Transport Costs and Rural Development

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Working Paper 95-WP 133
April 1995

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TRANSPORT COSTS AND RURAL DEVELOPMENT

Rural areas can be succinctly characterized as (i) remote, (ii) sparsely populated, and (iii) dependent on natural resource industry. These are also the challenges to rural development (GAO 1994). Why not tackle rural remoteness directly by improving accessibility? More people could live in the "hinterlands." And once transportation costs are reduced, wouldn't cheap transport promote rural industrial diversification as well? On the other hand, some analysts would say that increasing transport access to rural areas just provides the way for people to flow away into the cities.

This paper is about how transport costs condition the choices by firms and people to concentrate in cities or to spread out across agricultural hinterlands. Location theorists have long known that in general, lower transport costs promote clustering of firms at the hub of a market (Gabszewicz and Thisse, 1986). Agglomeration economies reinforce the low transport cost incentives favoring concentration. More recently, the role of declining transport costs in promoting the growth of cities at the expense of the countryside has been demonstrated by Nerlove and Sadka (1991) and by Krugman (1991,a,b).

With a simple general equilibrium model in which agricultural transport costs 5 to 25 times industrial transport costs, Nerlove and Sadka show that reducing agricultural transport costs, by making it economically feasible to cultivate land farther from the city, encourages less labor use per acre, lowers agricultural terms of trade, reduces rural population, and increases the proportion of the labor force working in town. (Welfare in both the city and the countryside, however, rises unambiguously.) With an even simpler model focusing only on costly industrial good transport, Krugman obtains similar results about concentration of population, employment, and industry.

This paper considers the case between zero and relatively high agricultural transport costs. In this generalization of Krugman's ad hoc model, agricultural goods are required in fixed proportions relative to either population or industrial output (e.g. food, fuel), and are also costly to transport. Since precisely equal distributions of population and resources across space are improbable (Krugman's assumption), we focus on the asymmetric cases. Farmers are tied to farm land while other firms can locate anywhere. We find, like Krugman, that reducing transport costs reinforces historical patterns: concentration if historically concentrated, and equally dispersed if historically

equally dispersed. However, we also find that there are many plausible conditions under which a hinterland location would be preferred to concentration or diversification.

Furthermore, we uncover useful insights about the role of declining *relative* industrial versus agricultural transport costs. We show that footloose firms would prefer a hinterland location if transport costs to the final market are sufficiently low relative to the transport costs for necessities from the hinterland. In other words, the hinterland becomes more and more attractive to firms producing items for which transport costs to market are relatively low and falling (e.g. information processing, electronic services). Since market forces and technological changes drive this desirable outcome, government intervention to force firms to choose rural locations appears unnecessary.

The elements of our model concern a country that produces two goods, "manufactures" and "food." Land is asymmetrically distributed across the two jurisdictions: "East" ($1-\phi$) and "West" (ϕ). Both manufactures and food are consumed in constant proportions per person. This, in conjunction with constant unit labor requirements, implies that the proportion of the total population (N) who are workers is given by manufacture's share in expenditure (μ). Arbitrage will equate local product with c.i.f. import prices for both types of goods. Thus, at any market prices, the inframarginal manufacturing firm maximizes profits by locating relative to consumers (workers and farmers) and food suppliers (farmers) to minimize costs. Manufacturing costs include fixed (F) and transport costs (t per unit), but are otherwise common to all locations because production technologies are the same and workers are mobile. Food transport costs (α per unit) must be covered by firms if total local demand exceeds local supplies.

Table 1. Population Distribution

	Location of Manufacturing Industry		
Regional Population	East	Both	West
East	$\mu N + (1-\phi)(1-\mu)N$	$(1-\phi)\mu N + (1-\phi)(1-\mu)N$	$(1-\phi)(1-\mu)N$
West	$\phi(1-\mu)N$	$\phi\mu N + \phi(1-\mu)N$	$\mu N + \phi(1-\mu)N$

Since demands are strictly proportional to population, the size of each region's market depends on population in the region. By the same token, population is given by the distribution of

total employment across regions. Table 1 presents the population distributions under three polar cases of industrial location: concentrated in East, dispersed across *both* regions, or concentrated in West. Note that we assume that the historical distribution of manufacturing employment across regions in the diversified case matches the distribution of the farm population.

