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THE ROLE OF TRANSPORTATION IN POPULATION DISTRIBUTION

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If the effects of transportation on population distribution and land use policy are to be properly evaluated, the subject must be defined more precisely as the role of population in transportation economics, with emphasis on the role of *population as the determining transportation factor* in enterprise selection and location theory. With the existing technology in physical distribution and transportation, any amount of goods or commodities can be moved effectively and efficiently between any two or more points on the continent. The difficulty is that physically efficient moves are not necessarily economically efficient moves.

Our goal is: (1) to develop the relationship between transportation and population distribution as it pertains to enterprise selection and location theory and (2) to develop this relationship in such a manner that it can be understood by those individuals involved in the decision making. This requires an objective approach to the development of regional economic activity rather than the strongly subjective "we shall overcome" approach to enterprise development which has long prevailed in rural and semirural areas. Too often this approach makes overly optimistic assumptions concerning both supply and demand.

TERMINOLOGY AND CONCEPTS

Before developing this discussion certain concepts and principles must be understood and accepted. Some of these are elementary principles of economics. Some are basic concepts of transportation. All of them have historically been ignored or misunderstood in considering the role of transport in economic growth and development, if the role of transport has been considered at all.

First, the supply of transport is physically limited and the limits of economic transport are clearly defined.

Second, the transport sector is subject to all of the basic principles of economics. Price theory is as applicable to the transport sector as it is to all other areas of economic activity.

Third, *back-haul* is the "distressed" pricing of surplus transport. The movement of each commodity must be analyzed in terms of the

economics of the movement of that commodity at all levels of flow to specified markets and not as a function of a carrier's pricing activity in disposing of only a fixed amount of surplus capacity. Back-haul is valid only as long as the commodity demand does not exceed the carrier's surplus capacity.

Fourth, transport takes place in a complex environment of interaction between goods and commodities, and it must be recognized that changes in any commodity market, supply or demand, have an impact on the movement of other commodities that depend on the same transport mode.

Fifth, the capacity of transport vehicles and the cost of ultilizing them vary with the type of vehicle and not the commodity transported. Transport vehicles are not entirely interchangeable.

DISCUSSION

Having spelled out and accepted the above, we can now develop the relationship of population to transportation. The basic transportation cost equation is:

$$TC_{mc} = [1 + (1 - \{\text{prob bal}_R\})]\ [\alpha t + w_p\ (hr_p) + f(hr_a)]$$

where:

TC_{mc} = the total transport cost of a commodity movement by motor carrier.

$\{\text{prob bal}_R\}$ = the *probability of revenue balance* against the specific commodity movement (the probability that revenue will be generated on the return trip). The expression $[1 + (1 - \{\text{prob bal}_R\})]$ is the *revenue balance factor.*

αt = the fixed cost per day of ownership of the power unit and its supporting trailers multiplied by the number of days required for the specific commodity movement.

w_p = actual fully costed wage paid.

hr_p = hours paid for—not necessarily worked.

f = fuel expended per hour of operation.

hr_a = hours actually operated—not necessarily the same as hours paid.

In considering the above equation two things should be emphasized: (1) transport must be costed on a time, not a distance basis, for all of the hours involved in the movement; and (2) the revenue balance factor determines the actual cost burden with a potential

variance of 100 percent. Expressing the cost function in cost per unit of time rather than cost per unit of distance allows a very accurate description of costs with linear components.

If the probability of revenue balance equals 1, the revenue balance factor becomes $[1 + (1 - 1)] = 1$, and the cost of the commodity movement becomes:

$$[(1 + 0)\ (\alpha + w_p(hr_p) + f(hr_a)]$$

but where the probability of revenue balance equals 0, the revenue balance factor becomes $[1 + (1 - 0)] = 2$, and the cost of the commodity movement becomes:

$$[(1 + 1)]\ [\alpha + w_p(hr_p) + f(hr_a)]$$

thereby doubling the cost of the movement.

The importance of this multiplier is clear when it is realized that the raw, out-of-pocket, cost approximates $15.50 per hour. Such a relationship clearly ties the economic ability of a region or community to market a commodity directly to the ability of that same community to consume a second commodity or a good derived from the destination region. This linkage brings the relationship of population and transportation into focus. Since the ability of a community or a region to absorb a good or commodity is primarily a function of its population size, it must be axiomatic that a community or region can absorb no more of any good or commodity than its annual per capita consumption times its population. The amount of the good or commodity actually imported will be annual per capita consumption times population minus local production consumed. (Due to the mobility of the transport sector, particularly the motor freight sector, empty movement within a region is common. Thus, generally the region is the dominant area.)

INTERREGIONAL COMPETITION

The ability of any community or region to achieve balanced transport is equal to the total of all imports segregated by type of product and by community or region of origin. Beyond this point the probability of balance for each additional shipment of any given commodity is 0. Each additional load with a 0 probability of balance diminishes the over-all probability of balance until the point where the total probability of balance approaches 0. For example, that point is reached very rapidly when a processing plant is located in a sparsely populated area. A diminishing over-all probability of balance, of course, adds to the advantage of a competitive region of greater population density. The competitive cost position of a densely popu-

lated commodity supply area with a probability of balance of 1 located twice the hours from a given market is exactly equal to the competitive transportation cost of the commodity supply area with a probability of balance of 0, all other other factors remaining equal.

