SSr_i = b_{40} + b_{41}Sr_i + b_{42}F_i + b_{43}W_i + u_i$

R5. $Yr_i = b_{50} + b_{51}SSr_i + b_{52}TW_i + u_i$

where Mr = total manufacturing employment, and Mr' differs from Mr by mining employment, which has not been estimated;

V = total value added in manufacturing;

F = farm value per acre;

D = the distance to the nearest metropolitan center;

W = the local annual wage rate in manufacturing;

Sr = the total service sector employment;

Pr = total rural employment;

Ssr = total rural sector sales in retailing, service and wholesaling;

Yr = total rural sector income;

TW = total manufacturing wage bill;

u = the error terms; and

i indexes the regions, 1 ... 46.

In the reduced form discussion of Chapter III, it was noted that, given an urban size for an isolated city, there is only one manufacturing population consistent with the land use ratios. By fixing the agricultural land and allowing no constraint on the urban area, a similar situation arises. Thus Equation R1 could be interpreted as an attempt to estimate the manufacturing employment based on relatively crude surrogates for the determinants of the manufacturing land area. However, the necessity for using total manufacturing value added requires that this equation be read in the contexts of the export base model where the national economy dictates the value of the export commodities of the region. Since the major exogenous variable is in value terms, farm value, distance to the nearest metropolitan center and annual manufacturing wage rate are introduced in order to deflate the value added. Thus, if there is a fixed labor-land ratio, the farm value serves as an estimate of the cost of manufacturing land incorporated into the value added figure. Similarly, the distance variable proxies for transportation costs and the manufacturing wage rate adjusts for differing labor costs.

Equation R2 estimates the regional service population as a function of the base population. The coefficient b_{21} is an estimate of the Beckmann-McPherson first order urban multiplier, which has been shown to be equal to the economic base ratio for the lowest order places. The intercept term and the geographic dummy variables should provide a test for the equality of the average and marginal propensities to consume locally and of any geographic variability if such equality does not hold (6).

Equation R3, like F2, estimates the subsector population given the total work force. Total rural service sales, R4, is estimated in essentially the same fashion as manufacturing employment. The farm value per acre and the annual manufacturing wage rate are used as surrogates for the price of service land and labor. The fifth equation estimates total rural income as a function of the basic and nonbasic wages. However, since there is no data on service wages, total service sales serves as a proxy.

The urban sector is composed of the regional central place and the second order cities. Thus for each region there are two observations as opposed to one in the previous sectors. In addition, the availability of land area data allows for the urban size to be estimated. The six equations for this sector are

U1. $Mu_{ij} = c_{10} + c_{11}V_{ij} + c_{12}F_i + c_{13}D_i + c_{14}W_{ij} + u_i$

U2. $Su_{ij} = c_{20} + c_{21}(N_i/N_i{+}1)C_2(Mr'_i + Ea_i) + c_{22}C_2Mu'_i$
$+ c_{23}(1/N_i{+}1)C_1(Mr'_i + Ea_i) + c_{24}[(N_i/N_i{+}1)C_1(Mr'_i + Ea_i)$
$+ C_1Mu'_i] + c_{25}Mu'_i + c_{26}s_i + c_{27}n_i + u_{ij}$

U3. $Pu_{ij} = c_{30} + c_{31}(Mu_{ij} + Su_{ij}) + u_{ij}$

U4. $Lu_{ij} = c_{40} + c_{41}Pu_{ij} + c_{42}Mu_{ij} + c_{43}Su_{ij} + c_{44}Z_{ij} + c_{45}F_i + u_{ij}$

U5. $SSu_{ij} = c_{50} + c_{51}C_1Su_{ij} + c_{52}C_2Su_{ij} + c_{53}F_i + c_{54}W_{ij} + u_{ij}$

U6. $Yu_{ij} = c_{60} + c_{61}SSu_{ij} + c_{62}TW_{ij} + u_{ij}$

where Mu = the urban manufacturing employment;

Mu' = the manufacturing employment in the second order cities;

Mu" = the manufacturing employment in the central place;

Su = the urban service employment;

N = the number of second order places in the region;

C_1 = 1 if j = 1, zero otherwise;

C_2 = 1 if j = 2, zero otherwise;

P_u = total urban population;

L_u = total urban land area;

Z = 1 if j = 1, zero otherwise;

SSu = total sales in retailing, service and wholesaling;

Yu = total urban income;

s = 1 if the region is in the south and zero otherwise;

n = 1 if the region is in the north and zero otherwise;

TW = total manufacturing wage bill;

u = the error terms;

i indexes the regions, 1 ... 46.; and

j indexes the order of the places, 1 = the central place and 2 = the second order places.

Equations U1, U3, and U6 are the same as their counterparts in the rural sector. Equation U2 is similar to R2. The differences are a result of the different order of goods that higher order places provide. Thus the first term after the intercept represents the total basic population buying only second order goods in the second order cities, and the next term accounts for the basic population which buys first and second order goods in the second order cities. Correspondingly, the third term after the intercept is the regional basic population which buys goods of order two and three at the central place, the fourth term is the basic population which buys only third order goods at the central city, and the fifth term represents the basic population which buys all three levels of goods at the central place. For places above the first order, the coefficients on the basic populations are not directly the Beckmann-McPherson urban multipliers. However, they can be converted to a comparable basis. This conversion will be discussed with the presentation of the results.

Equation U4 estimates the urban land required to support the urban functions. Ideally, the urban limit should be determined as in the first equation of the reduced form on Chapter III. A second best alternative would be to estimate individually the service, residential and manufacturing land as functions of their respective populations. The insufficiency of the data made both of these alternatives impossible. Therefore, Equation U4 represents the sum of the results expected from the second alternative. Since the land area of both second and third order places is estimated by one equation, a dummy variable is included to pick up differences in the intercept. In addition, the regional farm value per acre is introduced to serve as a measure of the expense of converting farm land to urban use.

The service sales equation, U5, is comparable to R4 except that the service populations have been segregrated by city order. This is in keeping with the distribution of service sales which indicated a higher sales per employee in the central place.

The model just presented is fully recursive. Thus, with traditional least squares assumptions about the error structure for each equation and the assumption that the errors among equations are statistically independent, each of the fourteen equations can be estimated using ordinary least squares. The results of this estimation follow.

Farm sector results

The results of the estimation of the three farm sector equations are found in Table 8. Agricultural employment is significantly and positively related to the quantity and value of the regional farm land. Both results are as expected. With respect to the quantity of regional farm land, the relationship between agricultural employment and the amount of farm land reflects differences in the regional size so that FEA;s which are larger in area would be expected to contain a larger number of agricultural employees. However, there are some regional differences indicated. Whereas the coefficients on Southern and Northern agricultural land are similar, that on Western agricultural land differs significantly from either of the others. These differences imply a more intensive utilization of Southern and Northern agricultural land.

The farm value per acre variable summarizes a variety of influences which may account for differing levels of labor intensity. If the original assumption about the nature of the agricultural production functions holds, i.e., that it is linear, and that land value is a residual, the positive relationship between agricultural employment and farm value implies that demand is relatively greater for farm commodities which have higher labor-land ratios. Since there is no clear reason why this should

Table 8. Farm sector results

Dependent Variable/ Independent Variable	Regression Coefficient	T-Value
Equation F1, Agricultural Employment (in thousands)/		
Intercept	1.567	1.44
Southern Agricultural Land[a]	0.00269	3.22***[b]
Northern Agricultural Land[a]	0.00307	3.47***
Western Agricultural Land[a]	0.00045	2.22**
Southern Dummy Variable	-1.987	-1.52
Northern Dummy Variable	-2.236	-1.43
Farm Value per Acre ($)	0.00925	2.60**
F Test	9.16***	
$\bar{R}^2$	.52	
Equation F2, Farm Population (in thousands)/		
Intercept	0.597	0.35
Southern Agricultural Employment (thousands)	3.302	9.49***
Northern Agricultural Employment (thousands)	3.823	12.97***
Western Agricultural Employment (thousands)	2.768	7.34***
F Test	59.93***	
$\bar{R}^2$	.80	
Equation F3, Agricultural Income ($ million)/		
Intercept	10.802	2.81***
Agricultural Sales ($ million)	0.335	9.02***
F Test	81.3***	
$\bar{R}^2$	.64	

[a]Thousands of acres.

[b]Significant tests are indicated as *, **, and *** at the 10%, 5%, and 1% levels respectively.

be true, a reevaluation of the assumptions may prove profitable. A more realistic assumption would be to recognize differing levels of land productivity. Under such an assumption, more productive land would be worked more intensely, output would be greater, and the returns to land also higher. In this case the positive sign on the farm value coefficient is the expected sign.

An additional point must be considered when viewing the results of this and subsequent employment equations. The employment series used in this analysis is that for the regional residents. Thus commuting to a work place in a higher or lower order sector is assumed to be zero. In this case, the reported coefficients understate the true labor-land ratios to the degree that there is in-commutation to farm work places from non-farm residential places. Correspondingly, a differential rate of in-commutation among the geographic regions will lead to the regionalized coefficients being differentially impacted.

Equation F2 estimates the relationship between the farm sector work force and the total population. Under the assumption of one working member per household, the coefficients on the farm employment variables are comparable to average family size statistics. However, to the extent that more than one member of each family may be employed, these coefficients will understate the true average family size.

It is interesting to note the rather substantial variation in the population to employment ratios evidenced across the geographic regions. These differences may be due to geographic differences in the average family size or to variations in the average number of family members employed in the farm sector. It seems probable that it is this last possibility which should account for most of the variation noted. Differences in the average number of farm household members employed in the farm sector may, in turn, be due to differences in the level of alternative employment present in the region. Thus, where there is a low level of alternative employment in either manufacturing or service, the ratio of farm population to employment should be lower as a result of higher average per family farm employment.

In addition to the availability of alternate employment, the wage rate of such employment relative to the returns to farm employment may affect the choice between farm or nonfarm employment. In this case, if alternate wage rates are high relative to farm income, a greater portion of farm residents might be expected to work outside of the agricultural sector. The average annual manufacturing wage rate for the South, North, and West are 5.1, 5.3, and 6.2 thousand dollars respectively. These average figures imply that, other things being equal, the Western coefficient should be relatively high and the Southern and Northern coefficients low.