These population distributions determine total transport costs for manufacturing firms. Transport costs to deliver manufactures to the market will be incurred unless the firm locates where all the workers and farmers reside. Transport costs for food will be incurred to the extent that the local demand for food exceeds local food production. Since farmers are tied to the exogenously distributed land, regional food production is fixed at $(1-\phi)N$ in the East and ϕN in the West. Thus, nonzero transport costs for food dampens the incentives for firms to concentrate.

This is a generalization of the ad hoc model presented by Krugman in *Geography and Trade*, in essence the general equilibrium model in his 1991 *Journal of Political Economy* paper. We introduce positive costs of transporting food and an asymmetric distribution of farmers. If industry locates in only one region, transport costs must be incurred to serve the other region's market *and* (if necessary) to obtain food. If industry locates in both regions, transport costs are avoided but an additional fixed cost is incurred.

Table 2 shows the costs that a new firm would face under three possible location strategies, given the location of other firms. For example, the first row represents the costs given the historical firm location pattern that East is a region with a history of manufacturing as well as farming, while West is populated only by farmers. From Table 2 it is clear that when agricultural transport cost is nonzero, costs for an agglomerated location are increased because local food needs exceeds local food output.

How regions evolve as transportation costs change may be understood by considering how transport costs determine an inframarginal firm's location choice. Consider the case in which manufacturing is concentrated in the East. Agglomeration will be preferred if the costs of locating in the same region as all other firms are less than *both* the fixed costs of two locations and the cost of locating in the hinterland (West). Agglomerate (in the East) if both (i) and (ii) are true:

(i) $t\phi(1-\mu)N + \alpha\phi\mu N < F,$

(ii) $t\phi(1-\mu)N + \alpha\phi\mu N < t[\mu N + (1-\phi)(1-\mu)N].$

According to criterion (i), lowering the cost of food transport (α) increases the likelihood that concentration entails lower costs than opening plants in both regions (diversification). By the same token, reducing the transport cost for manufactures (t) also favors agglomeration. When $\alpha = t$, as long

Table 2. Total Costs Under Nine Location Strategies

All Other Manufacturing	Firm Location: East	Both	West
East	$F + t\phi(1-\mu)N + \alpha\phi\mu N$	2F	$F + t[\mu N + (1-\phi)(1-\mu)N]$
Both	$F + t[(1-\phi)\mu N + \phi(1-\mu)N]$	2F	$F + t[\phi\mu N + (1-\phi)(1-\mu)N]$
West	$F + t[\mu N + \phi(1-\mu)N]$	2F	$F + t(1-\phi)(1-\mu)N + \alpha(1-\phi)\mu N$

as East has a minimum farm population ($\phi < F/N$), manufacturing will continue to concentrate in the East as all transport costs fall.

Figure 1 plots the cost savings with agglomeration in the East over the alternative locations Both and West, assuming that agricultural and manufactures transport costs are equal. The downward sloping line shows the inverse relationship between transport costs and agglomeration relative to diversification. The higher transport costs are, the less advantageous agglomeration is. Conversely, the lower transport costs are, the more advantageous agglomeration is. If we stop here, we see why some people conclude that transport should be taxed to avoid agglomeration in cities at the expense of the countryside.

