Appendix B — The Economics of Agricultural Transportation

Background

America's agricultural producers depend upon transportation, for it is transportation that links the fields of producers to the tables of consumers, both here and abroad. Lowering the cost of transportation services (or increasing the quality of those services) creates opportunities for specialization among producers that are beneficial to society. For example, because of refrigeration, consumers can purchase more and better quality produce, much of which is grown in areas far from this Nation's metropolitan areas.

Because much of this country's agricultural production occurs in the interior of the North American land mass, far from the ports that link our economy to the world, transportation is critical to the competitiveness of U.S. agriculture in international markets. By investing in an extensive inland waterway system and providing a climate conducive to efficient rail transportation, the United States has been able to compete effectively in international market. By contrast, many nations that compete with American producers have not been able to create efficient transportation and distribution systems. As a result, even though much of their agricultural production occurs in regions much closer to the ocean, their international competitiveness has suffered. Thus, the U.S. transportation system has been a key competitive advantage for U.S. agricultural producers in international markets.

The importance of international trade to American agricultural producers is considerable. Throughout the 1980's and 1990's, the export market accounted for 25 to 30 percent of total agricultural sales. Crop production is especially dependent upon the export market. During the period 1992-96, U.S. wheat producers exported an average of 51 percent of their annual production and accounted for 33 percent of total wheat traded in the world market. During this same period, U.S. coarse grain producers exported an average of 22 percent of their annual production and accounted for nearly 60 percent of world trade in coarse grain. Producers of rice and white wheat are particularly dependent upon foreign consumers. In general, these commodities are increasingly dependent upon foreign consumers. With increased current production, and even higher prospective levels in wheat, apples, soybeans, and value-added exports, foreign markets will continue to be a necessary complement to the domestic demand for U.S. agricultural products.

Recently, however, concerns have been raised about the adequacy of the U.S. transportation system. Indeed, many observers feel that the historical, competitive advantage that U.S. agricultural producers have enjoyed, thanks to an efficient transportation system, is threatened, and with it their ability to maintain access to critical international markets. Among these concerns are: (1) the increasing market power of railroads as a result of consolidation; (2) concerns that the inadequate and inefficient service provided by railroads last year may not be an aberration but may reflect fundamental capacity constraints; (3) an increasing need for public investments in highway and waterway infrastructure; (4) differential regulation of international commerce that affects overall transportation system performance; and (5) the major investments that some foreign competitors are making in their transportation infrastructure.

This appendix takes a deliberate look at why transportation and successful trade are inexorably linked. In so doing, the theoretical relationship between transportation and trade is developed, identifying how transportation ultimately allows economies of scale in production via access to new markets. Broadened competition among producers, production areas, and nations enhances customer-oriented service and encourages product and production innovation. This competition then prevents or minimizes price distortions to consumers and provides a general overall discipline to market pricing. Clearly, customers are well served by transportation-induced market competitiveness; indeed, these competitive elements have positive long-term impacts on consumers, producers, and the nation's economy.

Finally, this appendix examines those characteristics of agricultural production and agricultural commodities that make adequate and efficient transportation especially critical to successful marketing. For the individual producer, it is important to realize that any dollar saved in his or her transportation bill or marketing expenses is a dollar that goes into that producer's pocket; no deductions are necessary for fertilizers, chemicals, or other farm inputs. This basic concept holds for firms, industries, regions, and economies.

Theoretical Relationship Between Transportation and Trade

Before the rise of agriculture, few items other than those necessary for survival were produced or sought out. Opportunities for exchange and specialization were largely confined to the ordinary tasks an extended family would confront. That is, early man produced not for a market but for a household's consumption. The development of agriculture allowed for individuals to specialize as hunters, farmers, merchants, etc. Society became more complex as more roundabout methods of production were adopted and exchange activity spread over broader agricultural areas and wider timespans.

Since the time of Adam Smith, it has been recognized that exchange activity (trade) between specialized producers forms the basis of economic development. For specialization to be useful or even possible, trade must occur. But trade depends upon transportation; goods must be brought to the proper place at the proper time. Hence, transportation is vital to the economic well-being of society and developed economies.

The commercial agriculture sector of the modern U.S. economy is incredibly productive; however, it is increasingly dependent upon production in regions distant from urban consumers. Marketing and transporting these goods efficiently, effectively, and profitably to each consumer when, where, and in the desired form are necessary tasks that allow consumers to maximize their utilities (or desires). Marketing is often defined as the creation of utilities, and a market is often defined in terms of geographic boundaries, but marketing depends upon transportation to deliver the desired goods in the first place.