A final consideration might be the need for multiple employment. High income per farm unit has dual implications. In the first instance, such income may act to induce retention of the labor force in the agricultural sector. However, if high income is a result of land productivity and production techniques which reduce the required labor-land input ratio, the manpower released may seek employment outside the agricultural sector or not seek employment at all. A review of the average farm income shows that Southern farms have relatively low incomes of 2.2 thousand dollars per farm resident as compared to farms in the North and West which both have average incomes of 2.5 thousand dollars per resident.

Since the estimated coefficients fall into none of the patterns described above, it is not possible to clearly rationalize the observed pattern. Presumably, the actual coefficients summarize the interaction of the various forces in such a fashion that it is not feasible to specify the individual impacts within the contexts of this model.

Equation F3 estimates the relationship between total regional farm income and total regional agricultural sales. Farm income is defined as the total income accruing to farm residents regardless of the place of employment. It therefore overstates the income derived solely from agricultural sales. With this qualification in mind, equation F3 implies that farm income averages in excess of one third of farm sales with the marginal change in income with changes in sales at .335 of the sales change.

The results of the estimation of the farm sector equations are in general agreement with the assumptions pertaining to this sector vis a vis the urban sectors. Although it is beyond the scope of this investigation to explain the complex forces which shape the detail of the farm sector, it was considered informative to present the basic form based on the assumption that the regional farm variables are simply related to the regional size and national levels of demand for farm output. Thus the convenient assumption of a uniformly distributed farm population may be retained in the construction of the nonfarm places serving the region.

Rural sector results

The results of the rural sector estimation are shown in Table 9. As a general statement, the results of the central place relationships in equations R2 and R3 are more satisfying than those of the export base relations. This is especially true in light of the results of comparable relationships specified in the urban sector. Perhaps the diversity of places included in the rural sector may partially explain the quality of the results.

Equation R1 was proposed as an explanation of the level of manufacturing employment in which the level of output was assumed to be exogenously determined in an economic base framework. Thus the sign and the significance of the coefficient associated with value added in manufacturing are consistent with this assumption. The other variables which were introduced to adjust for the fact that the dependent variable is in real terms and the primary independent variable is in value terms were all insignificant. Nonetheless, the signs on the distance and wage variables were negative and indicate that potentially the additional costs accruing to regions lying farther from major metropolitan areas or having higher wage rates should be accounted for prior to estimation of the employment to value added relationship. On the other hand, the coefficient on farm value per acre is positive. This is unexpected under the assumption that the value of farm land acts in deflating land cost differentials entering into the value added figures or under the framework initially discussed in which farm value serves to define the limits of the urban places. The dummy variables were included based on the

Table 9. Rural sector results

Dependent Variable/ Independent Variable	Regression Coefficient	T-Value
Equation R1, Rural Manufacturing Employment (in thousands)/		
Intercept	7.2288	0.99
Value Added in Manufacturing ($ million)	0.0732	2.70***[a]
Farm Value per Acre ($)	0.0080	0.61
Distance to Metropolitan Center (miles)	-0.0071	-0.63
Annual Manufacturing Wage Rate ($ thousands)	-0.8691	-1.04
Southern Dummy Variable	2.4102	0.61
Northern Dummy Variable	4.4535	1.06
F Test	4.30***	
$\bar{R}^2$	.30	
Equation R2, Rural Service Employment (in thousands)/		
Intercept	7.9007	5.09***
Rural Basic Employment and Farm Employment (thousands)	0.4267	5.06***
Southern Dummy Variable	4.3302	2.08**
Northern Dummy Variable	0.6073	0.25
F Test	15.33***	
$\bar{R}^2$	.49	
Equation R3, Rural Population (in thousands)/		
Intercept	23.432	3.36***
Rural Basic Employment (thousands)	1.889	8.16***
F Test	66.58***	
$\bar{R}^2$	.59	

[a] Significant tests are indicated as *, **, and *** at the 10%, 5% and 1% levels respectively.

Table 9. Continued

Dependent Variable/ Independent Variable	Regression Coefficient	T-Value
Equation R4, Rural Service Sales (in $ million)/		
Intercept	-33.663	0.83
Service Employment (thousands)	5.026	4.14***
Farm Value per Acre ($)	0.315	3.74***
Annual Manufacturing Wage Rate ($ thousand)	3.477	0.50
F Test	15.68	
$\bar{R}^2$	.49	
Equation R5, Total Rural Income (in $ million)/		
Intercept	60.381	5.26***
Rural Service Sales ($ million)	0.230	3.06***
Total Wage Bill in Manufacturing ($ million)	2.519	10.33***
F Test	80.31	
$\bar{R}^2$	.78	

geographic variation observed in the average level of manufacturing employment. However, these variables also proved to be insignificant.

The overall results for this equation are summarized by the $\bar{R}^2$ of .30. Thus a substantial amount of variation remains unexplained. Although the coefficient of 0.073 associated with value added in manufacturing is not substantially different from the comparable coefficient in the urban sector of 0.087, the explanatory power of this variable is much weaker in the rural sector. Since the amount of manufacturing employment in the rural sector is large relative to that in either the second or third order places, the differences between these equations is probably a result of greater variation in the types of manufacturing performed in the rural sector rather than a variation based upon the delineation of the regions or of the regional subsectors.

The rural service employment equation, R2, introduces the first intraregional dependency between employment sectors. As was discussed earlier, the coefficient on the basic employment variable yields an estimate of the Beckmann-McPherson (6) urban multiplier for first order places. Thus, 0.43 service employees are necessary to provide first order goods and services for each basic employee in the first order market areas. This figure is comparable to the multiplier noted as k_1 in previous discussions. However the Beckmann and the Beckmann-McPherson discussions are primarily in terms of the ratio of the serving population to the serviced population, noted above by h where

$$k_1 = h_1/1-h_1.$$

Given the estimate of k_1 of 0.43, an estimate of h_1 is

$0.43 = h_1/1-h_1$, or

$h_1 = .30.$

Thus the implication is that three service employees are needed to provide first order goods and services for every ten regional employees, either basic or service.

The fact that the intercept term in this equation is highly significant indicates that the underlying assumptions in the economic base theory and hence in the Beckmann-McPherson analysis may not be satisfied. It has been shown that in order for the base ratio to be applicable, it is necessary that the marginal propensity to consume locally provided goods and services be equal to the average propensity to consume local goods. Thus, if the base ratio is valid over a wide range of domestic production, the expected value for the intercept term is zero. The fact that the estimated value is significantly different from zero implies that an observed ratio of service to basic employment is applicable only for the particular level of total observed population.

In addition, the dummy variables indicate a geographic variation in the intercept. Although this variation is consistent with the average level of service employment variation observed among regions, it also has consequences for the economic base theory such that a particular base ratio at a given population may not even be appropriate for use nationwide.

Equation R3 estimates the rural sector population as a function of total rural employment. The results of this equation must be viewed in light of the residential population equations in the farm and the urban sectors. Perhaps the most obvious point is the rather low coefficient on employment. Other things being equal, the implication is that the average family size in the rural sector is 1.9 people. Of course, this conclusion results only if a single member of each household is employed. However, even if multiple employment per household is accepted, the estimated coefficient of 1.9 is still low in relation to the coefficients for the farm and urban sectors. Thus smaller family sizes or greater multiple employment per household is indicated.

However the size of the intercept term in this equation is such that the previous statement must be qualified. If this term were near zero, the small coefficient on employment would approximate the average family size per employee; but since the intercept is positive and large, the coefficient of 1.9 understates the actual average, potentially by a substantial amount. Thus this coefficient should not be compared directly to the coefficients in the farm or urban sectors without qualification.

A final point of consideration is the amount of regional variation left unexplained by this equation. The $\bar{R}^2$ for this equation is .59 as compared to $\bar{R}^2$'s of .80 and .96 in the farm and urban sectors respectively. Apparently there is greater variation in either the average family size or the number of family members employed for the rural sector than for the other sectors. This increased variation may be a result of the method used to define the sector and therefore a point of questionable importance, or it may represent a true difference in the characteristics of the rural population. Unfortunately, there is insufficient data in this study to distinguish between these alternative explanations.

The relationship between service sales and service employment is estimated by Equation R4. The underlying theory for this equation is the same export base concept which was employed in Equation R2. Recall that the export base theory was framed both in population and, via a transformation, value terms. Hence appropriate base ratios can be used to express the local service population as a function of the export population or the value of service income as a function of export income, so that population and income are two measures of the same base relationship.

Where Equation R2 estimated the multiplier impact between service population and export population, Equation R4 estimates the transformation of service population to value of output. The results indicate that service employees have a marginal impact upon sales volume of slightly more than $5 thousand. This value is low in comparison to the impacts estimated for higher order places and is in keeping with earlier statements as to the value of the product sold at the various orders of urban places.

Farm value per acre and the annual manufacturing wage rate were incorporated into this equation in order to account for regional variations in the price levels of the inputs. The farm value variable proved to have a significant impact and to be of greater consequence in the rural sector than in the urban places. The wage rate variable is insignificant for all sectors.

The last equation for the rural sector estimates total rural income as a function of the manufacturing wage bill and total service sales. If the only regional factor were labor and if the service sector wage bill were available, this equation would be an identity such that total rural income would be equal to the sum of the service sector and manufacturing sector wage bills. Given labor as only one of several factors, a regression of rural income on the wage bills should yield coefficients in excess of one on each of the subsector wage bills. In fact this is true for the manufacturing wage bill. However, the estimated coefficient is substantially larger than one and indicates that the addition to rural income associated with one dollar of wages is $2.5. The implication is that the payment to other factors is large and hence the productive techniques may be surprisingly capital or land intensive.

The coefficient on service sales is 0.23. Since the wage bill for the service sector is unavailable, total service sales is used as a proxy. Thus if the service wage bill is a proportion of the sales level, the estimated coefficient associated with the sales variable is understandably less than one. However, the total income generated by this sector is greater than that associated with the labor payment alone, and therefore the estimated coefficient should be larger than the proportion of the service wage bill to service sales.

The results of the estimation for the rural sector have provided a set of base relationships against which the results of the urban sector can be compared. Again it is necessary to point to the substantial variations which are left unexplained, presumably due to the method of classifying the available data. However, under the assumption that the results adequately represent a uniformly distributed rural, nonfarm population and the lowest level of urban places, the central place and export base relationships generated are useful in evaluating the hierarchial interdependencies of the entire region.