For those concerned with rural development, the correct comparison is not between diversified locations and agglomeration, but between a hinterland location and agglomeration. This is criterion (ii), illustrated in Figure 1 by the *upward* sloping line. Since population concentrates where the mobile employers are, the higher transport costs are, the larger the cost savings of the agglomerated location over a single hinterland one. The optimistic implication is the corollary: the cost advantage of a hinterland location *rises* with *falling* transport costs. In the particular case of

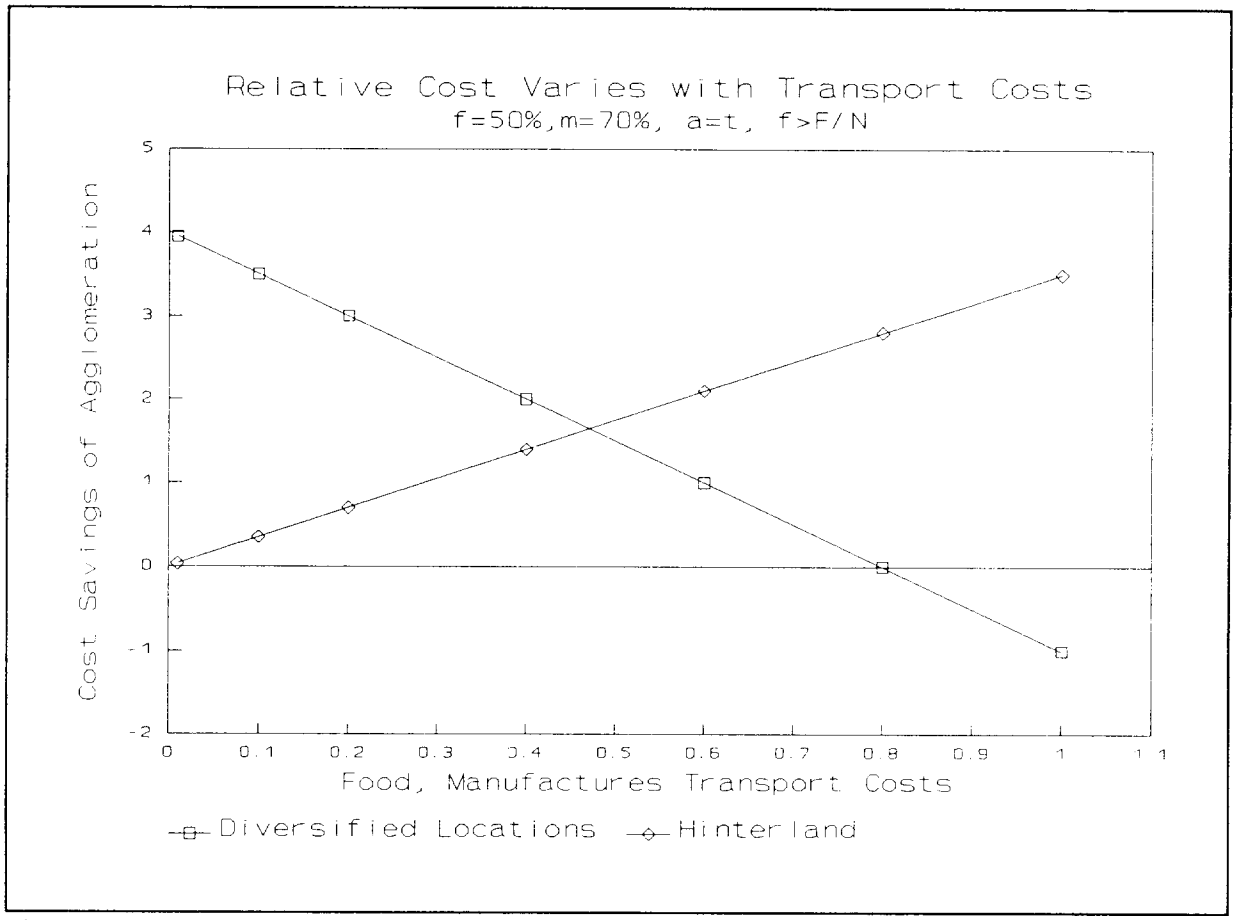

Figure 1. Cost savings with agglomeration, East versus Both and West.

equal transport costs, a relatively large proportion of workers, and an equal distribution of farmers across regions as illustrated in Figure 1, the hinterland never offers a cost advantage. This is not a general implication.