Place utility (usefulness) consists of, or is created by, getting the product to the consumer where it is desired. Wheat, cotton, soybeans, etc., are produced great distances from the urban populations of the United States and even farther from markets in other parts of the world. Transportation of these commodities to the location where they are desired (and where customers will pay for them) generates place utility. For the farm input supply manager, place utility needs generate decisions about how best to deliver fertilizer to the field or where to buy commodities that are later resold. For some agricultural commodities, which tend to be bulky and inexpensive, transportation costs can be equal in magnitude to the raw product value on the farm.

Transportation improvements affect demand by increasing access to markets. In the simplest terms, as shown in figure B1, if the market price determines the value of a product, the market price itself is determined by the classic intersection of demand and supply curves in a marketplace. The demand curve's location and shape are affected by price, consumer income, population, tastes and preferences, and price/availability of substitute goods. A more efficient transportation system will lower consumer prices and make it increasingly attractive for consumers to purchase larger quantities. Further, when transportation availability and capacity provide access to new trade opportunities, many of these demand shifters can be affected. Access to new markets will increase the population of buyers available to purchase our production. When transportation makes available higher quality products or products with new tastes and appeals, demand is increased.

Increased demand due to transportation-facilitated trade increases the quantity sold from Q_1 to Q_2, and the value of production on a per-unit basis, from P_1 to P_2. The benefits to the individual producer and region are evident — higher prices, expanded sales, and increased revenues. Similar results of improved producer net prices are realized from any increases in efficiency of transport.

However, the impacts do not stop there. The benefits of the increased value of production (price increases) are heightened by increased investments in new production technologies, technologies that may not have yielded an adequate rate of return at the lower market price. Thus, improvements in transportation stimulates innovative activity in the production sector, which may lower the price risk faced by the producer.

The decreased risk and access to markets facilitates further specialization, the underpinning of trade. As depicted in figure B2, the increased market volume and market-clearing quantity at

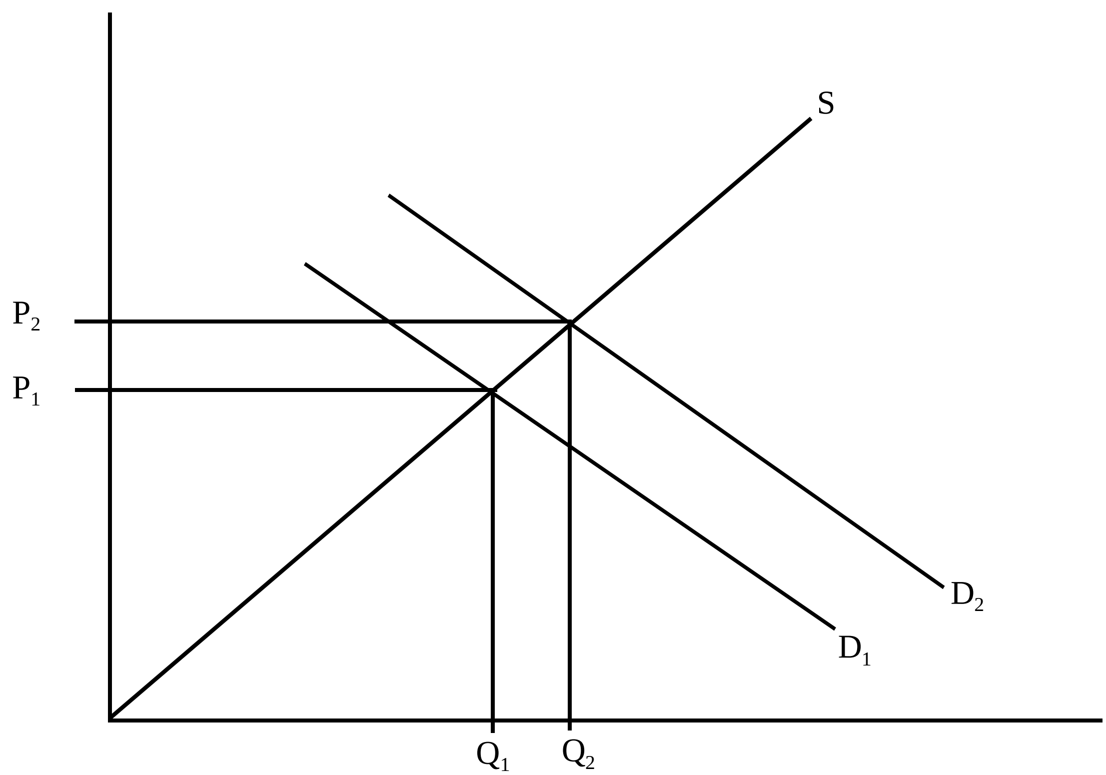

Figure B1 — Impact of trade on value of production

equilibrium (figure B1) allow economies of scale to be achieved in the long run. As the firm or region produces increased quantities in response to new trade opportunities, the average cost of production decreases from P_1 to P_2, allowing increased profits to the producer, a shift of the supply curve (enhancing trade possibilities), or both. Again, both the producer and consumer, depending on relative elasticities (market power), can gain from this transportation-facilitated trade.