Urban sector results

The six equations comprising the urban sector present evidence for concluding that there exists an hierarchial ordering of urban places in nonmetropolitan regions. This ordering is supported by the location of service functions distributed in a fashion consistent with central place theory. Correspondingly, Keynesian-type relations between base and nonbase activity also appear to be valid, although the simple economic base assumptions again are shown to be unsupported. The results of the urban sector estimation are presented in Table 10.

Equation U1 is the urban sector equivalent of Equation R1. Urban manufacturing employment is significantly related to the assumed exogenous level of value added in manufacturing. The magnitude of this relationship is 0.087 as compared to the comparable figure of 0.073 in the rural sector. Thus the labor inputs in both the rural and urban manufacturing sectors are quite similar on the average. However the variability within each sector is quite different. The standard error of the coefficient in the rural sector is 0.027 as opposed to that in the urban sector of 0.007. In addition, the $\bar{R}^2$ for Equation R1 is 0.30, whereas that for U1 is 0.75.

The farm value, distance, and wage rate variables are not significant. This is consistent with the results for the rural sector. However, all three variables have negative signs which is consistent with the intent that they be used to adjust for regional variations in the

Table 10. Urban sector results

Dependent Variable/ Independent Variable	Regression Coefficient	T-Value
Equation U1, Urban Manufacturing Employment (in thousands)/		
Intercept	0.794	1.24
Value Added in Manufacturing ($ million)	0.0872	11.63***[a]
Farm Value per Acre ($)	-0.0003	-0.28
Distance to Metropolitan Center (miles)	-0.0006	-0.68
Annual Manufacturing Wage Rate ($ thousands)	-0.0313	-0.35
Southern Dummy Variable	0.8507	3.04***
Northern Dummy Variable	0.7487	2.47***
F Test	46.72***	
$\bar{R}^2$	.75	
Equation U2, Urban Service Employment (in thousands)/		
Intercept	3.926	4.48***
Basic and Farm Employment in the Second Order Good Market Area of the Second Order Cities (thousands)	0.210	4.10***
Basic and Farm Employment in the Highest Order Good Market of the Third Order City (thousands)	0.110	2.52***
Southern Dummy Variable	-1.094	-1.16
Northern Dummy Variable	-0.756	-0.69
Dummy Variable for the Central Place	7.044	5.67***
F Test	19.30***[b]	
$\bar{R}^2$	.50[b]	

[a]Significant tests are indicated as *, **, and *** at the 10%, 5%, and 1% levels respectively.

[b]These figures are based upon the sums of squares associated with the adjusted service employments.

Table 10. Continued

Dependent Variable/ Independent Variable	Regression Coefficient	T-Value
Equation U3, Urban Population (in thousands)/		
Intercept	1.076	1.57*
Urban Employment (thousands)	2.608	46.43***
F Test	2155.8***	
$\bar{R}^2$	.96	
Equation U4, Urban Land Ares (square miles)/		
Intercept	4.666	2.71***
Urban Manufacturing Employment (thousands)	1.313	2.73***
Urban Service Employment (thousands)	0.729	3.70***
Dummy Variable for Central Place	-1.015	-0.76
Farm Value per Acre ($)	-0.009	-1.54
F Test	14.43***	
$\bar{R}^2$	.37	
Equation U5, Total Urban Service Sales ($ million)/		
Intercept	-19.409	-1.04
Service Employment in Second Order Places (thousands)	14.245	12.22***
Service Employment in Third Order Places (thousands)	16.204	15.43***
Farm Value Per Acre ($)	0.107	2.99***
Annual Manufacturing Wage Rate ($ thousands)	0.695	0.20
F Test	76.55***	
$\bar{R}^2$	.77	
Equation U6, Total Urban Income (in $ million)/		
Intercept	11.617	2.21**
Urban Service Sales ($ million)	0.453	15.86***
Total Manufacturing Wage Bill ($ million)	0.445	1.69*
F Test	133.43***	
$\bar{R}^2$	.74	

factor price levels. The dummy variables for the south and north geographic regions both have significant coefficients in the urban sector, indicating that there is a significant regional variation in the intercept term.

Equation U2 was estimated in accordance with the form presented above. The results of this estimation were considered to be questionable based upon problems within the data. The coefficients for each of the basic sectors are forms of the Beckmann-McPherson urban multipliers and as such should have positive signs (6). The actual results were grossly contrary to these expectations. In fact all coefficients except that on an urban place's own basic employment were negative. The problem lies in the additive nature of the equation as opposed to the interdependent nature of the system hypothesized. A look at the correlation matrix for this equation supports the conclusion that the data are plagued by multicollinearity. The matrix of raw correlation coefficients is presented in Table 11. The high correlation among the basic employment sectors impacting a particular service level, noted by the underscored figure for second order service employment and the figures in parentheses for the third order service employments, makes it impossible to interpret the estimated coefficients of the regression equation.

The presence of multicollinearity leads to difficulty in sorting out the influence which should be attributed to each independent variable. However, the structure of this system does afford a method of estimation which adjusts for the data difficulty. Consider equation U2.1, which is the analogue to U2 for estimating the service employment in only the

Table 11. Raw correlation coefficients among basic populations

	(1)	(2)	(3)	(4)	(5)
(1) Farm and rural basic employment demanding second order goods at a second order city	1.000				
(2) Manufacturing employment in a second order city	<u>0.885</u>	1.000			
(3) Farm and rural basic employment demanding second order goods at a third order city	-0.460	-0.451	1.000		
(4) Basic employment demanding only third order goods from a third order city (1+2)	-0.531	-0.521	(0.895)	1.000	
(5) Manufacturing employment in a third order city	-0.480	-0.471	(0.743)	(0.917)	1.000

second order city.

$$\text{U2.1} \quad Su_{i2} = c_{2.1,0} + c_{2.1,1}(N_i/N_i+1)(Mr'_i+Ea_i) + c_{2.1,2}Mu'_i$$
$$+ c_{2.1,3}s_i + c_{2.1,4}n_i + u_i$$

This service employment is composed of two sectors, that which provides order one goods to the local basic employment and that which provides second order goods to the local and the surrounding lower level basic employments. Thus the coefficient $c_{2.1,1}$ should represent the impact on the second order service employment resulting from the surrounding basic employment, and the coefficient $c_{2.1,2}$ should represent the additive impact of the local manufacturing employment on both service sectors. If it is assumed that the local and the surrounding basic employments have equal demand for order two goods, $c_{2.1,2}$ can be expressed as

$$c_{2.1,2} = c_{2.1,1} + c,$$

where c is the multiplier for order one service employment alone. If it also is assumed that local and the surrounding basic employments have equal demand for order one goods, c is equal to b_{21}. Since b_{21} has been estimated at 0.42, equation U2.1 may be restated as

$$Su_{i2} = c_{2.1,0} + c_{2.1,1}\ (N_i/N_i+1)(Mr'_i+Ea_i) + (c_{2.1,1} + 0.42)Mu'_i$$
$$c_{2.1,3}s_i + c_{2.1,4}n_i + u_i$$
$$= c_{2.1,0} + c_{2.1,1}\left[(N_i/N_i+1)(Mr'_i+Ea_i) + Mu'_i\right] + 0.42Mu'_i$$
$$c_{2.1,3}s_i + c_{2.1,4}n_i + u_i.$$

Thus

$$U2.1' \quad Su_{i2} - 0.42Mu'_i = c_{2.1,0} + c_{2.1,1} (N_i/N_i+1)(Mr'_i+Ea_i)$$
$$+ Mu'_i + c_{2.1,3}s_i + c_{2.1,4}n_i + u_i.$$

Estimation of U2.1' yielded an estimate for $c_{2.1,1}$ of 0.21.

The relationship between the service employment in only the third order cities can be similarly stated as

$$U2.2 \quad Su_{i3} = c_{2.2,0} + c_{2.2,1}(1/N_i+1)(Mr'_i+Ea_i)$$
$$+ c_{2.2,2} \left[(N_i/N_i+1)(Mr'_i+Ea_i) + Mu_i\right]$$
$$+ c_{2.2,3}Mu''_i + c_{2.2,4}s_i + c_{2.2,5}n_i + u_i,$$

where the first variable is the basic employment about the third order place which demands goods of orders two and three from that place, the second term is the regional base population demanding only goods of order three from the third order place, and the third variable is the third order place's own basic population which purchases all orders of goods at the central place. Under the assumption that all basic employments have identical demand for each particular level of goods, the coefficients associated with the first and the third variables can be stated in terms of that associated with the second and previously estimated coefficients. This restatement for the first coefficient is

$$c_{2.2,1} = c_{2.2,2} + c_{2.1,1}$$
$$= c_{2.2,2} + 0.21,$$

and for the third coefficient is

$$c_{2.2,3} = c_{2.2,2} + c_{2.1,1} + b_{21}$$
$$= c_{2.2,2} + 0.21 + 0.42$$

$$= c_{2.2,2} + 0.63.$$

Substituting these expressions into U2.2 yields

$$Su_{i3} = c_{2.2,0} + (c_{2.2,2} + 0.21)(1/N_i+1)(Mr'_i + Ea_i)$$

$$+ c_{2.2,2}\ (N_i/N_i+1)(Mr'_i + Ea_i) + Mu'_i + (c_{2.2,2} + 0.63)Mu''_i$$

$$+ c_{2.2,4}s_i + c_{2.2,5}n_i + u_i.$$

Thus

$$\text{U2.2}' \quad Su_{i3} - 0.21(1/N_i+1)(Mr'_i+Ea_i) - 0.63Mu''_i = c_{2.2,0}$$

$$+ c_{2.2,2}(Mr'_i + Ea_i + Mu'_i + Mu''_i) + c_{2.2,4}s_i$$

$$+ c_{2.2,5}n_i + u_i.$$

Although Equation U2.2' could have been estimated, it was considered convenient and consistent with the estimation of the other urban sector equations to estimate a single equation for the service employment of all urban places. Thus equation U2' was estimated and the results presented in Table 10. Equation U2' is specified as

$$\text{U2}' \quad Su'_{ij} = c_{20} + c_{21}\left[(N_i/N_i+1)(Mr'_i+Ea_i) + Mu'_i\right]$$

$$+ c_{22}(Mr'_i + Ea_i + Mu'_i + Mu''_i) + c_{23}s_i$$

$$+ c_{24}n_i + Z_{ij} + u_{ij},$$

where

$$Su'_{ij} = Su_{i2} - 0.42Mu'_i \text{ when } j=2, \text{ and}$$

$$= Su_{i3} - 0.21(1/N_i+1)(Mr'_i + Ea_i) - 0.63Mu''_i \text{ when } j=3;$$

and where

$$Z_{ij} = 0 \text{ when } j=2, \text{ and}$$

$$= 1 \text{ when } j=3.$$

The most salient features of Equation U2' are the coefficients associated with the basic employment figures of 0.21 for second order and 0.11 for third order service employment. These figures should be compared to that associated with first order service employment of 0.43. The progression is as expected under various interpretations of the concept of order of a good. If, for example, order corresponds to frequency of purchase, the higher ordered goods are those purchased less frequently by any particular resident, and therefore fewer service employees would be necessary to service one resident.

