A Quantitative Approach to the Study of Railroads in American Economic Growth: A Report of Some Preliminary Findings

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*A Quantitative Approach to the Study of Railroads in American Economic Growth: A Report of Some Preliminary Findings**

Is it legitimate for the historian to consider alternative possibilities to events which have happened? . . . To say that a thing happened the way it did is not at all illuminating. We can understand the significance of what did happen only if we contrast it with what might have happened.

MORRIS RAPHAEL COHEN

I

LELAND Jenks's article describing the pervasive impact of the railroad on the American economy first as an idea, then as a construction enterprise, and finally as a purveyor of cheap transportation, has become a classic of economic history.[1] The particular contribution of the Jenks article was not the novelty of its viewpoint, but the neat way in which it summarized the conclusions both of those who lived during the "railroad revolution" and those who later analyzed it through

* This paper was originally presented in December 1960 at the Purdue Conference on Quantitative Methods in Economic History and at the St. Louis meeting of the Econometric Society. It is a progress report on one aspect of a larger study entitled *Railroads and American Economic Growth: Essays in Econometric History*. The study is being conducted under the supervision of Simon Kuznets and G. Heberton Evans, Jr. They, of course, are not responsible for any errors which appear below. All computations presented in the paper are preliminary and subject to revision.

I am grateful to the Social Science Research Council, which generously supported portions of the research on which this paper is based.

[1] Leland H. Jenks, "Railroads as an Economic Force in American Development," THE JOURNAL OF ECONOMIC HISTORY, IV, No. 1 (May 1944), 1–20; reprinted in F. C. Lane and J. C. Riemersma, *Enterprise and Secular Change* (Homewood, Ill.: Richard D. Irwin, 1953), pp. 161–80; and in J. T. Lambie and R. V. Clemence, *Economic Change in America* (Harrisburg, Pa.: Stackpole Co., 1954), pp. 52–68.

the lens of elapsed time. Out of this summary the railroad emerges as the most important innovation of the last two thirds of the nineteenth century. It appears as the *sine qua non* of American economic growth, the prime force behind the westward movement of agriculture, the rise of the corporation, the rapid growth of modern manufacturing industry, the regional location of industry, the pattern of urbanization, and the structure of interregional trade.

Research since the Jenks article has further buttressed the idea that the railroad was an imperative of economic growth. Christopher Savage, in his recent *Economic History of Transport,* states that the influence of the railroad in American development "can hardly be overemphasized" since "agricultural and industrial development and the settlement of the West would scarcely have been possible" without it.[2] W. W. Rostow has administered an even stronger fillip to this viewpoint. In the projection of his concept of a "take-off into self-sustained growth," Rostow assigns railroads a crucial role. The railroad, he argues, was "historically the most powerful single initiator of take-offs." It "performed the Smithian function of widening the market," it was a "prerequisite in many cases to the development of a major new and rapidly expanding export sector," and most important, it "led on to the development of modern coal, iron and engineering industries." Rostow lists the United States first among the countries in which the influence of the railroad was "decisive." [3]

The idea of a crucial nexus between the railroad and the forward surge of the American economy following 1840 appears to be supported by an avalanche of factual evidence. There is, first of all, the impact of the railroad on the growth of cities. Atlanta was transformed from a spot in the wilderness to a thriving metropolis as a result of the construction of the Western and Atlantic. Chicago eclipsed St. Louis as the commercial emporium of the West by virtue of its superior railroad connections. And Louisville throttled the growth of Cincinnati by its ability to deny the "Porkopolis" rail connection with the South.[4]

[2] Christopher I. Savage, *An Economic History of Transport* (London: Hutchinson & Co., 1959), p. 184.

[3] W. W. Rostow, *The Stages of Economic Growth* (Cambridge: The University Press, 1960), p. 55.

[4] See, for example, Wyatt W. Belcher, *The Economic Rivalry Between St. Louis and Chicago, 1850–1880* (New York: Columbia Univ. Press, 1947), and "Cincinnati Southern Railway: Struggle Between Two Rival Cities for Metropolitan Dominance," in N. S. B. Gras and Henrietta M. Larson, *Casebook in Business History* (New York: F. S. Crofts, 1939).

Further, the decisive victory of the railroads over canals and rivers in the contest for the nation's freight is beyond dispute. One waterway after another was abandoned as a result of its inability to compete with the locomotive. The Pennsylvania Main Line Canal was driven out by the Pennsylvania Railroad, the Blackstone by the Providence and Worcester Railroad, and the Middlesex by the Boston and Lowell line.[5] The Mississippi, which in the early decades of the nineteenth century was the main traffic highway of the center of the continent, had fallen into relative disuse by the end of the century. In 1851–1852 boats carried six times as much freight as railroads; in 1889 the railroads carried five times as much freight as boats.[6]

Finally, there is the high correlation between new railroad construction and both population growth and commercial activity. Illinois, Michigan, and Ohio, for example, experienced a marked increase in population, construction, and manufacturing following the completion of rail lines within and across their borders. For the country as a whole, the undulations in indexes of total output seem to follow closely the cycles in railroad construction.[7] Of particular note is the apparent upsurge in manufacturing output which paralleled the boom in railroad construction. Between 1839 and 1859 railroad mileage in the United States increased by 26,000 miles.[8] The construction of such an immense transportation network required a large volume of manufactured goods, especially iron, lumber, and transportation equipment. Between 1841 and 1850, for example, when railroad mileage increased by 160 per cent, lumber production rose by 150 per cent and pig iron by 100 per cent.[9]

The evidence is impressive. But it demonstrates only an association between the growth of the rail network and the growth of the economy. It fails to establish a causal relationship between the railroad and the

[5] A table of the canals abandoned during the nineteenth century is given in U. S. Congress, Senate, *Preliminary Report of the Inland Waterways Commission,* Doc. No. 325, 60th Congress, 1st Sess. (1908), pp. 205–9.

[6] There was double counting in the data on which these ratios are based. U. S. Congress, Senate, *Andrews Report,* Executive Doc. No. 112, 32nd Cong., 1st Sess. (1853), pp. 903–6; U. S. Census Bureau, *Eleventh Census of the United States: 1890, Report on the Transportation Business in the United States,* Part I, pp.452, 548, 640; Part II, pp. 9, 10, 163, 308, 384, 436, 479.

[7] Walter Isard, "Transport Development and Building Cycles," *Quarterly Journal of Economics,* LVII, No. 1 (Nov. 1942), 90–112; Jenks, "Railroads as an Economic Force," pp. 4–5.

[8] U. S. Census Bureau, *Historical Statistics of the United States, Colonial Times to 1957* (Washington: Govt. Printing Office, 1960), p. 427.

[9] U. S. Agriculture Dept., *Yearbook of Agriculture, 1933,* p. 748; Frank W. Taussig, "The Tariff, 1830–1860," *Quarterly Journal of Economics,* II (1888), 379.

regional reorganization of trade, the change in the structure of output, the rise in per capita income, or the various other strategic changes that characterized the American economy of the last century. It does not establish even *prima facie* that the railroad was a necessary condition for these developments. Such a conclusion depends not merely on the traditional evidence, but also on implicit assumptions in its interpretation.

One cannot, for example, leap from data that demonstrate the victory of railroads over waterways in the competition for freight to the conclusion that the development of the railroad network (particularly the trunk lines) was a prerequisite for the rapid, continuous growth of the internal market. The only inference that one can safely draw is that railroads were producing the same (or a similar) service at a lower cost to the buyer. For if rail transportation was a perfect, or nearly perfect, substitute for the canal, all that was required for a large shift from canal to railroad was a small price differential in favor of the latter. Whether the shift produced a significant increase in the size of the internal market depends not on the volume of goods transferred from one medium to the other, but on the magnitude of the associated reduction in transportation costs. If the reduction in cost achieved by the railroads was small, and if canals and rivers could have supplied all or most of the service that railroads were providing without increasing unit charges, then the presence of the railroads did not substantially widen the market, and their absence would not have kept it substantially narrower. The conclusion that the railroad was a necessary condition for the widening of the internal market flows not from a body of observed data, but from the assumption that the cost per unit of transportation service was significantly less by rail than by water.

Other propositions regarding the role of the railroad involve even stronger assumptions than the one just cited. The view that the quantity of manufactured goods used in the construction and maintenance of the railroad was of decisive importance in the upward surge of manufacturing industry during the two decades preceding the Civil War involves a minimum of three assumptions. It not only assumes that the volume of the goods purchased by the railroad was large relative to the total output of the supply industries, but also that railroad purchases were directed toward domestic rather than foreign markets. It assumes further that if there had been no railroad, the demand for manufactured goods by the other forms of transportation would have been

significantly less or its impact strategically different from the demand associated with railroads.[10]

The preceding argument is aimed not at refuting the view that the railroad played a decisive role in American development during the nineteenth century, but rather at demonstrating that the empirical base on which this view rests is not nearly so substantial as is usually presumed. The fact that the traditional interpretation involves a number of basic assumptions is not in itself a cause for rejecting it. In the absence of data, the economic historian has no alternative but to make the best possible guess. Without such guesses or assumptions, no analysis is possible. The only question is, "How good are the guesses?" Is there any way of testing them?