The impact of increased trade is quite direct, but multilayered. It increases the price and quantity of traded goods, encourages larger scale and more efficient production methods, entices investments into new production techniques, and allows new or different combinations of inputs to be used as the producer searches to maximize profits and take advantage of these trade opportunities. Also, it should be noted that the improvements in efficiency that result from enhanced transportation and trade are enjoyed not only enjoyed by producers; consumers benefit from lower prices, better quality, and greater quantity of goods available to them.

The core concept in the theory of trade is the notion of *comparative advantage*. Based on the economies of specialization, this principle states that firms, areas, or countries should produce those products in which they have a comparative advantage (or in which their comparative

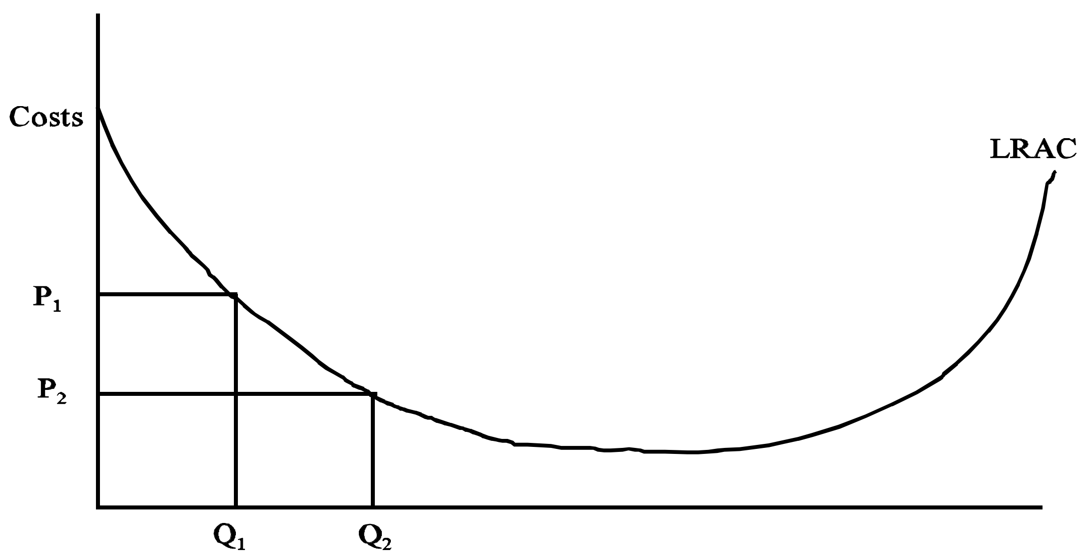

Figure B2 — Long-run average cost of production

disadvantage is the smallest). The advantage of one area over another arises from the production functions or cost of inputs available in each area, and the resultant differing costs of production. Table B1 reflects a hypothetical example of two countries, Canada and Ireland, producing two different commodities, wheat and computers.

Table B1 — Production of wheat and computers in Canada and Ireland when both nations possess an absolute advantage

	— Total Production at Five Units of Input —	
Country/Product	Wheat	Computers
Canada	30	7
Ireland	6	14

This is a situation in which, with 5 units of input, Canada could produce 30 units of wheat or 7 units of computers, as compared to Ireland, which could produce 6 units of wheat or 14 computers. In this example, Canada has an absolute production advantage in wheat, and Ireland has an absolute production advantage in computers. If no trade occurred and each county has 10 units of input that it divides equally between wheat and computers, the total output of wheat would be 36 units (30 from Canada, 6 from Ireland) while total computer output would be 21 (7 from Canada, 14 from Ireland). However, if each nation specialized in the product it produced most efficiently and trade occurred, then for the same 10 units of input (in each country), 60 units of wheat from Canada and 28 units of computers from Ireland would be produced. Thus, specialization and trade would have increased the amount of wheat available by 24 units (60-36=24) and increased computer output by 7 units (28-21=7), thereby making both countries better off.