However, as indicated previously, the estimated coefficients are not exact analogues to the Beckmann-McPherson (6) urban multipliers. To account for the differences a more complex derivation is required than that needed at the lowest level. For the second order city, the service population may be divided into that providing order one goods to the urban population alone and that providing second order goods to the city and surrounding population. Let these two populations be

$${}_2S_1 = h_1({}_2S_1 + {}_2S_2 + {}_2B), \text{ and}$$

$${}_2S_2 = h_2({}_2S_1 + {}_2S_2 + {}_2B + {}_1B + {}_1S_1);$$

where

${}_iS_j$ = the service population in the i^{th} order place providing the j^{th} order good,

${}_iB$ = the basic population in the i^{th} order place (including the farm employment for i=1), and

h_j = the Beckmann-McPherson urban multiplier for the j^{th} order good.

Earlier discussion showed that

$$ {}_1S_1 = (h_1/1-h_1)\,{}_1B. $$

Solving the first equation above for ${}_2S_1$ yields

$$ {}_2S_1 = (h_1/1-h_1)({}_2S_2 + {}_2B) $$

Substituting these relationships into the second equation gives

$$ {}_2S_2 = h_2\left[(h_1/1-h_1)({}_2S_2 + {}_2B) + {}_2S_2 + {}_2B + {}_1B + (h_1/1-h_1)\,{}_1B\right] $$

$$ = (h_2/1-h_1)({}_2S_2 + {}_2B + {}_1B). $$

Solving for ${}_2S_2$ yields

$$ {}_2S_2 = (h_2/1-h_1-h_2)({}_2B + {}_1B). $$

Since $({}_2B + {}_1B)$ equals $(N_i/N_i+1)(Mr'_i+Ea_i) + Mu'_i$ in Equation U2', the coefficient c_{21} may be taken as an estimate of $(h_2/1-h_1-h_2)$. If the estimate of $h_1 = 0.30$ is accepted from above, an estimate of h_2 is

$$ (h_2/1-0.3-h_2) = 0.21, $$

$$ h_2 = 0.12. $$

The equivalent statement for the coefficient associated with the demand for third order goods can be shown to be

$$ (h_3/1-h_1-h_2-h_3) = c_{22}, $$

$$ (h_3/1-0.30-0.12-h_3) = 0.11, $$

$$ h_3 = 0.06. $$

The progression of urban multipliers in a form comparable to the Beckmann-McPherson discussion is 0.30 for first order goods, 0.12 for second order goods, and 0.06 for third order goods. However, there are problems involved in the evaluation of these coefficients. First there is the statistical problem associated with the adjustment of the estimated coefficients to the Beckmann-McPherson basis such that, where the estimated coefficients are assumed to be unbiased, the adjusted figures are not. In addition, the significance of the estimated intercept terms in Equations R2 and U2' and the coefficient on the central place dummy variable in Equation U2' causes the Beckmann-McPherson and the export base formulations to be viewed as resting upon questionable assumptions.

The results of the estimation of urban population as a function of urban employment, both basic and service, yielded a highly significant relationship as shown by the $\bar{R}^2$ of .96. However the coefficient on urban employment of 2.6, although significant, differs from the comparable coefficients in the other sectors. Like the coefficient for the farm sector, this coefficient approximates the average family size per employee since the intercept term is relatively small. This average, in turn, approximates the average family size under the assumption that there is only one employee per household. Reconciliation of the urban sector coefficient to that in the farm sector, where the coefficient is higher, must either conclude that farm households are generally larger or have fewer employed members.

The comparison of the urban sector to the rural sector is complicated by the large intercept term in the rural sector equation. However, if these coefficients are interpreted in the marginal sense and the basic employment variable is viewed as a measure of job opportunity, an increase in job opportunities apparently will result in a differential rate of growth for the region depending upon the location of the job. Thus farm population would rise more rapidly than urban population and urban population growth would exceed the rural population growth. This conclusion may be reasonable to the extent that the type of employment and the level of remuneration differ among the various sectors. Such a difference may be systematic between farm and nonfarm sectors, but it is not clear that such a difference must persist between rural and urban sectors.

Equation U4', the estimation of land use, does not have a counterpart in the rural sector because there exists no consistent set of data for the rural places. This is not to imply that sufficient land use data is available for the urban sector but only that there is some data appropriate to this study. Since the available data are only in terms of total urban area, it is not possible to directly estimate the land use for the manufacturing, service, and residential activities within the urban sector.

An indirect estimate of the urban land uses could have been provided if the independent variables were not highly intercorrelated. However, as Equation U3 clearly shows, there is a high correlation between the total urban population and the sum of manufacturing and service employments. Thus, the results from Equation U4 were ambiguous, and it was necessary to estimate total urban land as a function of the employment variables alone. Equation U4' was used for this estimation where U4' is

$$\text{U4}' \quad Lu_{ij} = c_{40} + c_{42}Mu_{ij} + c_{43}Su_{ij} + c_{44}Z_{ij} + c_{45}F_i + u_{ij}.$$

The results of the estimation of urban land area show a large and significant intercept term of 4.666 square miles. The coefficient on the dummy variable for the third order places, although insignificant, is relatively large and negative, perhaps implying a tendency toward greater density in the larger places.

The impacts of manufacturing and service employment upon the urban area are highly significant. The results indicate that for every one thousand employees in manufacturing one and one-third square miles of land are added to the city and that for every one thousand service employees three-quarters of a square mile of land are added. What is not indicated, of course, is the distribution of this land area between residential and work area. However, if it is assumed that service and manufacturing employees require comparable residential area, it is clear that manufacturing activities are substantially more land extensive by nearly one-half a square mile per 1,000 employees.

Finally, the farm value per acre variable was included to account for any impacts that land values might have on city size. It is expected that greater land values would lead to greater costs of converting agricultural land to urban use and thus would have a negative impact upon the urban area. The estimation resulted in the expected negative sign, but the coefficient was not significant.

Equation U5 is analogous to R4. It differs, however, in the inclusion of two service employments defined by the order of the places. Thus, if the service sales variable is for second order places, service employment for the third order place is zero; and, correspondingly, if the service sales is for the third order places, the service employment for the second order places is set equal to zero. In this fashion it is possible to estimate the separate influence of the service populations in a single equation.

The results of the estimation of U5 are consistent with those of Equation R4. Both coefficients associated with the service employments are significant and the differences among the coefficients are in line with the concept of orders of urban places and goods. The impact of a service employee supplying order one goods in the rural sector is $5 thousand, whereas the impact of a service employee supplying a package of order one and two goods to the second order places is $14 thousand. Thus the second order goods tend to be of greater value per employee. Similarly, the impact of a service employee providing a package of order one, two, and three goods in the third order place is over $16 thousand, implying that the value of the third order goods alone tend to be of greater value per employee than either the first or the second order goods.

As discussed earlier with respect to Equation R4, the farm value and wage variables were included to account for variations in regional price levels. Farm value per acre proved to have a significant effect upon the level of service sales; however, the manufacturing wage rate was again insignificant.

Equation U6 is the final equation in the urban sector and is comparable to R5 for the rural sector. Unfortunately, where the interpretation of R5 was relatively clear, the results of U6 are less so. It was expected that the coefficient on urban service sales would be less than one. However, even though this expectation was met, the size of the coefficient of 0.45 is larger than the coefficient of 0.23 found in the rural sector. On the other hand, it was expected that the coefficient associated with the manufacturing wage bill should exceed one. In fact, this coefficient was estimated to be substantially below one at 0.44. These results apparently are not distorted by multicollinearity within the data, since the raw coefficient of correlation between urban service sales and the manufacturing wage bill is fairly low at 0.137.

A comparison of Equations R5 and U6, however, does indicate an increasingly important role being played by the service sector in the urban places. Where both equations have nearly the same explanatory power, as indicated by the $\bar{R}^2$'s of .78 and .74 for the rural and urban sectors respectively, the manufacturing wage bill for the rural places has a greater relative impact, measured by the mean elasticity of this variable of 0.42 as compared to the service sales mean elasticity of 0.20. In the urban sector the ranking of relative impact is shifted so that the mean elasticity of the manufacturing wage bill variable is 0.07 and that of service sales is 0.79. This shift in importance is consistent with the central place functions and with the average data on the distribution of manufacturing and service activities noted earlier.

Summary

This chapter has discussed the development of the fourteen equations of the empirical model in light of the theoretical structure. Compromises with available data which were necessary to estimate the dependency of the regions upon the national economy, the distributional characteristics of the central place structure, and limited land use features were pointed out.

Following the model specification, each subregion was discussed based upon the results of the estimation. These discussions were by subregion with comparisons across the subregional disaggregation. In general the central place structure was shown to be a reasonable basis for disaggregation of the regional activity. However, the simple economic base and the Beckmann-McPherson assumptions were shown to be questionable.

The following chapter will draw upon the results of the model estimation in order to more clearly show the distributional consequences of natural evolution or of planned changes for nonmetropolitan regions. These consequences should prove helpful in analyzing future changes and planning for the needs of the regions under various growth or decline conditions.

CHAPTER VI. SUMMARY AND CONCLUSIONS

The last chapter presented the results of the empirical estimation of aspects of the theoretical model. These results were organized by subregional sectors. In this chapter the distributional implications of the model are discussed by integrating the subregional results. The typical regional distributions developed provide information helpful in anticipating the needs of a region. Following this discussion, suggestions for additional research and for data collection are outlined.