It is always easier to point out the need to test a given set of assumptions than to propose a feasible method for testing them. The remainder of this paper deals with the problems involved in evaluating one of the most common presumptions regarding the influence of the railroad on American economic development. The question to be considered is: did the interregional distribution of agricultural products—a striking feature of the American economy of the nineteenth century—depend on the existence of the long-haul railroad? To answer the question, I define a concept of "social saving" in interregional transportation attributable to the existence of the railroad, and propose a method of measuring it. The discussion that follows turns largely on the consistency between the size of this "social saving" and the hypothesis that railroads were a necessary condition for interregional agricultural trade. However, the analytical approach described below transcends the particular hypothesis to which it is applied. The same method is being used to obtain information on such additional questions as the effect of the railroad on the determinants of urbanization, the developmental consequences of various trade rivalries, and the extent to which railroads increased the utilization of land and other resources. The basic issue posed by this paper is the feasibility of applying the analytical techniques of contemporary economics to the re-evaluation of one of the major questions in American history—the influence of railroads on economic growth.

[10] The relationship between the railroads and the growth of manufacturing industries is the subject of one of the other essays in *Railroads and American Economic Growth: Essays in Econometric History.*

II

The massive change in the geographical pattern of agricultural output during the nineteenth century has been a leading theme of American historiography. The meager data at the start of the century strongly suggest that the main sections of the nation were agriculturally self-sufficient.[11] By 1890 the North Atlantic, South Atlantic, and South Central divisions, containing twenty-five states and 60 per cent of the nation's population, had become a deficit area in various agricultural commodities, particularly foodstuffs.[12] The greatest deficits appear in the North Atlantic region, that is, New England, New York, New Jersey, and Pennsylvania. In 1890 this division produced only 36 per cent of its estimated wheat consumption, 45 per cent of the corn requirement, 33 per cent of the beef requirement, and 27 per cent of the pork requirement.[13] The South produced a bigger share of its local needs, but it too had to look outside its borders for a significant part of its food supply. The local supply of foodstuffs in the deficit regions appears even more inadequate when the product needed for the export market is added to domestic consumption. In the North Atlantic division, for example, local production of wheat supplied only 24 per cent of the combined local and export requirement.[14]

In contrast to the decline in regional self-sufficiency in foodstuffs in

[11] New England is the only notable departure from this pattern of complete, or virtually complete, agricultural self-sufficiency. Even here the deficiency in grain appears to have been relatively small. Thomas Jefferson, writing in 1808, estimated that "90,000 persons in Massachusetts subsisted on imported flour." This implies that, although deficient, the state's output of wheat was large enough to meet the needs of 80 per cent of the population. And the Massachusetts deficit was offset, at least in part, by the surpluses of Vermont and New Hampshire. Percy W. Bidwell and John I. Falconer, *History of Agriculture in the Northern United States, 1620–1860* (Washington: Carnegie Institution of Washington, 1925), p. 236; U. S. Census Bureau, *Historical Statistics*, p. 13.

[12] U. S. Census Bureau, *Eleventh Census of the United States, Compendium*, Part I, p. 2.

[13] Estimated local requirements and supplies for the North Atlantic region (in thousands of tons) are:

	Wheat	Corn	Dressed Pork	Dressed Beef
Local requirement	2,507	4,956	297	381
Local supply	895	2,219	79	127
Deficit	1,612	2,737	218	254

The procedure followed in the construction of these estimates is discussed below, pp. 179–85.

[14] Wheat exports from ports in the North Atlantic region were approximately 1,260,000 tons. St. Louis Merchants' Exchange, *Annual Report, 1890*, p. 168.

the East and South, the North Central division of the country had become a great agricultural surplus area. Virgin territory at the start of the century, these twelve states were producing 71 per cent of the country's cereal grains by 1890 and were also the national center of cattle and swine production.[15] The magnitude of their surpluses is well illustrated by wheat. In the crop year 1890–1891, the twelve states produced 440,000,000 bushels. At five bushels per capita this was enough to feed 88,000,000 people—four times the region's population.[16] Approximately two thirds of the grain surplus of the North Central states was consumed in the East and South, and one third was exported to Europe and South America.

The process by which the agricultural surpluses of the Midwest were distributed can be divided into three stages. In the case of grain, the first stage was the concentration of the surplus in the great primary markets of the Midwest: Chicago, Minneapolis, Duluth, Milwaukee, Peoria, Kansas City, St. Louis, Cincinnati, Toledo, and Detroit. Over 80 per cent of the grain that entered into interregional trade was shipped from the farms to these cities.[17] The second stage involved the shipment of the grain from the primary markets to some ninety secondary markets in the East and South.[18] Among the most important secondary markets were New York City, Baltimore, Boston, Philadelphia, New Orleans, Albany (N. Y.), Portland (Me.), Pittsburgh, Birmingham, and Savannah. The third stage was the distribution of the grain within the territory immediately surrounding the secondary markets, and exportation abroad. The distributional pattern of meat products roughly paralleled that of grain. Perhaps the most important difference was that the first stage of the distribution process—concentration of livestock in the primary markets—was dominated by only four cities: Chicago, St. Louis, Kansas City, and Omaha.

With this background it is possible to give more definite meaning to the term "interregional distribution." For the purposes of this paper, "interregional distribution" is defined as the shipments of commodities from the primary markets of the Midwest to the secondary markets of the East and South. For all other shipments—from farms to primary

[15] U. S. Congress, House, *Report of the Industrial Commission on the Distribution of Farm Products*, Doc. No. 494, 56th Cong., 2nd Sess. (1901), p. 37.

[16] U. S. Statistics Bureau, *Wheat Crops of the United States, 1886–1906*, Bulletin No. 57 (1907), p. 18.

[17] See below, pp. 178–79.

[18] *Ibid.*, pp. 179–84.

markets and from secondary markets to the points immediately surrounding them—the term "intraregional distribution" is used. Similarly, the term "interregional railroad" is reserved for lines between primary and secondary markets, and the term "intraregional railroad" is used for all other lines. These terms are useful in distinguishing between the railroad in its role as a long-distance mover of agricultural products and its other functions.[19] It also helps to clarify the hypothesis to be examined in this paper, which can now be stated as follows:

Rail connections between the primary and secondary markets of the nation were a necessary condition for the system of agricultural production and distribution that characterized the American economy of the last half of the nineteenth century. Moreover, the absence of such rail connections would have forced a regional pattern of agricultural production that would have significantly restricted the development of the American economy.

III

In the year 1890, a certain bundle of agricultural commodities was shipped from the primary markets to the secondary markets. The shipment occurred in a certain pattern, that is, with certain tonnages moving from each primary market city to each secondary market city. This pattern of shipments was carried out by some combination of rail, wagon, and water haulage at some definite cost. With enough data, one could determine both this cost and the alternative cost of shipping exactly the same bundle of goods from the primary to the secondary markets in exactly the same pattern without the railroad. The difference between these two amounts I call the social saving attributable to the railroad in the interregional distribution of agricultural products—or simply "the social saving." This difference is in fact larger than what the true social saving would have been.[20] Forcing the pattern of shipments in the nonrail situation to conform to the pattern that actually existed is equivalent to the imposition of a restraint on society's freedom to adjust to a new technological situation. If society

[19] A progress report on the essay dealing with the impact of the railroad on the intraregional distribution of agricultural commodities ("The Social Saving Attributable to American Railroads in the Intraregional Distribution of Agricultural Products in 1890") was presented at the New York meeting of the Regional Science Association in December 1961.

[20] The definition of social saving used in this paper is the difference between the actual level of national income in 1890 and the level of national income that would have prevailed if the economy had made the most efficient possible transport adjustment to the absence of the interregional railroad. As noted in the text, this figure is larger than the more ideal social saving

had had to ship interregionally by water and wagon without the railroad, it could have shifted agricultural production from the Midwest to the East and South, and shifted some productive factors out of agriculture altogether. Further, the cities entering our set of secondary markets and the tonnages handled by each were surely influenced by conditions peculiar to rail transportation; in the absence of the railroad some different cities would have entered this set, and the relative importance of those remaining would have changed. Adjustments of this sort would have reduced the loss in national income occasioned by the absence of the railroad, but estimates of their effects lie beyond the limits of tools and data. I propose, therefore, to use the social saving, as defined, as the objective standard for testing the hypothesis stated above.

With such a test, one cannot make definite statements about the relationship between the social saving and the geographic structure of agricultural production except for extreme values of the social saving as measured. If the calculation shows the saving to be zero, then obviously the absence of the interregional railroad would not have altered the existing productive pattern. On the other hand, if the social saving turns out to be very large, say on the order of magnitude of national income, it would be equally obvious that in the absence of the interregional railroad all production of surpluses in the Midwest would have ceased. For small differences in the cost differential, there is very little that can be said about the change in the geographic structure of output. It is theoretically conceivable that even a social saving as small as one fourth of 1 per cent of national income would have ended all or most surplus production in the North Central states. But this limitation in the proposed index is not quite so serious as it might seem. For the central concern here is with the influence of the railroad on the course of American economic development. The crucial question is not whether the absence of the railroad would have left agricultural production in a different regional pattern, but whether such a pattern would have significantly restricted economic growth. Sharp regional shifts in production associated with very small values of the social saving would

figure, which would take into account the production adjustments that would obtain with a different system of transportation.

In treating the differential in transportation costs as a differential in levels of national income, I am assuming that there would have been no obstacles to an adjustment to a nonrail situation. In other words, I am abstracting from market problems by assuming that national income would have dropped only because it took more productive resources to provide a given amount of transportation, and that all other productive resources would have remained fully employed. The relationship between the railroad and the demand for output is the subject of one of the other essays in my study (cf. note 10).

be immaterial from this point of view. They would have served to demonstrate that many geographic patterns of production were consistent with a given rate of economic development, and the geographic pattern of agricultural production could be dismissed as a significant element in the growth of the American economy.