A little analysis of condition (ii) indicates that whether or not the hinterland could ever offer a cost advantage depends on *relative* transport costs and a lot of other things. To highlight this, we reorganize condition (ii) as follows. Agglomeration is cost-effective if:

(ii′) $t/\alpha > \phi\mu/(1-2\phi+2\mu)$.

In other words, if manufactures transport costs fall *below* a certain proportion of agricultural transport costs, a hinterland location will minimize costs. This is because when food is relatively costly to transport, a reduction in manufactures transport costs makes it possible to reduce total costs even

further by locating closer to the food. At low relative costs of transport for manufactures, footloose firms will find it more advantageous to locate closer to the excess supplies of food.

There is a point at which *relative* reductions in transport costs cease to favor concentration and begin to favor the hinterland. This depends on the characteristics of the economy. We have already identified the role of the distribution of population across regions, summarized by the parameter ϕ. The share of industry is also important (summarized by μ). We highlight these conditions by investigating how the cost differentials (i) and (ii) vary as relative transport costs (t/α) change, under various assumptions about ϕ and μ. Industrialized countries are characterized by high ϕ (large proportion of farm population in one region), and μ (large share of manufactures in expenditure, equivalently, of workers in the total population).

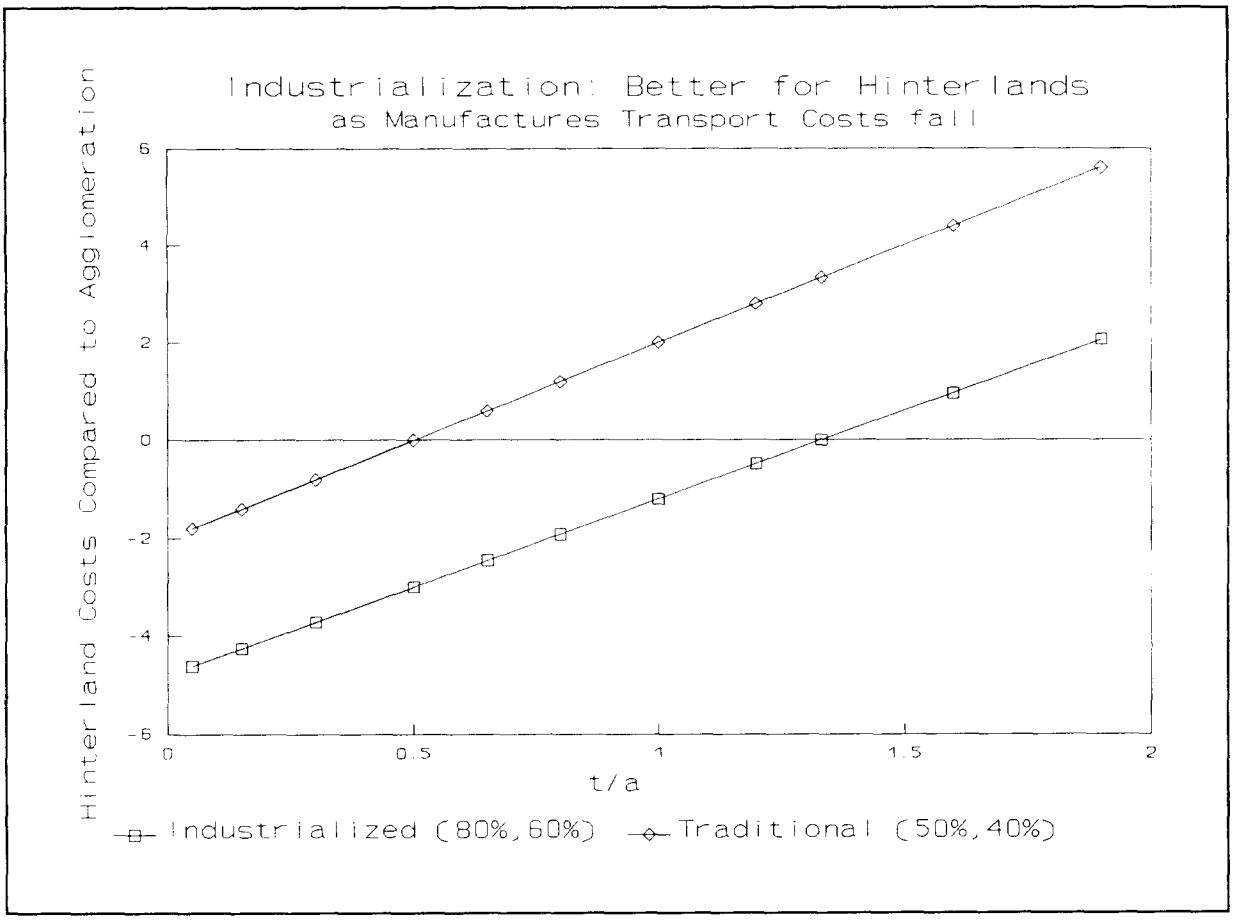

Figure 2. The difference in "break point" between two stylized economies.

For example, if $\phi=80\%$ and $\mu=60\%$ (an industrialized country with most of the farms in one region), further reductions in t after it falls below 1.33α favor the hinterland. At these relative transport costs, a firm could do better by locating nearer the farmers than by agglomerating. For a traditional country where $\phi=50\%$ and $\mu=40\%$, t can fall to as low as 0.5α before concentration is no longer cost-effective.

Figure 2 shows the difference in the "break point" between our two stylized economies. This squares well with our intuition. It suggests that, in developing countries, reducing the costs of goods transport more likely accelerates rural to urban migration because relative manufactures transport costs can change substantially without changing the fact that agglomeration is cost effective relative to diversified and hinterland locations. In industrialized economies, a relative reduction in the cost of transporting manufactures is more likely conducive to hinterland development.