Regional distributions

The current distributions of employment, population, sales, and income were presented in the discussion of the regional characteristics. However, the distributional implications of shifts in exogenous variables upon the current distributions may not yet be clear. In order to demonstrate the regional mechanism of adjustment, it is convenient to trace the impact of increasing manufacturing population upon the typical region. Manufacturing employment will be used as the driving variable since the theoretical link to exogenously determined export prices was not testable and because changes in manufacturing employment are fairly easy to observe and measure in practice.

The following analysis is done by example. The reason for this is twofold. First, since the export base assumptions as to the equality of the marginal and the average relationships among variables have not been supported, it becomes necessary to make assumptions about the initial magnitude of the regional variables. It is convenient to accept the current distributions as a base against which changes can be compared. Secondly, it is necessary to make an assumption about the size of the changes in the exogenous variables. Two approaches will be taken here. One will be to assume that basic employment shifts are proportionate to the current distribution. Although there is no reason for this assumption to be any more realistic than any other, it does demonstrate the population interdependencies more clearly than the others. On the other hand, it may be of interest to determine that pattern of changes in the basic employment which would leave other variables distributed in the current fashion. This will be the second approach.

Assume that the agricultural population remains constant but the manufacturing employment increases such that the distribution of manufacturing employment among the three orders of places stays constant at the percentages given in Table 12. Hence, 18% of the increased manufacturing will reside in the third order place, 16% in the second order places, and 66% in the first order places. This increase in manufacturing population will force an expansion in the service employment figures for the nonfarm places in the following fashion. For each new manufacturing employee in a first order place in the market area of a second order city 0.43 service employees will be added in the first order place, 0.21 service employees will be added to the second order place, and 0.11 employees will be added to the third order place. However, for each manufacturing employee added to a first order place in the second order market area of the third order place, 0.43 service employees will be added to the first order place and 0.32 service employees will be added to the

Table 12. Distribution of marginal service employees resulting from an increase of 100 manufacturing employees

Change in Manufacturing Employment \ Change in Service Employment	First Order Places	Second Order Places	Third Order Places	Total
80% of Change in First Order Places (53)	22.8	11.1	5.8	39.7
20% of Change in First Order Places (13)	5.6	0.0	4.2	9.8
Change in Second Order Places (16)	0.0	10.2	1.8	12.0
Change in Third Order Places (18)	0.0	0.0	13.5	13.5
Total Service Employment	28.4	21.3	25.3	75.0
Total Manufacturing Employment	66.0	16.0	18.0	100.0
Change in Total Employment	94.4	37.3	43.3	175.0
Distribution of the Marginal Service Employment	37.9%	28.4%	33.7%	100.0%

third order place, 0.21 for second order goods and 0.11 for third order goods. Similarly, for each new manufacturing employee in a second order place, 0.64 service employees will be added to the second order place, 0.43 providing order one goods and 0.21 providing order two goods, and 0.11 service employees will be added to the third order place. Finally, for each manufacturing employee added to the third order place, there will be an increase of 0.75 service employees in that place; 0.43 providing order one goods, 0.21 providing order two goods, and 0.11 providing order three goods.

Let the total increase in manufacturing employment to the region be 100. A summary of the marginal service employment impacts is found in Table 12. Assuming the manufacturing employment distribution remains constant, 66 employees will be added to the first order places. Of the 66, 53 will be located in those first order places served by second order places for second order goods and 13 will be in first order places served by the third order place for the second order goods. This allocation is based on the average number of second order places in a typical region. Given an average of four second order places, there are typically five places providing second order goods to the lowest order places. Thus the allocation of four-fifths and one-fifth. In addition, the increases in manufacturing employment to the second and third order places are 16 and 18 respectively.

The increases in service employment resulting from the increased manufacturing employment are 28.4 employees in the first order places, 21.3 in the second order places, 25.3 in the third order places, and 75.0

for the region as a whole. This distribution as a percent of the total is 37.9%, 28.4%, and 33.7% for the first, second, and third order places respectively. Comparing this distribution to the current distribution of service employment, given in Table 13, indicates a tendency for increasing dominance of the higher order places under conditions of growth. Whereas 48% of the current service employment is found in the lowest order places, only 38% of any increase in service employment accrues to this sector so that as the total service population increases the relative share of the lowest order places declines. On the other hand, the current proportions for the second and the third order places are less than their proportions of any increase leading to rises in the average share of the service population as the regional manufacturing employment increases.

Returning to the particular example, the 100 manufacturing employee increase resulted in a total increase of 75 service employees. Thus the total employment change in the region is 175, distributed approximately as 94 to the first order places, 37 to the second order places, and 43 to the third order places. The impact upon total population, however, is not proportional to that for employment. In order to estimate the population change in the first order places, the rise of 94 employees must be increased by the population coefficient of 1.9; and for the urban places the employment figures must be increased by the urban population coefficient of 2.6. Thus, the population rise in the lowest order places will be about 179 residents, and in the second order places the rise will be 96 residents, and for the third order places the rise will be 112 residents. Hence, regional population increases by 387 people.

The distribution of the increased population may also be compared to the current distribution. The proportions of the total increase of 387 residents which accrue to the first, second, and third order places are 46.5%, 24.8%, and 28.9% respectively. However, the comparable figures for the present typical distribution, given in Table 1, are 54.9%, 18.9%, and 26.1%. Once again the marginal gain for the first order places is less than the current average, indicating the declining relative importance of these places as compared to the higher order places.

Because the assumed distribution of the shifts in manufacturing employment is admittedly arbitrary, it may be more informative to estimate the necessary changes in manufacturing employment which would result in a constant distribution of a particular variable. This can be done by reversing the approach taken above. In doing so, there are three distributions of manufacturing employment to be considered, that which results in the total manufacturing employment after any increases being distributed as before the change in manufacturing employment, that which results in the total service employment after any increases being distributed as before the change in manufacturing employment, and that which results in total residential population after any increases being distributed as before the change in manufacturing employment. Since the first distribution is obvious, the determination of the necessary manufacturing employment changes for the last two cases follows.

The present distribution of service employment is 48% in the first order places, 21% in the second order places, and 31% in the third order places. Assume that the increase in manufacturing employment is such that 100 new service employees are added to the region and are distributed in the current fashion. Thus 48 service employees are added to the first order places, 21 are added to the second order places, and 31 are added to the third order places. The increase in the first order places is a direct result of increased manufacturing employment in these places. Since the marginal coefficient for first order goods is 0.43, the increase of 48 service employees implies an increase of (1/0.43)(48), or 111.6, manufacturing employees. If the average distribution between first order places served by second order places and first order places served by third order places is assumed to be 4 to 1, the 111.6 manufacturing employees may be disaggregated as 89.3 and 22.3 to each of these classes.

The increase of 21 service employees in the second order places results from changes in the manufacturing employment in these places and from the change in manufacturing employment in the first order places served by the second order places. The estimate of 89.3 manufacturing employees in the first order places implies an increase in the service sector of the second order places of (0.21)(89.3), or 18.8, providing goods of order two. Thus only 2.2 service employees are a direct result of increased manufacturing employment in the second order places. The second order multiplier is 0.64, 0.43 for first order goods and 0.21 for second order goods. Hence, the increased manufacturing employment in the second order places is (1/0.64)(2.2), or 3.4.

Given the previously calculated estimates of the changes in manufacturing employment of 89.3 in the first order places served by second order places, 22.3 in first order places served by the third order places, and 3.4 in the second order places, the manufacturing employment in the third order places can be estimated. The total increase in service employment is assumed to be 31 employees. Of this total, 9.7, (0.11) (89.3), service first order places with order three goods; 7.1, (0.32)(22.3), serve the second class of first order places with both order two and three goods; and 0.4, (0.11)(3.4), serve the second order places with order three goods. Thus, only 13.7 of the 31 added service employees are serving the increased manufacturing employment in the third order place. Since the service multiplier at this level is 0.75, 0.43 for first order goods plus 0.21 for second order goods plus 0.11 for third order goods, the 13.7 service employees imply an increase of 18.3 manufacturing employees.

A percent breakdown of the changes in the manufacturing employment which would result in the service distribution remaining constant and a summary of the calculation given above are presented in Table 13. It is important to note that 83.6% of the new manufacturing employment would have to be allocated to the lowest level places in order to maintain the current distribution of service employment. However, these places currently have only 66.2% of the manufacturing employment. Thus, a substantial amount of decentralization would be necessary. It then becomes a matter of estimating the feasibility of such a drastic decentralization if it is deemed desirable to maintain the first order places.

If such decentralization is considered desirable, it would have to be undertaken at the expense of the higher order places and, in particular, of the second order places. In fact, it is estimated that only 2.6%

Table 13. Distribution of the marginal manufacturing employment which leaves the distribution of service employment unchanged

Work Site	First Order Places	Second Order Places	Third Order Places	Total
Increase in Service Employment	48.0	21.0	31.0	100.0
Selling to First Order Basic Employment				
(80%)	38.4	18.8	9.9	67.1
(20%)	9.6	0.0	7.1	16.7
Selling to Second Order Manufacturing Employment	0.0	2.2	0.4	2.6
Selling to Third Order Manufacturing Employment	0.0	0.0	13.7	13.7
Implied Change in Manufacturing Employment	111.6	3.4	18.3	133.3
% Distribution of the Added Manufacturing Employment	83.6	2.6	13.7	100.0

of the new manufacturing employment could be allocated to the second order places, as compared to the current distribution of 16.2%; whereas the comparable figures for the third order places are 13.7% and 17.7%.

This distribution of manufacturing and service employment does have implications upon the population distribution. The distribution of the total population based on the service and manufacturing employments given above are shown in Table 14. It can be seen that increased decentralization of the regional population is also indicated, but the increased percent of the population in the lowest order places is at the expense of the second order places alone.

Perhaps the variable of greatest concern to the regional scientist is the total population, such that the distribution of this variable is a more relevant topic. It thereby becomes of interest to determine that distribution of added manufacturing employment which would leave the total population distributed in the current proportion. Given this distribution as a benchmark, the consequences of anticipated changes in manufacturing employment may be estimated.

Assume that the regional population rises by 100 and that this increase is distributed among the nonfarm places according to the current distribution. Thus, 26 of the 100 will reside in the third order places, 19 in the second order places, and 55 in the first order places. The changes in total population imply an underlying increase in the employment population. Using the urban multipliers of 2.6 for the third and second order places and 1.9 for the first order places, estimates of the changes in total employment are 10.0 employees in the third order place, 7.3 employees in the second order places, and 28.9 employees in the first order places; for a total increase to the region of 46.2.