The social saving is calculated in my estimates for only one year, 1890. Yet the hypothesis to be tested refers to a period covering almost half a century. How sound an inference about the significance of the railroad's role with respect to agricultural development over such a period can be made on the basis of only one year's data? The answer depends on the relative efficiency of the railroad in 1890 as compared to earlier periods. If the railroad was relatively more efficient in 1890 than in any previous year, the social saving per unit of transportation in 1890 would have exceeded the saving per unit in all previous years. The available evidence suggests that this was indeed the case.[21] The four decades between 1850 and 1890 were ones of continuous advance in efficiency. The size, speed, and pulling capacity of the locomotive were steadily increased, as was the weight of the load a freight car could carry. At the same time, the scattered rail lines were integrated into a network, thus eliminating or reducing transshipment costs. Terminal facilities were expanded, and such important loading devices as the grain elevator were brought into general operation. Perhaps the most significant indication of the increase in the railroad's relative efficiency is the very considerable shift of heavy, low-value items away from water carriers. In 1852 boats and barges dominated the interregional transportation of these items, while in 1890 they were carried mainly by the railroad. Since the volume of agricultural commodities transported between regions had also increased over the period in question, it seems apparent that the social saving in 1890 exceeded in absolute amount the saving of previous years. While it is true that national income rose over the period, the amount of agricultural goods shipped interregionally appears to have risen just as rapidly. In the case of wheat, population and production figures suggest that local requirements in the deficit states were at least 1.1 million tons less in 1870 than they were in 1890. Export requirements were 1.8 million tons less. These

[21] See, for example, J. L. Ringwalt, *Development of Transportation Systems in the United States* (Philadelphia: the author, 1888); Walter A. Lucas, ed., *100 Years of Steam Locomotives* (New York: Simmons-Boardman, 1958); Thomas C. Clarke, *et al., The American Railway: Its Construction, Development, Management and Appliances* (New York: Scribner & Sons, 1892); Baldwin Locomotive Works, *History of the Baldwin Locomotive Works, 1831 to 1907* (Philadelphia: Edgell Co., 1907).

figures indicate that the quantity shipped interregionally increased by 145 per cent over two decades—showing approximately the same rate of growth as real national income.[22] Thus, if it is shown that the social saving of 1890 was quite small relative to national income, the relationship would hold with equal force for the half-century preceding 1890.

The problem posed here would be trivial if the wagon were the only alternative to the railroad in interregional transportation. By 1890 the average cost of railroad transportation was less than a cent per ton-mile. On the other hand, the cost of wagon transportation was in the neighborhood of twenty-five cents per ton-mile.[23] According to estimates made here, approximately 7.7 million tons of corn and 5.0 million tons of wheat entered into interregional transportation.[24] Taking the differential between rail and wagon transportation at twenty-five cents per ton-mile, the social saving involved in moving these 12.7 million tons one mile would have been $3,180,000. Assuming that on the average the corn and wheat shipped interregionally traveled nine hundred miles, the total social saving would have been $2,860,000,000. Even this figure is low, since wagon rates did not reflect the cost involved in road construction and maintenance. If account were taken of these and other omitted charges, and if a similar calculation were performed for livestock, the figure for the social saving would probably increase by 50 per cent, to four billion dollars, or more than one third of gross national product in 1890.[25] This magnitude exceeds Gallman's 1889 estimate of gross income originating in agriculture by 43 per cent.[26] Such a loss would have pushed the economy back two decades and probably cut the rate of investment by a third.[27] The calculation is very crude, of course, but there seems little doubt that the order of magnitude is correct.

The problem is not trivial, because water transportation was a

[22] U. S. Statistics Bureau, *Wheat Crops of the U. S.*, p. 7; U. S. Census Bureau, *Historical Statistics*, pp. 12, 13, 139; U. S. Statistics Bureau, *Exports of Farm Products from the United States, 1851–1908*, Bulletin No. 75 (1910), pp. 44, 46.

[23] U. S. Statistics Bureau, *Changes in the Rates of Charge of Railway and Other Transportation Services*, Bulletin No. 15, rev. (1901), p. 14; U. S. Congress, House, *Report of the Industrial Commission on Agriculture and Agricultural Labor*, Doc. 179, 57th Cong., 1st Sess. (1901), X, 690–91.

[24] See below, pp. 179–84, and Table 6.

[25] U. S. Census Bureau, *Historical Statistics*, p. 139.

[26] Robert E. Gallman, "Commodity Output in the United States," *Trends in the American Economy in the Nineteenth Century*. Studies in Income and Wealth of the National Bureau of Economic Research, Vol. 24 (Princeton: Princeton Univ. Press, 1960), p. 47.

[27] This statement is based on the assumption of the relative constancy of the saving and capital-output ratios over the range of national income being considered here.

practical alternative to the railroad in interregional transportation. A glance at a map will show that all of the primary market cities were on navigable waterways. Duluth, Milwaukee, Chicago, Toledo, and Detroit were on the Great Lakes; Omaha and Kansas City were on the Missouri; Minneapolis and St. Louis were on the Mississippi; Cincinnati was on the Ohio; and Peoria was on the Illinois River, midway between the Mississippi and Lake Michigan. The lakes, inland rivers, canals, and coastal waters directly linked the primary market cities to most of the secondary market cities. Of the forty-three most important secondary markets, thirty-two were located on navigable waters still in use in 1890. Seven were on waterways that had been forced into inactivity as a result of railroad competition, but which could have been used in the absence of the railroad. Only four cities were without direct water connection to the Midwest, and each of these was within a relatively short wagon haul of a major water artery.

The importance of a water-route alternative lies in the fact that on a per ton-mile basis, water rates were not only less than wagon rates but also less than railroad rates. The all-rail rate on wheat from Chicago to New York, for example, was about 0.52 cents per ton-mile, or nearly four times as much as the ton-mile rate by water.[28] This fact does not, of course, imply that the social cost or even the private cost on a given tonnage was less when shipped by water. Water routes were much more circuitous than rail routes, and the time in transit was considerably greater. Loss of cargo was more frequent. Terminal charges were higher. These and other problems raised the cost of water transportation to a point where shipments between most primary and most secondary markets were cheaper by rail than by boat. What makes the problem interesting is that the amount by which water costs exceeded railroad costs is far from obvious. As has already been suggested, the massive switch from rail to water transportation by no means implies that the cost differential was large. Consider the hypothetical case of a Chicago wheat shipper who made a profit of 10 per cent on the Chicago price of wheat or nine cents per bushel on a price of ninety cents. If the cost of shipment, all factors considered, was the same by both water and rail, the shipper would be indifferent as to which form he used. Suppose now that technological advances made it possible for the shipper to get his bushel to market for two cents less than before. How strong an inducement to switch from water to rail transportation would such a differential generate? By reducing his cost two cents per

[28] U. S. Congress, House, *Distribution of Farm Products*, p. 142; below, p. 187.

bushel, the shipper could increase his profit by 22 per cent. Clearly, the implication of this example is that a differential of two cents per bushel would have created a very strong pressure to shift all wheat that had been transported by water to railroads. Yet the social saving involved in such a shift would have been just $3,300,000—much too small an amount to prove the indispensability of the interregional railroad to American economic growth.[29]

Until now, the discussion has been carried on as if all the agricultural commodities that entered into interregional trade were to be included in the estimate. In fact, the estimate will be based on only four commodities: wheat, corn, beef, and pork. These four accounted for 42 per cent of income originating in agriculture in 1889.[30] Neglect of the other products is not so serious as it first seems. What is important is not the share of wheat, corn, beef, and pork in total output, but their share in that part of output which entered interregional trade. Obviously, if none of the neglected 58 per cent of output moved interregionally, the restriction is of no real consequence. The most important of the omitted items is cotton, which represented 11 per cent of output.[31] But relatively little cotton entered interregional transportation as here defined, and a large part of the crop shipped interregionally was carried by water.[32] This is illustrated by the distribution of the 1898–1899 crop. Of the output of that season, 79 per cent was shipped from southern farms to southern seaport cities, and carried from there by boat to Europe or to northern ports in the United States. Another 13 per cent was consumed in the South. Hence, at most only 8 per cent or 225,000 tons of cotton (that is, 900,000 bales) could have entered into interregional rail transportation.[33] But 225,000 tons is only 1.8 per cent of the combined wheat-corn tonnage. The case of dairy products, which accounted for 12 per cent of total product, is similar.[34] There are three main dairy products: milk, butter, and cheese. Of these, milk was entirely an intraregional product. Census data on butter and cheese production in the Midwest indicate that the amount entering interregional trade was about 166,000 tons or 1.3 per cent of the wheat-corn

[29] The average wholesale price in Chicago of a bushel of wheat during 1890 was eighty-seven cents. U. S. Census Bureau, *Historical Statistics*, p. 123.

[30] Gallman, "Commodity Output," pp. 46–48.

[31] *Ibid.*

[32] U. S. Congress, House, *Monthly Summary of Commerce and Finance*, Doc. 15, Part 7, 56th Cong., 1st Sess. (1900), pp. 2545–2636.

[33] U. S. Congress, House, *Distribution of Farm Products*, p. 174.

[34] Gallman, "Commodity Output," pp. 46–48.

tonnage.[35] Again, while virtually all wool was transported from west to east, it was less than 1 per cent (closer to one half of 1 per cent) of the wheat-corn tonnage. In short, neglected items probably do not account for more than 10 per cent of the goods entering into interregional trade, and would not justify the effort required to include them.