With the tremendous variation in technological expertise and natural resource endowment, it is probable that some areas or countries have no absolute advantage, but could have a comparative advantage. Consider the hypothetical example presented in table B2. Ireland has an absolute advantage over Canada in both wheat and computers. For every computer unit produced in Canada, Ireland can produce three (a 3:1 advantage), while Ireland can produce twice the wheat output of Canada for each unit of input. Ireland has its greatest comparative advantage in computers, and by specializing in computers, it would be able to produce 90 units of computers using its 10 units of input. Canada would specialize in the production of wheat and would produce 40 units of wheat with 10 units of input. Total production is 40 units of wheat and 90 units of computers, contrasted to 35 and 85 units, respectively, if no specialization occurred.

The concept of comparative advantage is ubiquitous: Specialization by area is seen in farming (wheat in the Great Plains, tobacco in the southern States), in individuals (lawyer versus mechanic), and in countries (Japan's high technology industry versus Mexico's manufacturing and assembly activities). Comparative advantage underlies trade but is always dependent upon production capabilities and availability of markets.

Our hypothetical examples assumed the availability of transportation, but if there was no transportation between Canada and Ireland, then the benefits of using comparative advantage specialization would be lost.

Table B2 — Production of wheat and computers in Canada and Ireland when both nations possess a comparative advantage

	— Total Production at Five Units of Input —	
Country/Product	Wheat	Computers
Canada	20	15
Ireland	40	45

A simple spatial equilibrium model shows how transportation efficiencies facilitate trade between regions. Such a model links transportation and trade through the concept of transfer costs. Transfer costs are any costs associated with moving a commodity between two regions; e.g., loading/unloading charges, handling charges, brokerage fees, and transportation costs.

A specific example is provided in figure B3, which illustrates the theoretical impact of a reduction in transportation costs on the volume of Washington apples exported to Mexico. In this example, hypothetical supply and demand functions are given for the apple markets in Washington (S_w and D_w) and Mexico (S_m and D_m). These functions are drawn to represent Washington as a potential surplus region and Mexico as a region of potential deficit.

From the top two diagrams, excess supply in Washington can be calculated. Excess supply is equal to the horizontal distance between the supply and demand curves (S_w and D_w) at points above the equilibrium price of $30 and shows what further production would be supplied by producers if the equilibrium price increased. Excess demand in Mexico can be similarly calculated as the horizontal distance between the supply and demand curves (S_m and D_m) at points below the equilibrium price of $50. This shows the additional amount consumers would purchase if the price decreased.