The total employment figures just estimated are the totals of the local manufacturing and service components. It is now necessary to disaggregate the totals into their components. This requires beginning with the figure of 28.9 for the first order places. Since all service employment in the first order places serves and is a multiple of local manufacturing employment, this total can be disaggregated easily. Given that local service employment is equal to 0.43 times the manufacturing employment, the total employment is equal to 1.43 times the manufacturing employment. The manufacturing employment is therefore 20.2, and the service employment is the residual of 8.7.

Table 14. Distribution of the added residential population resulting from an increase in service employment

	First Order Places	Second Order Places	Third Order Places	Total
Change in Service Employment	48.0	21.0	31.0	100.0
Change in Manufacturing Employment	111.6	3.4	18.3	133.3
Change in Total Employment	159.6	24.4	49.3	233.3
Population Multipliers	1.9	2.6	2.6	
Change in Total Population	303.2	63.4	128.2	494.8
% Distribution of the Population Change	61.3	12.8	25.9	100.0

A manufacturing employment level of 20.2 in the first order places generates service employment in the higher order places. If four-fifths of the 20.2 manufacturing employees purchase second order goods at the second order cities, the total employment increase in the second order cities will be partially due to service employment serving the first order places. Thus, out of the total increase of 7.3, 3.4, or (0.21)(4/5)(20.2), employees are a result of lower level increases and only 3.9 are a result of locally generated increases. Since local manufacturing employment results in local service employment of 0.64 per manufacturing employee, the local total of 3.9 must be equal to 1.64 times the local manufacturing. Therefore, local manufacturing in the second order places is 2.4, and the locally generated service employment is the residual of 1.5. Total service employment in the second order cities is the sum of the locally generated and that serving lower order places, in this case 4.9.

The total employment increase of 10.0 in the third order places is also composed of service employees generated by the manufacturing employees in lower order places and of the local service and manufacturing employment. The 16.2 first order manufacturing employees who buy second order goods at second order places generate 0.11 service employees in the third order city for every manufacturing employee, or 1.8; the 4.0 first order manufacturing employees who buy second and third order goods at the third order places generate 0.32 service employees per manufacturing employee, or 1.3; and the 2.4 manufacturing employees in the second order places generate 0.11 service employees per manufacturing employee, or 0.3.

Thus of the 10.0 added employees in the third order place, 3.4 are service employees serving lower order places and 6.6 are local manufacturing and service employees. Given the ratio of 0.75 service employees per third order manufacturing employee, the 6.4 increase in total employment implies a manufacturing employment increase of 3.8 and a service employment increase of 2.8 to serve the local manufacturing. The total increase in third order service employment is the sum of the locally generated and that serving lower order places of 6.2. A summary of these calculations is presented in Table 15.

If the percent distributions of manufacturing and service employments, also shown in Table 15, are compared to the current distributions, the magnitude of the regional decentralization of employment necessary to maintain the current residential distribution is apparent. The distribution of the added service employment is 31.3%, 24.7%, and 43.9% to the third, second, and first order places respectively. This is compared to the current distribution of 30.7%, 21.1%, and 48.2%. Although the two distributions are fairly similar, there is an indication of some centralization in the service sector, primarily favoring the second order places at the expense of the first order places. However, this tendency is offset by a more obvious decentralization necessary in the manufacturing sector. The distribution of the added manufacturing employment is 14.4%, to the third order places, 9.1% to the second order places, and 76.5% to the first order places. This can be compared to the current distribution of 17.7%, 16.2%, and 66.2%. Thus, expansion of the manufacturing sector must be predominantly in the lowest level, and at a rate of decentralization greater than in the cumulative past, in order to maintain the current residential population distribution.

This discussion has concentrated on the impacts of the manufacturing sector upon the distribution of the regional nonfarm residential population. However, the past has shown shifts in the farm sector which, if they continue, will have consequences upon the nonfarm sector, especially via the service functions of nonfarm places. It becomes of interest to estimate the probable distributional patterns which would result under various circumstances. Therefore, the following estimations are done in a fashion similar to the previous work, i.e., by establishing the direction of population shifts under a limited set of assumed farm changes. Several basic questions are raised: what is the effect upon the nonfarm sectors resulting from a reduction in farm employment; what is the effect upon the nonfarm sectors resulting from a reduction in farm employment which shifts to manufacturing employment in a fashion consistent with the current manufacturing distribution; and how must the increased manufacturing employment resulting from the shift of farm employees to the manufacturing sector be distributed in order to maintain the current relative distribution among nonfarm places.

The impact of a reduction in farm employment which does not find alternate employment in the region is relatively clear. Assume, for example, a drop of 100 farm employees. Given a first order multiplier of 0.43, 43 service employees would be released. All of this reduction in service employment would be in the first order places. With a second order multiplier of 0.21, 21 service employees providing order two goods

Table 15. Distribution of the employed populations resulting from 100 new residents distributed according to current percentages

	Third Order Places	Second Order Places	First Order Places	Total
Change in Residential Population	26.0	19.0	55.0	100.0
Population Multipliers	2.6	2.6	1.9	
Implied Change in Employment	10.0	7.3	28.9	46.2
Change in Manufacturing Employment	3.8	2.4	20.2	26.4
Change in Service Employment	6.2	4.9	8.7	19.8
% Distribution of the Added Manufacturing Employment	14.4	9.1	76.5	100.0
% Distribution of the Added Service Employment	31.3	24.7	43.9	100.0
Service Population Needed to Support: First Order Basic Employment				
(80%)	1.8	3.4	7.0	
(20%)	1.3	0.0	1.7	
Second Order Manufacturing Employment	0.3	1.5	0.0	
Third Order Manufacturing Employment	2.8	0.0	0.0	

would be released. Since four-fifths of the farm sector is assumed to purchase second order goods at second order places, and one-fifth purchase second order goods at the third order place, the distribution of the released service employment would be 16.8 in the second order places and 4.2 in the third order place. Finally, with a third order multiplier of 0.11, 11 service employees would be released, all in the third order place. In total, service employment would drop by 75, 43 in the first order places, 16.8 in the second order places, and 15.2 in the third order place. As a percent of the total decline, the distribution of released service employment is 57.3%, 22.4%, and 20.3% in the first, second, and third order places respectively. Comparing these figures to the current distribution of 48.2%, 21.1%, and 30.7% indicates that the lower order places would bear a disproportionate burden and that the service population would become even more concentrated in the third order place.

If, as is reasonable, some or all of the released farm employment seeks and finds alternate employment in the region, a different pattern of impacts will result. It is important to note at this point that within the contexts of the estimated model all alternate employment must be in the manufacturing sector. This results from the fact that it was not possible to estimate separate service multipliers for the manufacturing and farm sectors. Thus, a total of 75 service employees is estimated to be required to support 100 basic employees whether they are in manufacturing or farming. If the reduction in farm employment is 100 and they find alternate employment, all 100 must shift to the other basic sector in order to maintain the regional demand for the 75 service employees.

Any shift to the service sector would result in lowering the support level below 75, making some current service employees redundant. For example, if only 80 farm employees shifted to the manufacturing sector and 20 found service employment, only 60 service employees would be required to support the 80 basic employees of which 20 would be from the farm sector and 40 from the current service sector. Hence 35 current service employees would be released from the region. It is clear, therefore, that to be consistent with the estimated model, all released farm employment must shift to manufacturing employment if the entire regional work force is to be maintained within the region. Given this constraint, it is possible to estimate the distributional patterns resulting from the conversion of farm to manufacturing employment.

The employment distributions which would result from a shift in employment from the farm to the manufacturing sector are estimated in two steps. Assume the reduction of 100 in farm employment. The corresponding decrease in service employment has already been estimated and is shown in Table 16. If the farm employees find manufacturing employment such that the total pattern of manufacturing employment remains constant, the pattern of the supporting service employment is the same as that associated with an increase of manufacturing employment, shown in Table 12. The net change for the region would be the combined impacts of these two forces. This is shown in Table 16.

The shift in employment from farm to manufacturing will lead to a redistribution of the service population such that the service sector will become more centralized. In fact, there is a loss to the first order

Table 16. Net change in service employment resulting from a shift of 100 farm employees to manufacturing

	First Order Places	Second Order Places	Third Order Places	Total
Reduction in Service Employment from a Decline of 100 Farm Employees	-43.0	-16.8	-15.2	-75.0
Increase in Service Employment from an Increase of 100 Manufacturing Employees	+28.4	+21.3	+25.3	+75.0
Net Change in Service Employment	-14.6	+4.5	+10.1	0.0
Change in Manufacturing Employment	66.0	16.0	18.0	100.0
Change in Total Employment	51.4	20.5	28.1	100.0

places and gains to the second and third order places, with the third order place receiving the greater absolute and proportionate increase.

Although the lowest level places incur losses in terms of service employment, these losses are offset by the gains in manufacturing employment. The changes in manufacturing employment and the net changes in total employment are also shown in Table 16. Thus, the first order places will not actually lose population.

The gains in population in the first order places need not be sufficient to maintain their relative position in the region. In order to estimate the changes in residential population, it is necessary to make an assumption about the relationships between the work force and the residential population since estimates of these relationships differ among the farm, rural, and urban sectors. A short run assumption would be that the estimated coefficients apply to the employees moving among the various sectors. On the other hand, it could be assumed that in the long run the new employees would take on the characteristics associated with the old populations. Under the second assumption, the increased employment of 51.4 in the first order places would be associated with an increase of 97.6 residents, and the second and third order place increases of 20.5 and 28.1 would be associated with residential increases of 53.3 and 73.1. As a percent of the total residential population of 224.0, this amounts to an allocation of 43.6% to the first order places, 23.8% to the second order places, and 32.6% to the third order place. Again, there is the implication of increasing concentration of the regional population in the higher order places.

Finally, it is possible to estimate the necessary distribution of the absorption of released farm employment which would maintain the current distribution of the residential population. These calculations, made under the long run assumption about the relationship of total population to employment, are summarized in Table 17.

Let the total increase in nonfarm residents rise by 100 and be distributed according to the current pattern of 26% to the third order place, 19% to the second order places and 55% to the first order places. These population increases imply corresponding increases in nonfarm employment of 10.0, 7.3, and 28.9, for a total increase of 46.2. Since the net change in service employment for the region is zero, the total shift from farm to manufacturing employment is equal to 46.2.