The most direct method of determining the social saving is to find the 1890 pattern of the shipments of the four commodities, and then estimate both the actual cost of the pattern and the cost that would have obtained if the pattern had been executed with only boats and wagons. This method requires the following data: the amount of each commodity shipped from each primary market, the amounts received by each secondary market, the routes over which they were shipped, and the transportation costs by each medium. But not all of these data are available. The total volume of shipments from each of the primary markets can be determined, but not their destination and routes. Receipts of the secondary markets can be estimated, but not the markets from which these goods came. The impasse is, of course, only apparent. The gap in the statistics can be bridged by linear programming techniques which yield the solution at a cheaper cost in terms of data requirements. It seems likely, incidentally, that in this case and in others as well mathematical techniques of analysis can reduce the amount of information required to evaluate a given hypothesis.[36] The linear programming problem is not solved in this paper, but a short discussion will indicate its possibilities.

The actual method of analysis is simple. It involves a pair of linear programming models for each commodity. The procedure can be illustrated by considering the case of wheat. In 1890, a certain amount of wheat was shipped from the Midwest to the secondary markets. The first linear programming model will find the least cost of carrying the wheat from the primary to the secondary markets without imposing any restraint on the means of transportation that can be used—that is, allowing the shipments to be made in the cheapest manner, regardless of the transportation medium. The second model imposes the restriction that railroads cannot be used, and then finds the least cost of ship-

[35] This estimate is based on data for 1899. U. S. Census Bureau, *Twelfth Census of the United States, Agriculture,* Part I, pp. clxxxii–clxxxiii.

It should be remembered that the East did not run the heavy deficits on dairy products that it did on grains and meats. New York and Pennsylvania were two of the three largest producers of dairy products. U. S. Congress, House, *Distribution of Farm Products,* pp. 268–69.

[36] Cf. Robert W. Fogel, *The Union Pacific Railroad: A Case in Premature Enterprise* (Baltimore: The Johns Hopkins Press, 1960), especially pp. 81–85.

ping the same quantity of wheat from the primary to the secondary markets. Presumably these two least-cost figures will differ; but this difference will reflect only the absence of the railroad, since the quantities shipped from each of the primary markets and the requirements of each of the secondary markets will be the same in both models. The difference between the two least-cost figures is the estimate of social saving due to the use of the railroad in the interregional transportation of wheat. The cost differential obtained from such a pair of linear programming models will exceed the true social saving for the reasons specified in Section III, above.

The water rates to be used in the second model must (with some exceptions) be those that actually prevailed in 1890. Even if water rates in 1890 equaled marginal costs, their use in the second model would introduce a bias, since these rates applied to a tonnage which is less than the amount specified in the model. To use them is equivalent to assuming that the marginal cost of water transportation was constant over the relevant range. This assumption probably accentuates the upward bias of the estimate. If all costs except the construction of canals and channels are considered variable, then it seems quite reasonable to assume that marginal costs were constant or declining. The basic operating unit in water transportation was the boat, and boat building may have been subject to economies of scale. In any case, most water routes were greatly under-utilized in 1890 and would have been under-utilized even if they had carried some considerable share of the additional interregional tonnage. Maintenance and other operating costs (for example, dredging, repairing locks, supplying water) would have increased only slightly with additional tonnage. To the extent that these tendencies were operative, the 1890 water rates impart an upward bias to the estimate of social saving.[37] Finally, it is important to note that the published 1890 rates did not reflect all of the costs involved in water transportation. In order to avoid introducing a downward bias into the calculations, it will be necessary to take account of such factors as spoilage, transit time

[37] Preliminary calculations suggest that the Erie Canal was the only waterway on which a bottleneck might have arisen. In 1890 the Erie carried 3,200,000 tons. Capacity at the time was 10,000,000 tons. It is possible that without the railroad, the agricultural products shifted to the canal would have exceeded 7,000,000 tons, thus taxing the capacity of the Erie. On the other hand, it appears that the most the additional tonnage could have been was 10,000,000 tons. However, 13,000,000 tons was well below the capacity of the New York State Barge Canal. If the linear programming solution leads to shipments which exceed the capacity of the Erie, I will apply the cost figures of the Barge Canal, adequately adjusted for differences in the price level, etc., and find a new solution. The use of Barge Canal rates would further buttress the assumption of constant or declining marginal costs in water transportation.

and the unavailability of water routes for five months out of the year. The manner in which these factors will be dealt with is discussed in the final section of this paper.[38]

IV

Use of linear programming would reduce, but does not eliminate, the data problem. An enormous amount of information, some of which cannot be obtained directly, is needed. This section seeks to demonstrate how the necessary estimates can be derived from existing, but largely neglected, bodies of data. What is involved is the application of the estimating techniques usually reserved for the construction of national income accounts to a specific historical problem. It should be emphasized that the results presented below are tentative; many obvious adjustments have not yet been made. Nevertheless, the figures on tonnages entering interregional trade are sufficiently close to the truth for the use to which they are put in the final section of this paper. The problems encountered in translating a theoretically conceived estimate into an actual one can best be discussed by grouping them under four headings: shipments, requirements, railroad rates, and water rates.

Much has been written on the internal agricultural trade of the United States during the nineteenth century. In addition to Schmidt's series of articles in the *Iowa Journal of History and Politics* (1920–1922), there are the studies in the *Census of Agriculture* for 1860 and

[38] As already noted, the estimate of the social saving in the interregional transportation of wheat, corn, pork, and beef requires a pair of linear programming models for each commodity. It might be thought that more than one pair of programs is required for each commodity. Wheat, for example, was carried east both as wheat and as flour. Pork was transported in an even wider variety of forms, including live swine, dressed pork, canned pork, mess pork, ham, bacon, etc. To the extent that each form of pork or wheat is considered a different product, one might be inclined to argue that a separate pair of models is required for each form. This costly complication can be avoided if (in the case, say, of wheat) the ratio of wheat to flour demanded in each secondary market was roughly the same, and with information on the quantities of wheat and flour shipped from each primary market. For then, knowing the wheat equivalent of a given quantity of flour as well as the cost of shipping each form, there is obviously some transportation cost at which X ton-miles of flour can be converted into Y ton-miles of wheat. The assumption of a constancy in the ratio of wheat to flour shipments tends to introduce an upward bias in the estimate of social saving. If the relative transportation costs of flour and wheat were the same by both forms of transportation, no bias would be introduced. However, the cost of shipping flour relative to the cost of shipping wheat was greater by water than by rail. Hence, in the absence of the railroad more wheat and less flour would have been shipped. However, the conversion of flour into a grain equivalent is based on the proportions of each that were actually shipped in 1890.

1880, the biennial reports on internal commerce issued by the Treasury Department between 1876 and 1891, the volume on the distribution of agricultural products compiled by the Industrial Commission of 1900, and a series of articles which appeared in the *Monthly Summary of Commerce and Finance* in 1900.[39] All of these studies examined the system of primary markets, and they provide a considerable amount of data on the relative importance of the various cities. Surprisingly enough, however, these sources—whether considered separately or together—fail to yield enough data to compile a complete schedule of the shipments of grains and provisions for any year during the nineteenth century. Schmidt comes the closest, giving a schedule of the receipts of grains by primary markets for the year 1890. While there is a relationship between receipts and shipments, Schmidt does not indicate how to convert one into the other. An even more difficult problem is the absence of a complete series on shipments of provisions.

Fortunately, the desired data were relatively easy to obtain. Figures on the shipments of each of the various commodities were taken from the reports of the produce exchanges, the boards of trade or chambers of commerce of each of the primary market cities. These documents contain much highly reliable information, but except in the cases of Chicago, St. Louis, and New York, they have been badly neglected. Table 1 gives the preliminary figures on the shipments of corn and wheat from the primary markets.[40] The compilation of data on meat shipments is still in process.

The estimation of requirements of the secondary markets is much more difficult than the shipments from the primary markets. The problem here is not merely the absence of a convenient series on the requirements of the various secondary markets; with the exception of such obvious places as New York, Baltimore, and New Orleans, there was no way of knowing which of the various cities of the East and South comprised the relevant set of secondary markets.

The first task, then, was to find some basis for dividing the deficit regions into marketing areas and for determining the cities which served as distributing centers of the area. The basic reference for mak-

[39] The pattern of trade is summarized in Emory R. Johnson, *et al., History of Foreign and Domestic Commerce of the United States* (Washington: Carnegie Institution of Washington, 1915), Parts I and II.

[40] Table 1 includes only grain which was unloaded in the primary markets. Additional amounts were shipped through the primary markets without unloading. Obviously, these neglected amounts will eventually have to be included.

TABLE 1

SHIPMENTS OF CORN AND WHEAT
FROM PRIMARY MARKETS, 1890

(thousands of tons)

Primary Market	Wheat [a]	Corn [b]
Chicago	950	2,536
Minneapolis	1,322	53
Duluth-Superior	793	41
Milwaukee	516	7
Peoria	35	211
Kansas City	181	505
St. Louis	522	1,218
Cincinnati	181	70
Toledo	309	463
Detroit	125	32
Total	4,934	5,136

[a] Includes flour converted into wheat at the rate: one barrel of flour equals 0.1430 tons of wheat.

[b] Includes corn meal converted into corn at the rate: one barrel of corn meal equals 0.1262 tons of corn.

Sources: See discussion in text, pp. 169, 178–79.

ing this division was a study of wholesale grocery territories carried out by the Department of Commerce in the 1920's.[41] This study divided the country into 183 trading areas. Each of the areas was composed of a group of counties served by a single city. The Boston trading area, for example, was determined by a survey of the wholesale firms situated in Boston, and comprised the six counties immediately surrounding the city.