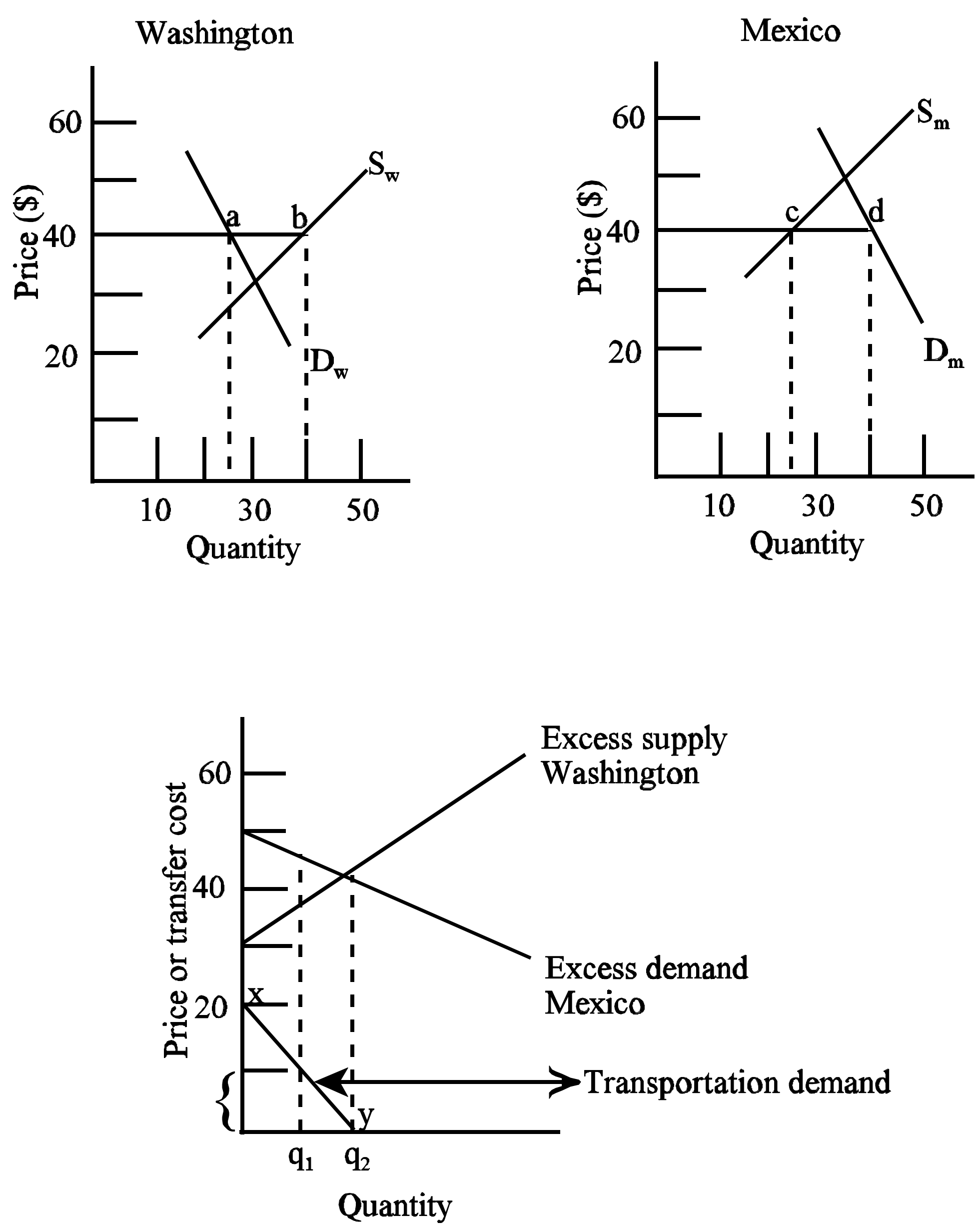

Figure B3 — Spatial equilibrium model depicting apple trade between Washington and Mexico

The excess supply and excess demand curves derived from the top diagrams are shown in the lower diagram. These curves intersect at a price of $40 per unit. Assuming zero transfer costs, a total of 15 units of apples would be exported from Washington to Mexico (AB=CD=15). As transfer costs increase, the volume of trade decreases along the line xy, which effectively becomes the demand for transportation. When transfer costs are equal to or greater than $20 per unit, no trade will exist between the two regions. It should be noted that, after trade, the market price in Washington will have increased, and the price in Mexico will have decreased. Any decrease in transportation cost would affect producers' price similarly.

While the numbers in this example are hypothetical, the conceptual basis is clear. Reducing transportation costs lowers total transfer costs which, in turn, can increase the value of trade between regions. Agricultural trade is especially sensitive to changes in transportation costs because transportation costs are often a relatively large portion of the delivered price, particularly for raw, unprocessed commodities. Thus, in the computers and wheat example, changes in transportation costs might have small impact on the trade of computer or high-tech items but a potentially greater impact on the trade of wheat or other unprocessed agricultural products.

It should be noted that transportation's role is only that of a facilitator of trade. Transportation has no value in and of itself, only in what value it creates in bringing producers and consumers together. Therefore, transportation should be viewed purely as an input into the productive process — one that, when improved, allows marketing areas to increase in size or causes net product prices received in an existing market to increase. With decreased transport costs, inputs delivered into production areas can shift effective supply curves, causing increased production or net returns or both.

In summary, trade is based on the benefits of specialization. The division of labor inherent in specialization is limited by the extent of the available market. The market itself is limited not by actual physical distance, but by the cost of overcoming this distance, the cost of transportation. Transportation costs thus act as a surrogate for the economic cost of distance, location, and geography.

Importance of Transportation to Agriculture

It is not an overstatement to say transportation was a necessary precursor to the development of the tremendous agricultural productivity of the United States. Agriculture was the keystone of early U.S. development, and transportation availability was the facilitator and, at times, even the instigator of that development. Transportation has a unique role in and relationship to agriculture because of the characteristics of agricultural production, agricultural commodities, and agricultural markets, which are described below.

The unique importance of transportation to agriculture can be illustrated most clearly by referring to Appendix A with its description of the transportation usage by U.S. agriculture relative to other economic sectors. Simply put, totaling the ton-miles of transportation services used to move farm inputs, raw agricultural commodities and processed agricultural products, U.S. agriculture, at 31 percent of total ton-miles, is shown to be the primary user of transport services in the United States.

Characteristics of Agricultural Production

Location theory helps explain why some farms and industries are inclined to locate either near markets or near raw material supplies, while others are free to move around as "footloose industries." Because of its absolute reliance upon resource endowments and weather (except for irrigated agriculture, greenhouse and aquaculture efforts, etc.), agriculture remains heavily dependent upon the location of land. As a result, agriculture is a geographically dispersed industry that, because of its reliance upon and heavy consumption of both space and land resources, cannot simply relocate near its customers.