Even though there is no change in total service employment, there is a redistribution of the service work force resulting from a change in the locational buying patterns of the new manufacturing employees. In order to account for this changing pattern, it is first necessary to estimate the decline in service employment which would occur if the released farm employment left the region. Given that 46.2 farm employees are released, the drop in the service employment in the first order places would be 0.43 per farm employee, or 19.9; the drop in service employees providing second order goods would be 0.21 per farm employee, or 9.7, of which 80% accrues to second order places and 20% is the drop in the third order place; and the decline in the service population providing third order goods from the third order place would be 0.11 per farm employee, or 5.1. The decreases in service employment by order of place is therefore 7.0

Table 17. Relocation of farm employees into the manufacturing work force which leaves the regional distribution of residential population constant

	Third Order Places	Second Order Places	First Order Places	Total
Change in Residential Population	26.0	19.0	55.0	100.0
Population Multipliers	2.6	2.6	1.9	
Net Change in Employment	10.0	7.3	28.9	46.2
Drop in Service Employment	7.0	7.8	19.9	34.7
Total Change Resulting from Manufacturing	17.0	15.1	48.8	80.9
Change in Manufacturing Employment	6.4	5.7	34.1	46.2
Change in Service Employment	10.6	9.4	14.7	34.7
% Distribution of the Added Manufacturing Employment	13.9	12.3	73.8	100.0
% Distribution of the Added Service Employment	30.5	27.1	42.4	100.0
Service Population Needed to Support:				
First Order Basic Employment				
(80%)	3.0	5.7	11.8	
(20%)	2.2	0.0	2.9	
Second Order Manufacturing Employment	0.6	3.7	0.0	
Third Order Manufacturing Employment	4.8			

in the third order, 7.8 in the second order, and 19.1 in the first order, for a total decline for the region of 34.7. However, since the released farm employment is assumed to shift to manufacturing within the region, the total work force to be accounted for is the 46.2 new manufacturing and the 34.7 service employees. The distribution of this work force is the distribution of the net regional nonfarm change and the add-back of the service employment reduction, or 17.0 in the third order place, 15.1 in the second order places, and 48.8 in the first order places.

The 48.8 employees in the first order places are either in the local manufacturing or local service sectors. Since each manufacturing employee at this level necessitates 0.43 local service employees, the total work force is equal to 1.43 employees for each manufacturing employee. Thus, out of the 4818 total employees, (1/1.43)(48.8), or 34.1, are in manufacturing. The residual of 14.7 are service employees.

The 80% of the first order manufacturing employment generates 0.21 service employees per person in the second order places. Thus, of the 15.1 total employees in these places, 5.7 are service employees supporting lower order places, and 9.4 are either local manufacturing or locally generated service employees. Since each manufacturing employee at this level requires 0.64 service employees, the increase in the second order manufacturing employment is (1/0.64)(9.4), or 5.7, and the locally generated service employment is the residual of 3.7.

The total work force in the third order place to be accounted for is 17.0. Of this amount a portion is composed of service employees providing goods of order two and three to the 20% of the first order manufacturing employment. This amounts to (0.32)(.2)(34.1), or 2.2. Another portion is the service population providing goods of order three to the remaining 80% of the first order manufacturing employment. This amounts to (0.11)(.8)(34.1), or 3.0. A third portion is composed of the service employees providing goods of order three to the manufacturing employees in the second order places. This amounts to (0.11)(5.7), or 0.6. Hence only 11.2 employees are either local manufacturing or locally generated service employees. Given the ratio of 0.75 service employees for each manufacturing employee, the manufacturing employment in the third order place is (1/0.75)(11.2), or 6.4, and the residual of 4.8 is the local service component.

The net impact of these calculations can be summarized in the percent distributions of the 46.2 employees shifting from farm to manufacturing. In order that the distributional pattern of the total regional residential population remains constant, it is necessary for 73.8% of the released farm employment to relocate in the first order places, 12.3% to relocate in the second order places, and 13.9% to relocate in the third order place. This is a greater degree of decentralization than currently shown in the typical region; and it again becomes a matter of estimating the probability that such decentralization would occur, or could be encouraged to occur. If such decentralization seems improbable, the relative distribution of the regional population must be considered to have a tendency toward centralization.

In summary, the central place structure of the service sector imposes a centralizing tendency upon the region which, if such centralization is considered undesirable, can be overcome only through substantial decentralization in the manufacturing sector. To the extent that the manufacturing sector tends to maintain the current distribution, increases in total regional manufacturing or reductions in farm employment, whether relocated within or without the region, leads to greater concentration of the regional population in the higher order places. Additionally, the tendency toward centralization exists under the current conditions of demand for the service sector output. If consumer preferences shift so that higher order goods and services gain relative to lower order commodities, the centralization of the regional population can be expected to become even more pronounced.

Summary

The purpose of this investigation has been to develop a model of the response of a nonmetropolitan region to changes in the exogenously determined levels of demand for the export commodities of the region. The model so developed is unique in several respects. First, it clearly demonstrates that the simple export base model and the Beckmann-McPherson formulation of the central place model are not only consistent but that the second is merely a disaggregation of the first (6). Based upon the inherent equality of the export base and central place models, the two traditional interpretations were integrated so that the driving force in the central place structure is identifiable as the export base of the region.

Although the export base-central place model demonstrates the linkages between the aggregate base sector and the service sector, it does not contain any mechanism which could explain the limits to growth within the region. However, by introducing a land use model, a constraint was imposed upon the regional economy which does act as a limiting factor in regional development and which allows the employment sectors to be disaggregated into subsectors competing for the limited amount of regional land. This disaggregation shows the role played by the price system in allocating land among the service, residential, and the various base sectors, and in establishing the urban boundaries.

The translation of the theoretical model into a form which could be tested presented many problems. In general, the problems resulted from insufficient data, and the solutions necessitated excluding portions of the model from the estimation process. With respect to the data insufficiency, it is unfortunate that there does not exist a comprehensive and consistent series of land use figures for nonfarm places. This lack of information occurs for nearly all sizes of urban places but is especially acute for small urban places. This is not to say that no data exists, for there have been land use inventories made for nonmetropolitan areas, and for many places zoning data could be taken as a close approximation of actual use. However, the crucial qualifiers are comprehensive and consistent. Thus, what is lacking is land use data for urban areas comparable to that available for rural land use.

As a result of the limited information, the model tested had to exclude portions of the theoretical model. The most noticeable exclusion was the postulated constraint imposed via the land use model. However, the model which was tested provided a basis for drawing several general conclusions. First, the central place structure of the regional service sector is strongly supported. On the other hand, the particular formulation given by Beckmann and McPherson and implied by the simple export base model is not supported. Thus, the use of average relationships between total or service populations and the base populations in estimating changes in the regional structure is not well founded.

Finally, there is a tendency toward concentration of the regional populations into the higher order places. This is a direct result of the nature of urban places as service centers. However, the centralizing impact of the service sector can be offset by a large decentralization of the manufacturing work force. Since it becomes problematic whether such decentralization is feasible, it becomes important to estimate the structure of the regional base population prior to allocating resources for the improvement or maintenance of the regional infrastructure. Allocation of funds on the basis of the current distribution may under fund higher order places and impede the natural development of the region.

Further research is needed in order to more clearly understand the structure of nonmetropolitan regions. The results of such research is important not only to assess the problems of the nonmetropolitan regions but to shed light upon the forces inherent in larger metropolitan places. However, the data base available is a major constraint. What is needed is a visible commitment which would lead to the development of sufficient information. From the point of view of the theoretical model presented in this investigation, it would be advantageous to test the constraining role of land use upon the regional population and income and the equilibrating function played by land prices in setting the division of the land among competing sectors. In addition, another perspective could be gained by taking a time series approach to the estimation of the model. This, of course, would require maintaining a consistent series of data over a period of time. Finally, an implied assumption throughout this study has been that of no commuting between work and residential sites. Given adequate commutation data, this assumption need not be made, thereby allowing for a cleaner estimation of the service to manufacturing relationships. It is hoped, however, that this study has added some new and needed insight into the structure of nonmetropolitan regions.

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APPENDIX A. COMPOSITION OF THE SAMPLE REGIONS

The regions included in the estimation study are listed below. The regional number refers to Figure 13. By definition, the third order city is the largest city within the region, and the second order cities are those which were determined to provide second order goods by meeting the Borchert and Adams (15) requirements for classification as complete shopping centers. The county specification is essentially that given by Berry in his delineation of the U.S. into FEA's. The geographic regionalization is based on that used by the Regional Economics Division of the U.S. Department of Commerce except that the Plains region has been subdivided such that the western tier of states is considered to be in the West, Minnesota and Iowa are included in the North, and Missouri is allocated to the South. Finally, the nearest metropolitan area is the closest city listed by the Rand-McNally City Rating Guide as a center of national importance.