Since grain and provisions were wholesale grocery products, the Department of Commerce survey provided an appropriate framework for the estimates. That the territories it defined pertained to the economy of the 1920's is not a crucial consideration. The basic rail network, especially in the East, was well established by 1890 and remained stable over the ensuing three decades. In the 1920's, trucks had not yet altered existing geographical patterns of trade. They appear to have affected the size of the inventories carried by outlying retailers rather than the boundaries of the marketing areas. The impression that motor vehicles

[41] U. S. Foreign and Domestic Commerce Bureau, *Atlas of Wholesale Grocery Territories*, Domestic Commerce Series, No. 7 (1927).

conformed to, rather than altered, pre-existing patterns is buttressed by a study of wholesale territories made in the late 1930's. The trading areas described by this survey were virtually identical with the earlier set.[42]

This demarcation of trading territories made it possible to devise a procedure for estimating the requirements of each territory by commodity. The area requirement for a given commodity was the difference between the area's total demand for the commodity (including exports) and the amount of the commodity supplied from within the area. Thus, to determine the requirements, estimates of both total demand and local supply were needed. The procedure for arriving at these estimates can be illustrated by the case of wheat.

The total demand for wheat in a given area consisted of two parts: the local demand and the export demand. The export demand was determined directly from export statistics provided by the Treasury Department; the local demand had to be estimated indirectly. The local demand for wheat was almost entirely for human consumption. For the country as a whole, about 10 per cent of the annual wheat crop was set aside for seed and about 2 per cent for animal feed.[43] However, the share of wheat demanded for seed in the deficit regions was considerably less than the national share, since wheat production was quite small. This was especially true in New England, where wheat used as seed was only one half of 1 per cent of the quantity consumed by humans. Similarly, the practice of feeding wheat to animals appears to have been practiced primarily in the areas of surplus production. Hence, the estimate of local demand was largely a matter of determining human consumption.

Total human consumption in a trading area was equal to per capita consumption multiplied by the population of the area. Statistics on area population were obtained from the 1890 census. The tentative estimate of average consumption by regions was calculated from a 1909 survey of urban workers conducted by the British Board of Trade.[44]

[42] U. S. Foreign and Domestic Commerce Bureau, *Atlas of Wholesale Grocery Trading Areas*, Market Research Series, No. 19 (1938).

[43] U. S. Agriculture Dept., *Yearbook of Agriculture, 1923*, p. 1140; U. S. Statistics Bureau, *Wheat Crops of the U. S.*, p. 18.

[44] Great Britain, Board of Trade, *Cost of Living in American Towns* (London: H. M. Stationery Office, 1911); reprinted in U. S. Congress, Senate, Doc. 22, 62nd Cong., 1st Sess. [ser. no. 6082].

The data needed to convert statistics on bread, cake, and macaroni consumption into a wheat equivalent were obtained from U. S. Experiment Stations Office, *Bulletin*, Nos. 35 (1896) and

Based on these data, the estimated per capita consumption of wheat is 4.80 bushels per year in the North and 4.70 bushels per year in the South. These figures do not include an adjustment for urban-rural differences in wheat consumption. However, it does not seem likely that the adjustment, when it is made, will significantly alter the results. A 1913–1914 survey indicates an average per capita wheat consumption of 5.08 bushels among 421 farm families in five North Atlantic states, and an average per capita consumption of 5.13 bushels among 149 families in three southern states.[45]

The local supply of wheat in a trading area was the sum of the annual local production of wheat and the supply (positive or negative) out of local inventories. The Department of Agriculture has published estimates of the production of wheat in 1890 by states but not by counties. However, county data were needed to determine local production in a trading area. The 1889 census production data by counties were multiplied by the 1890:1889 ratio of output for the state in which the particular county was located. Inventories of wheat were held by two

156 (1905); cf. U. S. Agriculture Dept., *Farmers Bulletin,* Nos. 23, 1450; William G. Panschar and Charles C. Slater, *Baking in America* (2 vols.; Evanston: Northwestern University Press, 1956).

A convenient review of various budget and diet studies is contained in Faith M. Williams and Carle C. Zimmerman, *Studies of Family Living in the United States and Other Countries,* U. S. Agriculture Dept., Miscellaneous Publications No. 223 (1935).

[45] W. C. Funk, *Value to Farm Families of Food, Fuel, and Use of House,* U. S. Agriculture Dept., Bulletin No. 410 (1916), pp. 5, 18. Funk's figures were in consumption per equivalent adult, with children twelve and under counted as one half of an adult. Funk's data were converted to a per capita basis on the assumption that the average proportion of persons twelve and under in all the families in his sample residing in a particular state was the same as that state's proportion of persons twelve and under in the rural population in 1910.

The finding that average wheat consumption in the South was about as large as in the North requires some explanation. The letters, journals, and diaries of noted travellers usually stressed the importance of corn in the southern diet. There is no necessary contradiction between the data culled from the budget studies and the commentaries of distinguished observers. Corn *was* the dominant breadstuff in the southern diet. During the period in question, southerners probably consumed an annual average of about six bushels per capita; the rest of the nation used about a bushel per person. One can easily see why travellers would stress the unique element of the southern diet, while passing over the fact that wheat was also consumed in sizeable quantities. Historians have inferred that since the quantity of corn used was unusually large, the consumption of wheat must have been quite small. The budget studies suggest another interpretation: while some corn was substituted for wheat, even larger quantities were substituted for other commodities, especially dairy products. Average caloric intake in the South also appears to have been greater than in the North [Edith Hawley, *Economics of Food Consumption* (New York: McGraw-Hill Book Co., 1932), p. 75].

A high rate of wheat consumption may have been characteristic of the South for the whole last half of the nineteenth century. Schmidt, in his series of studies on the grain trade, noted that the South imported an average of 10,000,000 bushels of wheat per year during the decade leading up to the Civil War. He estimated consumption of wheat for the year 1860 at 4.5 bushels per capita in the South, and placed the national at 5.5 bushels [Louis B. Schmidt, "The Internal Grain Trade of the United States, 1850–1860." *Iowa Journal of History and Politics,* XVIII, No. 1 (Jan. 1920), 101, 106].

main groups: wholesalers in the central cities of the trading areas, and farmers. It was not possible to obtain data on changes in the inventories of wholesalers. However, reports on the inventories in the hands of farmers on March 1, 1890 and March 1, 1891 were published by the Department of Agriculture.[46] It was therefore possible to estimate the change in farmers' inventories which, as a factor in supply, was probably more significant than the change in wholesalers' inventories.

The estimate of total wheat requirements of all the secondary markets in the deficit regions is given in Table 2. It is broken down into a local consumption deficit (obtained by subtracting local production and changes in farm inventories from my estimate of the local demand in each area) and foreign exports. The latter figure is based on the *Commerce and Navigation Reports* of the Treasury Department.

It is possible to test the procedure for estimating local requirements of wheat. Data are available in reports of local boards of trade on the receipts and foreign exports of the five largest secondary markets. Abstracting from inventory fluctuations, the receipts minus foreign exports will be equal to the local consumption requirement, providing that no wheat is grown locally. This method of estimation cannot be used for three of these largest marketing areas (New York, Philadelphia, and Baltimore) since they grew considerable quantities of wheat, an undetermined amount of which was processed at merchant mills for local consumption, and failed to enter into board of trade statistics. However, only 441 bushels of wheat were grown in the

TABLE 2

ESTIMATED REQUIREMENTS OF SECONDARY MARKETS
(thousands of tons)

	1	2	3
	Local Consumption Deficits	Exports	Total Requirements (Col. 1 plus Col. 2)
Wheat [a]	3,099	1,916	5,015
Corn [b]	5,415	2,320	7,735
Dressed Pork	729	347	1,076
Dressed Beef	701	304	1,005

[a] Includes flour converted into wheat at the rate: one barrel of flour equals 0.1430 tons of wheat.

[b] Includes corn meal converted into corn at the rate: one barrel of corn meal equals 0.1262 tons of corn.

Sources: See discussion in text, pp. 181–84.

[46] Baltimore Corn and Flour Exchange, *Annual Report, 1889, 1890.*

Boston trading area and 120 bushels in the New Orleans trading area, so virtually all the wheat demanded by these markets originated outside the trading areas and was recorded in commercial statistics. To eliminate inventory fluctuations, a nine-year average (centered on 1890) of receipts minus exports was taken. As shown in Table 3, local requirements estimated in this way tend to support the basic estimating procedure. The figure on the New Orleans marketing region (with 64 per cent of the population living in rural areas) lends support to the finding that wheat consumption in the South was considerably higher than has been generally realized.[47]

The procedure followed in estimating corn requirements was similar to that used in the case of wheat. The most important difference was that human consumption represented only 8 per cent of the total demand for corn. Estimates of average animal consumption per head were obtained for each of the main categories of animals.[48] But these averages were only available on a national basis. To the extent that there were regional differences in animal consumption of corn, the estimates tend to overstate requirements of some areas and understate those of others.

In estimating the local demand for beef and pork, national per capita disappearance figures were first obtained, following the method of the Department of Agriculture. The national figures were transformed into regional per capita estimates by using weights taken from a 1901 budget study conducted by the Bureau of Labor. Supply was determined in the manner described by Strauss and Bean.[49] Table 2 presents tentative estimates of the requirements of meat in the deficit areas. These figures will also have to be adjusted for urban-rural differences in consumption, but the adjustment will not significantly alter the aggregate meat requirement of the deficit areas. Funk's 1913–1914 study indicates that average consumption of beef and pork together in 570 northern and southern farm families was 157 pounds per equivalent

[47] Baltimore Corn and Flour Exchange, *Annual Report, 1890–1894;* U. S. Census Bureau, *Eleventh Census of the United States, Population in the United States,* Part I, Tables 8 and 89; cf. note 45, above.