Further, the specialization inherent in modern agricultural production depends upon a complete transportation system that includes all major modes (water, rail, and highway). This transportation system is available in both complementary and competitive roles to transport both the inputs to and outputs from agriculture. Modern agriculture's transportation-facilitated specialization has two specific effects. First, it permits consumers to leave agricultural production areas and migrate to urban areas for new employment opportunities, thereby facilitating the growth of manufacturing and other industries. Second, it allows the production of specific agricultural commodities to occur in areas where the resource base, weather, and resulting productivity are most conducive to agricultural development.

Location theory reenforces the fact that transportation costs influence the location of agricultural production and the resulting site rents. In addition, location theory helps identify the value of transportation as it is capitalized into the value of land and location. Many changes in the U.S. farm sector have been brought about by changes in locational advantage resulting from institutional and technological changes in transportation. For example, locational shifts in the wheat milling industry were induced changes in rail transit rates and hopper cars. In addition, the initial rise and continued success of California and the Southwest as major suppliers of fresh vegetables occurred only after the development of refrigerated rail cars and more efficient refrigerated containers; the continued domination of this market by these producers is a direct result of the availability of high-speed, long-haul refrigerated trucks. Similarly, the shift of the broiler industry from the East to the South reflected development of barge transportation and barge-competitive rail rates. More recently, changes in the structure of the grain marketing industry, as evidenced by reliance upon fewer but larger facilities, have come about primarily because of transport scale economies made possible by unit-trains, large barge flotillas, and the continuous abandonment of branch lines by the Class I railroads.[1] Transportation even played a role in the farm financial crisis of the 1980's when producing areas farthest from markets were the most heavily affected.

A final point is that while agricultural production remains driven by weather, agricultural marketing is driven by price and competitive conditions outside the individual producer's decision framework. The variation in year-to-year supplies caused by changes in production and inventories places great stress on the transportation system. This stress produces difficult private

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[1] In 1996, Class I railroads refers to those railroads with freight operating revenues of at least $255.0 million.

and public decisions regarding how much transport capacity is economically reasonable and who pays for missed marketing opportunities. There is a public role in answering these questions — as shown by the long-standing role of the Government in regulating transportation providers, especially regarding agricultural regions and rural communities.

Characteristics of Agricultural Commodities

Agricultural commodities are often perishable, seasonal, and relatively low-value, making the provision of efficient and appropriate transportation a difficult but critical task. Reviewing some of the basic characteristics of the different modes most commonly used in transportation of agricultural products reveals some traditional cost relationships and implications important to agricultural commodities. A very general cost structure of the three main modes, looking mainly at cost, not quality of service, is shown in figure B4. The cost functions reflect the high terminal costs of barge and rail but the significantly lower line-haul or per-mile costs as distance increases. Over a given distance, barge transportation — if available to the commodity being transported — is the most cost effective, followed closely by rail. For some low-value, bulk agricultural commodities such as grain, modal service differences (time, reliability, size of shipment) are relatively unimportant, and freight transportation by different modes can be considered as a single, homogeneous input.