Furthermore, condition (ii) suggests that a skewed regional distribution of farmers and farm land also plays an important role. Even if manufacturing is historically concentrated in the East, the larger the proportion of farmers in the West (ϕ larger), the more attractive is diversification. This is, however, just another angle on the well-known result that footloose firms prefer to locate nearest to the largest market when output transport is costly. That the optimal location is determined by the interaction between minimizing input costs (pull towards input supplies) versus maximizing net revenues (pull towards output demanders) is well known among math programmers solving applied spatial allocation problems. Unfortunately, these wise general implications have often been overshadowed by impressive programming algorithms or hidden within specific industry applications.

In sum, we have highlighted conditions under which further reductions in transport costs to market can favor the industrial development of a hinterland. We generalized a simple model to the case in which food can be transported between regions only at a cost, and the distribution of farms is not necessarily uniform across regions. In our simple model, as in the real world, regional population and employment opportunities are positively correlated. But in spite of this positive feedback favoring agglomeration, we show that firms producing products with *relatively* low transport costs to central markets can find a hinterland location to be profit maximizing.

To persons concerned about rural development in industrialized economies, this is a more optimistic scenario than the ones suggested by previous authors. In industrialized economies, by definition, rural areas are some distance away from population centers. As the economies developed, the rural areas declined. Manufacturing industries tended to expand in urban areas instead. The rural population fell to levels proportional to the employment in the natural resource-based industries

located there. This pattern of concentration of industry and population in urban areas at the expense of rural ones is predictable on the basis of reduced costs of final goods transport if we abstract from costly agricultural goods transport.

But development is not a one-way street away from the agricultural hinterlands. In this paper, we have shown that industrial development in itself increases the scope for new development in the hinterland as transport costs for outputs *relative* to primary products declines. New products and services are being developed that can be transported great distances electronically, for example, greatly reducing the *relative* cost of industrial transport compared to agricultural transport. This trend favors hinterland locations for footloose firms. Rural locations can be attractive to firms when the combined costs of supporting a rural work force and transporting output is lower than the cost of supporting an urban work force. Such incentives are provided by the market; government intervention is not required.

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