[48] These estimates are based on data for the years 1910–1914. The relevant figures are: horses, 27.811 bushels; hogs, 16.568; dairy cattle, 5.112; other cattle, 2.460; sheep, 0.413; poultry, 0.671. U. S. Agricultural Research Service, *Consumption of Feed by Livestock, 1909–1956,* Production Research Report No. 21 (Nov. 1958), pp. 28–31, 80.

[49] U. S. Agriculture Dept., *Consumption of Food in the United States, 1909–1952,* Agricultural Handbook No. 52 (1953); U. S. Labor Bureau, *Eighteenth Annual Report of the Commissioner of Labor, Cost of Living and Retail Food Prices* (1904). Frederick Strauss and Louis H. Bean, *Gross Farm Income and Indices of Farm Production and Prices in the United States, 1869–1937,* U. S. Agriculture Dept., Technical Bulletin No. 703 (1940).

TABLE 3

A COMPARISON OF THE ESTIMATES OF THE LOCAL CONSUMPTION DEFICITS OF WHEAT FOR TWO TRADING AREAS
(thousands of bushels)

	1	2	3
	Method One (local demand minus local supply)	Method Two (nine-year average of receipts minus exports)	Column One as a per cent of Column Two
Boston	6,996	7,215	97
New Orleans	3,504	3,070	114

adult. Department of Agriculture data indicate that for the population as a whole the corresponding 1913 figure was about 160 pounds per equivalent adult. However, since farm families ate considerably more pork than beef, the urban-rural adjustment will reduce the estimated amount of the aggregate beef deficit and increase the amount of the aggregate pork deficit in about the same proportions.[50]

Standard sources such as the *Annual Reports* of the Interstate Commerce Commission, the Treasury Department *Reports on Internal Commerce,* and the report of the Aldrich Committee provide information on less than 10 per cent of the relevant interregional routes. Fortunately, the tariffs filed with the Interstate Commerce Commission under the Interstate Commerce Act of 1887 are available. These files contain the published rates on all of the desired routes.

To the extent that rebating took place, published rates exceeded actual rates. State and Federal investigations produced voluminous reports and documents on the rebating problem. These contain data that can be used to adjust some of the published rates. Continuing research in archives may yield additional information. However, some procedure will have to be devised by which one can both check the reliability of the evidence in the public record and estimate rebates for which no direct evidence exists. One possible approach involves the

[50] Funk, *Value to Farm Families of Food,* pp. 5, 20; U. S. Agriculture Dept., *Livestock and Meat Statistics,* Statistical Bulletin No. 230 (July 1958), pp. 283, 284; U. S. Agriculture Dept., *Consumption of Food in the U. S.,* p. 197. Two adjustments were made to the Agriculture Department data to make them comparable to Funk's: the per capita estimates were transformed to equivalent adult estimates on the assumption that the proportion of persons twelve years old and under was the same in 1913 as in 1914 (cf. note 45); edible offals were added to the Agriculture Department figures on beef and pork, since farm families generally consumed all parts of the animals they slaughtered [Carle C. Zimmerman, *Consumption and Standards of Living* (New York: D. Van Nostrand, 1936), pp. 81–82].

use of published rates for a year like 1910, when rebating was rather generally eliminated. Abstracting from changes in the price level, the fall in average published rates between 1890 and 1910 is attributable to two factors: the elimination of rebating and the decline in actual rates.[51] Therefore, the differences between average published rates in 1890 and in 1910 (adjusted for changes in the price level) are the most that the average rebate could have been. Thus, by multiplying appropriate ratios of average 1910 rates to 1890 rates by the actual 1890 rates, one obtains an estimate of the least that average actual rates could have been in 1890.

Water transportation was dominated by three main routes: the Great Lakes and Erie Canal route, the Mississippi route and the intracoastal route. Every movement from a primary to a secondary market can be divided into a movement along one or more of these lines, plus an additional short movement along some other body of water. Rates on the main water highways are available in board of trade reports, tariffs filed with the Interstate Commerce Commission, and other documents. Thus only a small part of the charge to a shipper will have to be estimated. Moreover, possible deviations between published and actual water rates are less troublesome. To the extent that such deviations existed, the upward bias of the estimated social saving will be further accentuated.

V

There is no reliable way to predict the outcome of the linear programming problems. In computations of this sort, surprises are common. Even if all the required data were compiled, it would be difficult to anticipate such results as the efficient patterns of trade in the rail and nonrail situations or the breakdown of the social saving by products, routes, and regions. However, a crude estimate of the *aggregate* social saving is possible. The calculation that follows involves guesses about

[51] That actual rates declined between 1890 and 1910 is suggested by the fact that average freight revenue per ton-mile (adjusted for changes in the price level) declined by over a third (U. S. Census Bureau, *Historical Statistics*, p. 43). Of course, the decline in average revenue could have taken place even though actual rates were rising if there had been major changes in the composition of freight traffic. However, the available data suggest that the composition and pattern of traffic remained relatively stable during this period. Cf. data in U. S. Census Bureau, *Eleventh Census of the United States: 1890, Transportation*, Part I, and Interstate Commerce Commission, *Twenty-Fourth Annual Report on the Statistics of Railways in the United States for the Year Ending June 30, 1911* (Washington: Govt. Printing Office, 1913).

average transit distances and average freight rates by both water and rail—averages that cannot reliably be calculated until the linear programming problems are solved. Despite its crudity, the calculation is useful for two reasons. First, it provides a convenient format for demonstrating the ways in which a number of costs—costs that have been considered unquantifiable—can be quantified. Second, it provides a rough idea of the magnitude of the aggregate social saving that one can expect to obtain from the models.

The starting point of the calculation is the difference between the average ton-mile transportation rate by water and by rail. Various experts on transportation have pointed out that water rates were generally less than railroad rates.[52] Thus, over the route from Chicago to New York, the average all-rail rate on wheat in 1890 was 0.523 cents per ton-mile while the average all-water rate was 0.139 cents per ton-mile.[53] Casual examination of the available data suggests that these figures are approximately the same as those applying to all grains on this and other routes.[54] Hence, for the purposes of calculation it will be arbitrarily assumed that the New York to Chicago all-water rate per ton-mile on wheat equaled the average all-water rate (per ton-mile) on all grains over all the relevant routes. The assumption to be made on the all-rail rate is symmetric.

For the crude calculation of the social saving, the average national rate at which grain was actually transported in 1890 is needed. This actual rate must have been less than the all-rail rate. Not all grains shipped interregionally were carried exclusively by rail. Considerable quantities were shipped by a combination of rail and water or completely by water. In contrast to the 0.523 cents all-rail rate per ton-mile on wheat transported from Chicago to New York, the lake-and-rail charge was 0.229 cents, and the lake-and-canal charge was 0.186 cents.[55] The average of these three rates, weighted by the quantities of grain shipped under each one, is 0.434 cents (see Table 4). This last figure

[52] See, for example, Jenks, "Railroads as an Economic Force," pp. 12–13; and Harold G. Moulton, *Waterways versus Railways* (Boston: Houghton Mifflin, 1912), pp. 12–13, 33–38.

[53] U. S. Congress, House, *Distribution of Farm Products*, p. 142.

[54] See, for example, data in U. S. Statistics Bureau, *Changes in Rates;* U. S. Congress, Senate, *Preliminary Report of the Inland Waterways Commission;* and Louisville and Nashville Railroad, *Southwestern Freight Tariff*, No. 9 (Nov. 16, 1890).

[55] The lake-and-canal rate differs from the all-water rate cited in the previous paragraph by 0.047 cents because the former includes transshipment and insurance charges. The lake-and-rail rate includes insurance but not transshipment costs, since the ex-lake rail rates included transshipping charges. Cf. notes to Table 4.

will be taken as the "actual" national average rate on grains per ton-mile in 1890. In passing, it may be noted that the adjustment produced a figure which is less than a mill below the all-rail rate.

TABLE 4

ESTIMATE OF THE AVERAGE ACTUAL RATE

	1	2	3
Type of Transportation	Rate per Ton-Mile (cents)	Wheat and Corn (millions of tons)	Col. 1 × Col. 2 (cents)
1. All-water	0.186	1.254	0.2332
2. Water and rail	0.229	2.423	0.5549
3. All-rail	0.523	9.073	4.7452
4. Sum of columns		12.750	5.5333
5. Average actual rate in cents per ton-mile (sum of Col. 3 ÷ sum of Col. 2)			0.434

Sources and Notes:

Column 1. The three rates were determined by taking the Chicago-to-New York charges on wheat (including transshipment and insurance costs) and dividing each charge by the appropriate distance. U. S. Congress, House, *Distribution of Farm Products,* VI, 142; George G. Tunell, "The Diversion of the Flour and Grain Traffic from the Great Lakes to the Railroad," *Journal of Political Economy,* V, No. 3 (June 1897), 345; U. S. Congress, Senate, Select Committee on Transportation—Routes to the Seaboard, *Report No. 307,* Part 1, 43rd Cong., 1st Sess., p. 17; below, Table 6.

Column 2, Line 1. This is the total amount of wheat (including the grain equivalent of flour) and corn shipped by canal from the lake ports of Buffalo, Oswego and Tonawanda plus the quantity of the same commodities shipped by river from St. Louis. The amount of flour shipped from St. Louis by boat was obtained by multiplying the proportion of flour shipped by river in 1898 by the total 1890 shipments of flour. *Line 2* is the amount of wheat (including the grain equivalent of flour) and corn received at the lake ports of Erie, Buffalo, Oswego and Ogdensburg minus the grain shipped from lake ports by canal. *Line 3* is the total quantity of wheat and corn shipped interregionally minus lines 1 and 2. Buffalo Merchants' Exchange, *Annual Report, 1891,* pp. 71, 106, 108, 109, 112; U. S. Congress, House, *Report on the Internal Commerce of the United States for the Year 1891,* Executive Doc. No. 6, Part 2, 52nd Cong., 1st Sess., XXVI; U. S. Statistics Bureau, *Monthly Summary of Commerce and Finance,* 7 (Jan. 1900), pp. 2006–7, 2009; U. S. Congress, Senate, *Wholesale Prices, Wages, and Transportation (Aldrich Report),* Report No. 1394, Part 1, 52nd Cong., 2nd Sess., p. 558; Table 6, below.