Unfortunately all other factors do not remain equal. Many commodity demand markets are not level day by day but vary with retail consumer shopping patterns. A surging demand structure works to the advantage of the supply area in direct ratio to the distance from the demand market. This is because the total number of days of transport utilization will be increased by virtue of the longer transport arc charged against the commodity movement. A shipper in Oregon shipping beef to San Francisco could well be limited to two days of transport equipment utilization per week against a Thursday market while a shipper in Nebraska could achieve five days of equipment utilization against the same market. With labor and equipment being bought in five-day or longer increments the only reduction in cost offered by nonuse in terms of the basic equation becomes fuel. Obviously such a situation as two-day use would not exist in a market place if it could be eased by the use of multiple trailers or any other device. However, because any such device would increase cost, it can be seen that proximity to market can be a decided disadvantage if the proximity to the market is coupled with sparse population.

Tables 1, 2, 3, and 4 delineate the primary production areas for red meat, poultry, fruits, and vegetables in the United States. Dominance in market share goes almost without exception to production areas with the population density to support an economically efficient inbound flow of transport equipment.

Market dominance in agricultural processing is held by those areas where population density supports an inbound movement of the specialized transport requirements needed for effective marketing while less densely populated regions produce and market commodities adaptable to lower cost bulk forms of transport.

POLICY IMPLICATIONS

The interactions of transportation and population are well defined. The import sector must lead the export sector in a market economy. This is a truism well understood by the early traders and colonizers but somehow overlooked in the current scheme of things.

The implications of this relationship to programs of population distribution are clear. Any program of population redistribution must recognize the significance of the role of distributive transport in achieving the desired redistribution. This is true whether the redis-

TABLE 1. RED MEAT PRODUCTION: RANK OF STATES BY NUMBER OF HEAD SLAUGHTERED, 1969

Rank	Cattle		Calves	
	State	Number	State	Number
		1,000 Head		*1,000 Head*
1	Nebraska	4,159	New York	795
2	Iowa	4,130	Pennsylvania	459
3	Texas	3,011	Wisconsin	428
4	California	2,936	New Jersey	381
5	Minnesota	1,868	Texas	313
6	Colorado	1,714	Iowa	262
7	Kansas	1,664	New England	240
8	Missouri	1,590	California	235
9	Wisconsin	1,245	Louisiana	225
10	Ohio	1,123	Florida	203

Rank	Sheep and Lambs		Hogs	
	State	Number	State	Number
		1,000 Head		*1,000 Head*
1	California	1,748	Iowa	26,738
2	Colorado	1,351	Minnesota	6,090
3	Texas	1,184	Illinois	5,475
4	Nebraska	845	Ohio	4,470
5	New Jersey	841	Pennsylvania	3,870
6	Utah	830	Indiana	3,625
7	Illinois	720	Virginia	3,204
8	Minnesota	563	Missouri	3,118
9	Iowa	475	Wisconsin	3,084
10	South Dakota	376	Tennessee	2,893

TABLE 2. POULTRY PRODUCTION: RANK OF STATES BY NUMBER OF HEAD SLAUGHTERED, 1969

Rank	Young Chickens		Young Turkeys	
	State	Number	State	Number
		1,000 Head		*1,000 Head*
1	Georgia	32,217	California	1,424
2	Arkansas	28,788	Minnesota	982
3	Alabama	23,021	North Carolina	642
4	North Carolina	22,119	Texas	609
5	Mississippi	16,399	Virginia	530
6	Texas	14,238	Missouri	483
7	Maryland	14,145	Iowa	443
8	Delaware	7,688	Ohio	393
9	Virginia	7,082	Pennsylvania	282
10	Pennsylvania	6,237	Wisconsin	280

TABLE 3. FRUIT CROPS BY AREA AND STATE OF PRIMARY PRODUCTION: PERCENT OF TOTAL MARKET, 1970

Fruit	Region	Percent	Primary Producing States
Apples			
All	West	34	Washington, California
Delicious	West	50	Washington
Peaches			
Cling	West	100	California
Freestone	South	48	Georgia, North and South Carolina
	West	34	California, Washington
Pears	West	92	California, Washington, Oregon
Grapes	West	95	California, Washington
Cherries			
Tart	Great Lakes	94	Michigan, New York
Sweet	Great Lakes	30	Pennsylvania, New York, Michigan
	West	60	Oregon, Washington, California
Plums	West	80	California
Apricots	West	100	California
Dates	West	100	California
Figs	West	100	California
Nectarines	West	100	California
Olives	West	100	California
Berries			
Cane	West	100	Oregon, Washington
Strawberries	West	80	California, Oregon, Washington
Grapefruit	South	65	Florida
Oranges	South	80	Florida
Lemons	West	100	California

TABLE 4. LEADING FRESH MARKET VEGETABLE STATES, 1970

State	Percent of Total Production
California	39.3
Florida	12.6
Texas	10.1
Arizona	5.7
New York	5.3

tribution focuses on a single plant location or regional and national development.

Should the national decision be to concentrate the majority of the population into large urban areas, while simultaneously improving the lot of the urban dweller, the market mechanism discussed above requires no adjustments. However, should the national goal become one of population dispersion with the development of smaller urban centers throughout the land, then one of two general approaches must be adopted: (1) a policy of dispersing labor-intensive activities with

little or no export product (government agencies, military installations, electronic factories) to serve as a nucleus for the community; and then building export industries (agricultural or industrial) around these importing nuclei; or (2) a policy that recognizes the role of the market and defeats it by subsidizing export industries by an amount equal to the difference between the actual probability of balance and a probability of balance of 1.