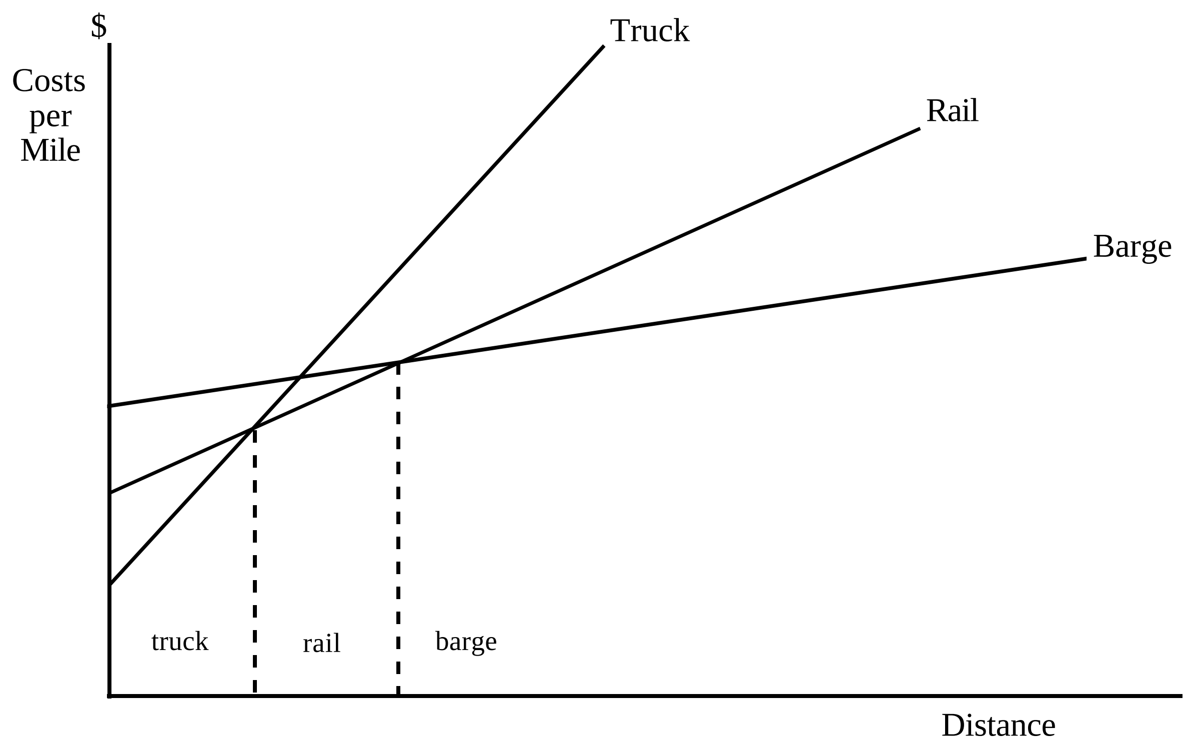

Figure B4 — Cost structures of alternative freight transportation modes

However, it is incorrect to always consider transportation as a single homogeneous input. If viewed from that perspective, transportation modes as an input are very substitutable for each other, and costs are the sole determinant. But some transportation modes are not, or are poor, substitute carriers for given commodities (Barges do not carry tomatoes, and airplanes do not move wheat).

When examining the relationship between lowering transportation costs and reducing total transfer costs, one must consider the full cost of transportation and not simply the freight rate. The total cost for each mode is composed of the freight rate plus costs associated with the service quality characteristics. Included in the service quality characteristics are factors such as speed of delivery, reliability, flexibility of scheduling, routing, shipment size, load handling and monitoring characteristics, claims handling procedures, and rate variability. It is apparent that commodities high in value or susceptible to deterioration or spoilage are relatively more sensitive to speed of delivery. It also follows that damage-prone cargo would be most sensitive to handling/monitoring characteristics and claim procedures. Differences in service quality, rather than the cost structure depicted in figure B4, are the primary consideration in selecting transport modes for fresh fruits and vegetables. Rail and barge characteristics, however, lend themselves well to bulk and lower value products such as wheat and soybeans, as long as marketing commitments are being met and market opportunities are being realized.

Compared with most other industries, agricultural production is bulky and has a low value-to-weight ratio. This decreases the value of time and perishability concerns, making barge and rail the most efficient modes. Most agricultural commodities arriving in distant countries look very similar to the bulk, homogeneous commodity that left the producer's field. This requires a high-volume, responsive/reliable, and especially low-cost transportation system. Transportation, therefore, accounts for a significant percentage of delivered costs to the consumer; hence, any increase in transportation costs to agriculture can be directly translated into higher consumer prices and/or decreased producer sales.

The traditional location of dairy farms close to urban consumption centers reflects the perishable characteristic of some agricultural products. Yet, as improvements in perishable product transportation have occurred, dairy farms have moved closer to lower cost land and animal feed supply regions, similar to the migration patterns of fresh fruits and vegetables as they left the "home gardens of the consumer" for the far fields of California and Florida.

A fairly recent development in transportation use within the logistics supply chain increases the importance of reliability and access. More firms, including agricultural processing firms, are using just-in-time and off-the-shelf inventory to lower overall logistics costs by reducing storage and inventory-carrying costs. In a way, this is a new manifestation of Japan's use of a steady stream of incoming ocean vessels, in effect, as their storage facilities. In both cases, the value of reliable and low-cost transportation increases because of the lowered storage and inventory costs it provides.

The seasonal nature of agricultural production was discussed earlier relative to year-by-year variation. Within-year seasonal peaks and valleys in production and transportation demands create similar strains on the transportation system. Strains of peak movements are associated with storage facility over- and underutilization. The year-to-year and month-to-month variability in agricultural demand and supply at various points in the nation and throughout the world makes the question of optimal location of storage capacity and the effect of this location on the overall domestic and international transportation system important issues.

The overall transportation system is a tight supply chain in a logistical framework, yielding an efficient assembly system that is influenced by competition and the interplay of a free market . Each link in this chain, whether it is the domestic or international transport systems or intermodal facilities like port systems, contributes to the efficiency of the whole. Large-volume movers are needed; so too are the small or regional railroads, which need the right to interchange with the Class I railroads. A competitive environment, including short line and regional railroads, helped fuel the 46 percent decrease in real rail rates from 1982 to 1996, as reported by the Surface Transportation Board.