In the case of meat and livestock products, the calculation is based on the St. Louis to New Orleans rates on pork. The all-rail rate was 1.07 cents per ton-mile and the all-water rate was 0.45 cents.[56] Again, these rates are comparable to those that prevailed on other meat

[56] The water rate is the highest that prevailed during the 1890 season of navigation. U. S. Congress, Senate, *Preliminary Report of the Inland Waterways Commission,* p. 343. The rail rate is taken from Louisville and Nashville Railroad, *Southwestern Freight Tariff,* No. 10.

products shipped on this and other routes. Furthermore, since the quantity of meat shipped by water was a small part of the total interregional tonnage, no further adjustment need be made; that is, the all-rail rate on pork will be assumed to equal the actual average rate on all meat products.

The quantity of corn, wheat, pork, and beef shipped interregionally in 1890 was approximately equal to the net local deficit of the trading areas plus net exports.[57] Assuming that half of the meat products was shipped as livestock and half as dressed meat, the amount transported interregionally was 15,700,000 tons.[58]

Estimates of average distances are based on a sample of thirty routes (pairs of cities). The sample was randomly drawn from a population of 875 routes. The average rail distance in the sample was 926 miles, and the average water distance was 1,574 miles.[59] Since only small amounts of meat were transported by water, 926 miles will be assumed to be the average distance over which meats were actually shipped in 1890. In the case of grains, an adjustment should be made for the tonnage that was carried partly or wholly by water. The adjusted figure, 1,044 miles, represents the estimate of the average distance over which grains were actually shipped in 1890.[60]

If rates and ton-miles were the only elements entering into the cost of transportation, it would have been cheaper to have shipped interregionally by water than by rail. As shown in Table 5, the social saving calculated on the basis of these elements is negative by about $38,000,-

[57] See above, Table 2.

[58] A breakdown of this figure is given in Table 6.

[59] The averages are simple arithmetic means.

Water distances between the points in the sample are an average of 70 per cent longer than rail distances. This suggests a somewhat greater degree of circuity in water transportation than was indicated by the study of the Bureau of Railway Economics, *An Economic Survey of Inland Waterway Transportation in the United States,* Special Series, No. 57 (Washington: Bureau of Railway Economics, 1930).

[60] The adjustment was made in the following manner:

Method	1 Distance (miles)	2 Tons of Grain (millions)	3 Millions of Ton-Miles (Col. 1 × Col. 2)
1. All-rail	926	9.073	8,402
2. Water-and-rail	1,302	2.423	3,155
3. All-water	1,398	1.254	1,753
4. Totals		12.750	13,310
5. Average distance (sum of Col. 3 ÷ sum of Col. 2)			1,044 miles

000. This odd result is not difficult to explain. While the estimated actual cost of transportation includes virtually all relevant items, the estimated cost of water transportation does not. In calculating the cost of shipping without the railroad, one must account for six neglected items of cost not reflected in the first approximation: cargo losses in transit, transshipment costs, wagon haulage from water points to secondary markets not on water routes, the cost resulting from the time lost when using a slow medium of transportation, the cost of being unable to use water routes for five months out of the year, and finally, capital costs not reflected in water rates.

When account is taken of the six neglected costs, the loss attributable to the railroad will be transformed into a saving. How big must the neglected costs be to produce a positive saving of 1 per cent of national income? In 1890 gross national product was about $12,000,000,000, and 1 per cent of this amount is $120,000,000. Without the neglected costs, interregional shipment of the four commodities would have been $38,000,000 cheaper by water than by rail. Consequently, in order to reach a social saving of 1 per cent of gross national product, the neglected costs will have to be approximately $158,000,000.

The literature on the interregional transportation of agricultural products indicates that cargo losses were greater on water shipments than on rail shipments. Insurance rates can be used to estimate the cost of these water transit losses. Since the average value of a loss on a given shipment was approximately equal to the insurance charge on the shipment, the total value of cargo losses in the absence of the railroad would have been approximately equal to the average insurance charge on a water shipment multiplied by the total value of the goods transported interregionally. Moreover, since railroad rates included insurance, this figure would also represent the neglected cost of cargo losses. The calculation is shown in Table 6. The cost of insurance (cost of cargo losses) in the absence of the railroad would have been approximately $6,000,000. Subtracting this figure from $158,000,000, there is left $152,000,000 to cover the remaining costs.

Transshipping costs were incurred whenever it became necessary to switch a cargo from one type of vessel to another. Grain shipped from Chicago to New York, for example, was transferred at Buffalo from lake steamers to canal barges. In the absence of the railroad there would probably have been an average of two transshipments on each

TABLE 5

FIRST APPROXIMATION OF THE SOCIAL SAVING

	1	2	3	4	5	6	7	8	9
Commodity	Quantity Shipped (millions of tons)	Millions of Ton-Miles of Water Transportation (Col. 1 × 1,574 miles)	Water Rate per Ton-Mile (dollars)	Cost of Water Transportation in Millions of Dollars (Col. 2 × Col. 3)	Average Actual Distance (miles)	Millions of Ton-Miles of Actual Transportation (Col. 1 × Col. 5)	Actual Rate per Ton-Mile (dollars)	Cost of Actual Transportation in Millions of Dollars (Col. 6 × Col. 7)	Social Saving in Millions of Dollars (Col. 4 — Col. 8)
Meats	3.000	4,722	.00451	21.296	926	2,778	.01071	29.752	—8.456
Grains	12.750	20,069	.00139	27.896	1,044	13,311	.00434	57.770	—29.874
Totals	15.750	24,791		49.192		16,089		87.522	—38.330

Sources: See notes to Tables 4, 6 and text, pp. 186–90.

TABLE 6

ESTIMATED COST OF INSURANCE

	1	2	3	4	5
	Tons Shipped Interregionally	Price per Ton	Value (Col. 1 × Col. 2)	Insurance Rate as a Proportion of Value	Cost of Insurance (Col. 3 × Col. 4)
1. Cattle	949,000	$ 97	$ 92,100,000	.01	$ 921,000
2. Dressed beef	503,000	138	69,400,000	.01	694,000
3. Hogs	1,008,000	79	79,600,000	.01	796,000
4. Dressed pork	538,000	110	59,200 000	.01	592,000
5. Corn	7,735,000	13	100,600,000	.01	1,006,000
6. Wheat	5,015,000	30	150,500,000	.01	1,505,000
7. Totals	15,748,000		551,400,000		5,514,000

Sources and Notes:

Column 1. Estimates of tons shipped interregionally are based on the local net deficits of the secondary markets plus exports. In the case of meats, it was assumed that half the deficit was shipped as dressed meats and half as livestock. Dressed pork was converted into a live weight equivalent at the rate of one pound of dressed pork equal to 1.874 pounds of live weight; for beef the conversion factor was one pound of dressed beef equal to 1.887 pounds of live weight. See above, pp. 183–85.

Column 2. The figures cited are the average Chicago wholesale prices except for dressed meats, which are New York quotations. In the case of wheat and corn, the prices represent unweighted averages of the twelve average monthly prices, with averages of missing months determined by linear interpolation. George K. Holmes, *Meat Situation in the United States,* U. S. Agriculture Dept., Departmental Report No. 109, Part I, pp. 289–98; U. S. Congress, Senate, *Aldrich Report,* Part 2, p. 10; U. S. Census Bureau, *Historical Statistics of the United States, Colonial Times to 1957* (Washington: Govt. Printing Office, 1960), p. 123.

Column 4. Insurance rates varied with the distance of a shipment and the route. In 1850, average insurance rates on the Mississippi and Ohio were about 1 per cent of the value of the cargo per thousand miles. In 1870, the rate on the Great Lakes was about the same. However, scattered data suggest that in subsequent years marine insurance rates fell sharply. By the 1890's, insurance on the Lakes was 0.3 per cent per thousand miles. A decade later the rate on cargo from Pittsburgh to New Orleans was about 0.7 cents per thousand miles, while the intracoastal rate was about 0.1 cents. In the absence of the railroad perhaps half of the tonnage would have been carried over the Lakes on intracoastal routes. In view of the foregoing, it seems reasonable to assume that in the absence of the railroad, the average insurance rate probably would not have exceeded the later Mississippi rate, that is, 0.7 cents per thousand miles or approximately 1 per cent for 1,574 miles. Louis C. Hunter, *Steamboats in Western Rivers* (Cambridge: Harvard Univ. Press, 1949), pp. 368–69; U. S. Congress, Senate, Select Committee on Transportation—Routes to the Seaboard, *Report No. 307,* Part 1, p. 17; George J. Tunell, "The Diversion of Flour and Grain Traffic," p. 345; U. S. Congress, Senate *Preliminary Report of the Inland Waterways Commission,* pp. 332–33.

ton carried from a primary to a secondary market. At a cost of fifty cents per ton per transshipment, transshipping charges on the grain and meat products in question would have been $16,000,000.[61] Subtracting this amount from $152,000,000, there is left $136,000,000 to cover the remaining costs.