Composition of the Sample Regions

Regional Number	Third Order Cities	Second Order Cities	Counties/ States	Geographic Region	Nearest Metro Area
1.	Dothan	Enterprise Ozark	Coffee, Ala. Dale " Geneva " Henry " Houston "	S	Atlanta
2.	El Dorado	Warren Camden	Bradley, Ark. Calhoun " Quachita " Union "	S	Dallas

3.	Eureka & Arcata	Cresent City & Cresent City, N.W.	Del Norte, Cal. Humbolt " Trinity "	W	San Francisco
4.	Redding & Enterprise & Bonnyville	Susanville Red Bluff	Lassen, Cal. Plumas " Shasta " Tehama "	W	San Francisco
5.	Valdosta	Nashville Quitman Adel	Atkinson, Ga. Berrien " Brooks " Cook " Lanier " Lowndes "	S	Atlanta
6.	Idaho Falls	Blackman Rexburg	Bingham, Id. Bonneville, Id. Jefferson " Madison "	W	Denver
7.	Twin Falls	Jerome Rupert	Gooding, Id. Jerome " Lincoln " Minidoka " Twin Falls, Id.	W	Portland
8.	Burlington & West Burlington	Mt. Pleasant Ft. Madison Keokuk Macomb Monmouth	Des Moines, Ia. Henry " Lee " Henderson, Ill. McDonough " Warren "	N	St. Louis
9.	Fort Dodge	Webster City Humboldt Eagle Grove	Calhoun, Ia. Hamilton " Humboldt " Pocahontas " Webster " Wright "	N	Minneapo- lis
10.	Mason City & Clear Lake	Charles City Osage Forest City Hampton	Cerro Gordo, Ia. Floyd " Mitchell " Winnebago " Franklin " Hancock " Worth "	N	Minneapo- lis

11.	Ottumwa	Centerville	Appanoose, Ia.	N	Kansas
		Fairfield	Davis "		City
		Albia	Jefferson "		
			Monroe "		
			Van Buren "		
			Wapello "		
12.	Great Bend	Larned	Barton, Ka.	W	Kansas
			Pawnee "		City
			Rush "		
			Stafford "		
13.	Salina	Abilene	Dickinson, Ka.	W	Kansas
		McPherson	Ellsworth "		City
		Concordia	Lincoln "		
			McPherson "		
			Ottawa "		
			Russell "		
			Saline "		
			Cloud "		
14.	Bowling	Glasgow	Allen, Ky.	S	Cincin-
	Green		Barren "		nati
			Edmonson "		
			Warren "		
15.	Paducah &	Murray	Ballard, Ky.	S	St. Louis
	Lone Oak	Mayfield	Calloway "		
		Metropolis	Carlisle "		
			Fulton "		
			Graves "		
			Hickman "		
			Livingston "		
			Lyon "		
			Marshall "		
			McCracken "		
			Johnson, Ill.		
			Massac "		
			Pope "		
			Pulaski "		
16.	Cumberland	Frostburg	Allegany, Md.	S	Pitts-
	& Lavale-	Keyser	Garrett "		burgh
	Narrows		Hampshire, W. Va.		
			Mineral "		
			Morgan "		
17.	Salisbury	Crisfield	Somerset, Md.	S	Baltimore
		Pocomoke City	Wicomico "		
		Seaford	Worcester "		
			Sussex, Del.		

18.	Sault Ste. Marie	St. Ignace	Chippewa, Mi. Mackinac, "	N	Detroit
19.	Traverse City	Manistee Cadillac City	Antrim, Mi. Benzie " Grand Traverse, Mi. Kalkaska, Mi. Leelanua " Manistee " Missaukee " Wexford "	N	Detroit
20.	Mankato & N. Mankato	New Ulm St. Peter Waseca	Blue Earth, Minn. Brown " Faribault " Watowan " Steele " Freeborn "	N	Minnea-polis
21.	Greenville	Cleveland Indianola Leland	Bolivar, Mis. Humphreys " Issaquena " Sharkey " Sunflower " Washington " Chicot, Ark.	S	New Orleans
22.	Hattiesburg	Laurel Columbia	Forest, Mis. Jones " Lamar " Marion " Perry "	S	New Orleans
23.	Meridian	Philadelphia Demopolis	Clarke, Mis. Kemper " Lauderdale Mis. Neshoba " Choctaw, Ala. Marengo " Sumter "	S	New Orleans
24.	Tupelo	West Point Amory Aberdeen Booneville New Albany	Chickasaw, Mis. Clay " Itawamba " Lee " Monroe " Pontotoc " Prentiss " Tippah " Union "	S	Houston

25.	Joplin & Webb City	Carthage Neosho Pittsburg Miami	Barton, Mo. Jasper " McDonald " Newton " Cherokee, Ka. Crawford, " Ottawa, Oka.	S	Kansas City
26.	Poplar Bluff	Malden Kennett	Butler, Mo. Carter " Dunklin " Reynolds " Ripley " Stoddard " Wayne "	S	St. Louis
27.	Bozeman	Livingston	Gallatin, Mon. Park "	W	Denver
28.	Farmington	Durango	San Juan, N. Mex. La Plata, Col.	W	Denver
29.	Roswell	Artesia Carlsbad Hobbs Portales	Chaves, N. Mex. Eddy " Lea " Lincoln " Roosevelt "	W	Dallas
30.	Jamestown & Lakewood & Falconer	Dunkirk & Fredonia Warren	Chautaqua, N.Y. Warren, Pa.	N	Buffalo
31.	Grand Forks & East Grand Forks	Grafton Thief River Crookston	Grand Forks, N.D. Griggs Nelson " Pembina " Traill " Walsh " Marshall, Minn. Pennington " Polk " Red Lake "	N	Minnea-polis
32.	Ardmore	Sulphur Ada	Carter, Oka. Johnston " Love " Murray " Pontotoc "	W	Dallas

33.	Enid	Alva	Alfalfa, Oka. Garfield " Major " Woods "	W	Dallas
34.	Medford & S. Medford & Central Point & Ashland	Grants Pass & Fruitdale & Grants Pass Southwest	Curry, Ore. Jackson " Josephine "	W	Portland
35.	Anderson	Abbeville Seneca Elberton Tocca	Abbeville, S. C. Anderson " Oconee " Elbert, Ga. Franklin " Hart " Stephens "	S	Atlanta
36.	Florence	Darlington Hartsville Dillon Lake City Conway Myrtle Beach Marion Mullins Bennetsville	Darlington, S.C. Dillon " Florence " Horry " Marion " Marlboro "	S	Atlanta
37.	Rapid City	Belle Fourche Hot Springs Lead Spearfish Sturgis	Butte, S.Dak. Custer " Fall River, S. Dak. Lawrence " Meade " Pennington " Shannon "	W	Denver
38.	Jackson	McKenzie, Humboldt Milan Lexington	Carroll, Tenn. Chester " Crocket " Gibson " Henderson " Madison "	S	St. Louis
39.	Johnson City	Elizabethton Greenville	Carter, Tenn. Greene " Unicoi " Washington "	S	Atlanta

40.	Victoria	Port Lavaca Cuero Edna Yoakum	Calhoun, Tex. DeWitt " Goliad " Jackson " Lavaca " Victoria "	W	Houston
41.	Charlottes-ville	Stauton Harrisonburg Waynesboro	Albemarle, Vir. Augusta " Greene " Madison " Rockingham "	S	Washing-ton
42.	Yakima & Selah & Fruitvale	Sunnyside Toppenish	Klickitat, Wash. Yakima "	W	Seattle
43.	Parkersburg & Vienna	Belpre Marietta	Pleasants, W. Va. Ritchie " Wood " Meigs, Ohio Washington, Ohio	S	Pitts-burgh
44.	Eau Claire & Altoona	Chippewa Falls Menomonie	Buffalo, Wisc. Chippewa " Dunn " Eau Claire " Pepin "	N	Minnea-polis
45.	Wausau & Rothschild	Antigo Merrill	Clark, Wisc. Langlade " Lincoln " Marathon " Taylor "	N	Milwaukee
46.	Casper	Lander Riverton	Fremont, Wyo. Natrona "	W	Denver

APPENDIX B. SOURCES OF AND ADJUSTMENTS TO PUBLISHED DATA

This appendix contains the sources of all data used in this study and an explanation of any adjustments made to the published data. Variables which enter the estimation but are not detailed below are simply combinations of this data.

1. Area Measurement Reports (54)

   a. City size statistics

2. Census of Agriculture, 1969, Area Reports (55)

   a. Agricultural land by county
   b. Farm value per acre by county--
      Regional farm value per acre figures are weighted averages of the county data.
   c. Agricultural sales by county

3. Census of Business, Retail Trade-Area Statistics, 1963 and 1967 (56, 57)

   a. Value of retail sales by county
   b. Value of retail sales by city--
      The 1967 census was the primary source of this data. However, in regions numbered 3, 4, 15, 16, 25, 34, 42, 44, and 45, data was not available for one of the "suburbs" of the higher order places. In these cases, if 1963 data were reported, the 1967 figures were extrapolated from the 1963 data based on the rate of change for the county. Where 1963 data was not available, 1967 figures were estimated as the county total less the known city sales times the ratio of the service population in the unknown places to the county service population less that in the known places.

4. Census of Business, Selected Services-Area Statistics, 1963 and 1967 (58, 59)

   a. Value of service sales by county--
      For one county in each of regions 16 and 21, service sales was not reported. The total regional ratio of service to retail sales was used to estimate the service sales in these counties.

b. Value of service sales by city--
For at least one "suburb" in each of regions 3, 4, 15, 16, 34, 42, and 44, 1967 service sales were estimated as in 3b.

5. Census of Business, Wholesale Trade-Area Statistics, 1963 and 1967 (60, 61)

a. Value of wholesale sales by county--
The 1967 census was the primary source of data for this series. However, for at least one county in each of regions 3, 5, 14, 15, 21, 23, 26, 32, 39, and 41, 1967 data were not disclosed. In those cases where 1963 data were reported, the 1967 figures were extrapolated from the 1963 data based on the rate of change shown for the region as a whole. Where 1963 data were also unavailable, values were estimated based on the regional ratio of wholesale to retail sales.

b. Value of wholesale sales by city--
Data for this variable was complete only in regions 1, 12, 14, 19, 20, 26, 27, 28, 31, 33, 36, 41, and 43. For all other regions, missing data were estimated as in 5a.

6. Census of Manufactures-Area Statistics 1963 and 1967 (63, 64)

a. Value added in manufacturing by county
b. Manufacturing employees by county, based on work site
c. Manufacturing payroll by county
For these three variables, 1967 data was used, where available. However, for at least one county in regions 2, 7, 8, 10, 11, 13, 14, 15, 19, 21, 22, 31, 32, 33, 38, and 40, only 1963 data were reported. 1967 figures were estimated by extrapolating the 1963 data at the rate of change shown for the total region.
d. Value added in manufacturing by city
e. Manufacturing employees by city, based on work site
f. Manufacturing payroll by city
For these three variables, complete 1967 data were available in only regions 1, 2, 3, 9, 12, 19, 24, 38, and 41. For all other regions, missing data were estimated as in 6a, b, c. If 1963 data were also lacking, figures were estimated as the ratio of manufacturing employees by city to manufacturing employees by county, both based on home site data, times the county counterpart of the missing figure.

7. Census of Population: 1970, Number of Inhabitants (67)

a. Total population by county
b. Total population by city

c. Farm population by county

8. Census of Population: 1970, General and Social Characteristics (68)

a. Employed by county based on home site
b. Manufacturing employed by county based on home site
c. Agricultural employed by county based on home site
d. Average income by county
e. Employed by city based on home site
f. Manufacturing employed by city based on home site
g. Average income by city
h. Average income of farm residents