The complexity and interconnectivity of this total transport system is striking. For example, the Asian economic crisis of 1997 has shifted trade flows, leading to an imbalance in price and availability of containers, which, in turn, has had a negative impact on U.S. industries. If anything, the links tying the transport system together are getting even tighter. Three railroads, Canadian National, Illinois Central, and Kansas City Southern, intend to jointly market their services, which will greatly strengthen the economic links between Canada, the Great Lakes region of the United States, and Mexico.

In some cases, the push for "value-added" production, in the form of the increased processing and manufacturing of bulk commodities, is causing a decreased need for bulk transportation by changing the type and characteristics of the transportation service demanded. The industry is adopting advanced information technology; companies like Hellmann InterForwarders can use the Internet to identify in real time the location, temperature, and condition of a perishable shipment. Other innovations are also at work: The development of the composite car body mechanical reefer (RBL) offers an increase in payload of 40 percent and a 100-percent increase in cubic capacity. The growth in intermodal (container) movement from 6.8 million trailers in 1993 to 8.8 million in 1997, a 30-percent increase, indicates the benefit of an integrated, systems approach to transportation services. Of course, making effective use of these innovations depends on the availability of quality infrastructure.

Characteristics of Agricultural Markets

The demand for transportation is a derived demand; transportation is desired for its ability to create place utility and value for the product being moved. Agricultural markets are generally characterized as being inelastic in both demand and supply. As a result, the inelastic demand for transportation services by producers simply means "a dollar saved in transport is a dollar earned." Price takers, as agricultural producers generally are, gain directly from increased markets or decreased transportation charges. This is obvious in international sales where the price is internationally set and posted at the port terminal. The producer receives the posted price minus transportation and handling charges associated with assembly from farm to port areas.

Because land is the ultimate "fixed" asset, agricultural production reacts very slowly to price decreases. This inelastic supply causes overproduction and market imbalance, again affecting the transport system's overall efficiencies by bringing about either shortages or surpluses in transportation capacity.

At the industry level, a producer's relative market power is enhanced as the number of marketing alternatives and potential buyers increases. Improvements in the transport system expand the number of marketing alternatives available to producers, which translates into changes in farm, regional, or national income. Agricultural movements, low in relative value, may receive inadequate transportation service as congestion in any segment of the transportation system becomes a bottleneck. An example of this behavior was observed earlier this year when the Union Pacific Railroad embargoed rail traffic to Laredo, Texas; while agricultural traffic was stopped, high-value automobile traffic continued to move. The Burlington Northern's embargo of grain shipments into tidewater ports in the Pacific Northwest in 1995-96 is another example showing how subsystem congestion can unfavorably influence the entire system.

This overall lack of market power by individual agricultural producers has influenced their transportation needs and their attitude towards transportation throughout U.S. history. It was this lack of market power that brought about the initial regulation of railroads in the United States, the support for an interstate highway system, and development of highway systems feeding into both rail and water systems. It also encouraged the provision of private and public transportation capacity in the country.

Transportation and Trade Reviewed

Transportation shapes trade, but desires for products that are made available through trade also shape the private and public provision of transportation services. Thus, trade and transportation are interdependent, simultaneously occurring events. The distribution of benefits among public and private entities determines who pays. While it is possible to influence the domestic provision of transportation services, if true system efficiencies are to be achieved, the domestic leg must connect to the international transportation sector. This has worked historically, is working currently (with some serious problems), and can continue to work in the future. Transport is the necessary facilitating function that allows for the realization of benefits associated with improved trade policies, marketing efforts, and promotional activities.

When the transportation system is constrained, potential trade benefits are lost. Currently, such constraints are most evident in the area of transportation capacity: railroad users have capacity concerns regarding trackage, cars, power, and system interfaces; highway users face seasonal closures, rationalization of local road systems, and deterioration and disinvestment in rural roads and bridges; waterways have fewer resources available for dredging, maintenance, rehabilitation of aging locks and dams, and significant environmental concerns; ports, terminal elevators, and country facilities are all faced with system imbalances and require substantial investments. An understanding of how transportation infrastructure is currently used, of needs that will likely arise in the future, and of how the current capacity constraints and policy issues affect agriculture is the prerequisite to solving the transportation problems of the 21st century.

In sum, the U.S. transportation system is perhaps the best in the world. This very fact has helped make the U.S. agricultural sector the world's most productive. But the U.S. transportation system also has some real problems that must be addressed if U.S. agriculture is to maintain its role as a leader in the world market.