The two indirect costs of water transportation most frequently cited are the cost of time lost in shipping by water and the cost of being unable to use water routes for about five months out of each year. Arguments based on the time factor and the limited season of navigation have been decisive in ruling out the possibility that water transportation could have been a good substitute for the railroad. Once invoked, these arguments are invincible, since the costs involved seem to be limited only by the intuition of the disputants. Without a means of quantifying the cost of time and the cost of the limited season of navigation, the hypothesis posed in this paper cannot be tested.

The key to quantifying the cost of the time that would have been lost in water transportation is the nexus between time and inventories. If entrepreneurs could replace goods the instant they were sold, they would, *ceteris paribus,* carry zero inventories. Inventories are necessary to bridge the gap of time required to deliver a commodity from its supply source to a given point. If, on the average, interregional shipments of agricultural commodities required a month more by water than by rail, it would have been possible to compensate for the time lost through an inventory increase in the secondary markets equal to one twelfth of annual shipments. Hence the cost of the time lost in using water transportation was the 1890 cost of carrying such an additional inventory.[62]

[61] The cost of transshipping meat products appears to have been included in the water rate. U. S. Corporations Bureau, *Report of the Commissioner of Corporations on Transportation by Water in the United States.* Part III, *Water Terminals* (Washington: Govt. Printing Office, 1910), pp. 329–34.

[62] The assumption that boats took an average of a month longer than trains to provide the same transportation service introduces an upward bias into the estimate of the cost of time. The minimum time required by *express* freight trains on the run from New York to Chicago in 1896 was seventy-five hours, indicating an average speed of twelve miles per hour (Joint Traffic Association, *Proceedings of the Board of Managers, 1896,* p. 627). About the same time, boats on the Great Lakes made the round trip from Duluth to Buffalo in nine days, indicating an average speed of over nine miles per hour [Joseph E. Ransdell, "Legislative Program Congress Should Adopt for Improvement of American Waterways," *Annals* of the American Academy of Political and Social Science, XXXI, No. 1 (Jan. 1908), 38]. In 1912 the average speed of freight boats on rivers was about seven miles per hour. (U. S. Agriculture Dept., *Bulletin No. 74,* p. 36.) These facts suggest that the average time advantage of railroads in the interregional transportation of agricultural products was less than a week. Some observers argued that in the transportation of bulk items boats actually provided quicker service than trains (Ransdell, "Improvement of American Waterways," p. 38).

The problems inherent in the limited season of water transportation could also have been met by an increase in inventory. Since water routes were closed for five twelfths of the year, I will assume that the absence of railroads would have increased the inventories of agricultural commodities held in secondary markets by five twelfths of the annual interregional shipment. It should be noted that this assumption overstates the additional inventory requirement. Abstracting from risk considerations, the limited season of navigation would—at least with respect to grains—have had no effect on the inventory requirements of the nation. A crop once harvested was placed in inventory and drawn down throughout the year. A shorter transportation season would only have affected the way in which a fixed total inventory was divided between the Midwest and the secondary markets. Exclusive reliance on water routes would have increased the inventory total only if risk factors were operative. Under conditions of risk, the availability of a central depository reduces the size of the stock that must be held by a given set of cities. Nevertheless, the five-twelfths assumption will be adopted to simplify the computation.

The cost of time lost in water transportation and the limited season of navigation would thus not have exceeded the cost incurred in carrying an inventory equal to one half of the annual amount of agricultural products that were transported interregionally. As shown in Table 6, the Chicago wholesale value of the corn, wheat, beef, and pork shipped interregionally was about $550,000,000. Another $43,000,000 should be added to approximate wholesale value at seaboard.[63] Hence, in the absence of the railroad, the limited season of navigation would have required an increase in the value of inventories of about $297,000,000. The cost of carrying such an additional inventory would have included the forgone opportunity of investing the same amount elsewhere. If it is assumed that on the average capital earned 6 per cent in 1890, the alternative cost of the investment in additional inventory would have been about $18,000,000 per year. To this, one must add about $30,000,000 for storage charges.[64] Subtracting $48,000,000 from $136,000,000 leaves $88,000,000 to account for the two remaining costs.

[63] To the Chicago values shown in Table 6, $2.83 per ton was added for wheat, $2.59 for corn, $4.00 for cattle and $5.00 for hogs. Dressed meats in Table 6 are quoted at the New York prices, so no further adjustment was necessary. U. S. Congress, Senate, *Aldrich Report*, I, 518–19, 526.

[64] The cost of elevating and storing grain in Buffalo from November 10 to the opening of navigation (about five months) was two cents per bushel or .4 cents per bushel per month (Buffalo Merchants' Exchange, *Annual Report, 1890*, pp. 88–89). At this rate, storage charges on

Cities receiving approximately 10 per cent of the interregional shipments were not on water routes. If these cities were an average of fifty miles from the nearest water point, the cost of wagon haulage (at twenty-five cents per ton-mile) would have been $20,000,000. Subtracting this amount from $88,000,000 leaves $68,000,000 to account for the last item—neglected capital charges.

Water rates failed to reflect capital costs to the extent that rivers and canals were improved or built by the government and financed out of taxes rather than tolls. If a complete statement of these uncompensated expenditures were available, one could easily estimate the neglected capital costs. Data exist on capital expenditures for water transportation, but much work remains to be done to develop a consistent and complete statement of uncompensated investment. Federal expenditures on river improvement over the years between 1802 and 1890 appear to have amounted to $111,000,000. Canals still in operation in 1890 were built at a cost of $155,000,000. In addition, there were abandoned canals which would have been in use in the absence of the interregional railroad. These were built at a cost of $27,000,000.[65] The total of the three items, $293,000,000, may either overstate or understate the uncompensated capital involved in water transportation. Assuming that the various upward and downward biases, the omitted items and the double counting, cancel each other out, at an interest rate of 6 per cent the neglected capital costs would have been about $18,000,000—$50,000,000 short of the amount required to bring the social saving to 1 per cent of gross national product.[66]

Thus casual examination of the available data suggests that the social saving attributable to the railroad in the interregional transportation of

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the six months of additional inventory of wheat and corn would have amounted to $5,300,000. In 1910 cold storage rates were $4.96 per ton per month on beef and $4.70 on pork (U. S. Agriculture Dept., *Statistical Bulletin No. 493*, p. 44). At these rates, the additional storage charges on beef and pork would have been $31,000,000 in dollars of 1910 or $25,000,000 in dollars of 1890. However, cold storage would have been the most costly way of maintaining the additional inventory of meat. It would have been cheaper to store meat in the East by sending live animals to eastern feeders. In this case, the cost of storage would have been essentially the cost of shipping more feed but smaller animals.

[65] U. S. Congress, Senate, *Preliminary Report of the Inland Waterways Commission*, pp. 180–81, 193–97, 202–3, 205–9; cf. U. S. Census Bureau, *Transportation by Water*, pp. 44–46.

[66] The preceding calculation may be summarized as follows:

First approximation of social saving	$—38,000,000
Neglected cargo losses	6,000,000
Transshipping costs	16,000,000
Additional inventory costs	48,000,000
Supplementary wagon haulage	20,000,000
Neglected capital costs	18,000,000
Total	**$ 70,000,000**

agricultural products was about 1 per cent of national income.[67] The calculation is, of course, subject to considerable error; but there are grounds for having confidence in the result. Four of the estimates—those dealing with transshipment, wagon haulage, time lost, and the limited season of navigation—probably overstate the actual cost of water transportation. While the estimates of some of the other items may be too low, it does not seem likely that the errors are large enough to alter substantially the magnitude of the indicated social saving. Suppose, for example, that railroad rates on a ton-mile basis were not above water rates, as has generally been assumed. If the initial water-rail rate differential had actually been zero on all commodities, the elimination of this error would increase the estimated social saving by only $56,000,000. Indeed, if railroad rates are assumed to have been zero, the social saving would rise to only $158,000,000, or about 1.3 per cent of gross national product.

This paper has focused on one aspect of the influence of the railroad on American economic development. A small aggregate social saving in the interregional transportation of agricultural products would not prove that the railroad was unimportant in American development. Conclusions regarding the over-all impact of the railroad require, as Simon Kuznets has suggested, a thorough examination of all the avenues through which the most celebrated innovation of the nineteenth century may have exercised a strategic influence on economic growth. In this connection it is important to re-emphasize that the linear programming models referred to earlier will do more than refine the crude estimate of the aggregate social saving. They will provide information on efficient patterns of agricultural distribution both in the rail and nonrail situations, as well as breakdowns of the interregional social saving by regions and commodities. This type of information,

[67] How significant is a social saving of 1 per cent of national income? This question cannot be answered without making further assumptions as to how the economy would have adjusted to the absence of the railroad. One consequence of the absence of the railroad would have been a rise in the seaboard prices of agricultural commodities. This could have had a significant effect on the U. S. balance of trade. Similarly, a shift from railroad to water and wagon transportation may have been a shift from a more to a less capital-intensive activity. Such a change might have aggravated market problems in the capital goods sector. On the other hand, it might have increased the demand for labor.

If one abstracts from these essentially Keynesian issues of insufficient demand and focuses on the economy's production possibilities, it is possible to interpret the social saving in a fairly simple way. Assuming that the marginal aggregate savings and capital-output ratios would have been what in fact they were when national income was 99 per cent of the 1890 level, the absence of the interregional railroad would have retarded the development of the economy by about three months.

supplemented by similar data on intraregional transportation, will facilitate a re-evaluation of such questions as the developmental significance of various commercial rivalries (for example, the triumph of Chicago over St. Louis and Cincinnati), the determinants of the geographic pattern of urbanization, and the extent to which the railroad promoted a more efficient utilization of certain productive resources.

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