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Author(s): Andreas Grotewold

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# VON THUNEN IN RETROSPECT

*Andreas Grotewold*

*Dr. Grotewold grew up in northeastern Germany not far from the place where von Thünen developed his theory. He is now Assistant Professor of Geography at the University of Missouri.*

THIS paper is a critical analysis of von Thünen's theory of the location of agricultural production. It is essentially a defense of that theory against false interpretations and unjust criticism in recent decades. My analysis of von Thünen's theory bears some relation to recent methodological writings in American geographic journals. Thus, the introduction presents some comments on such writings; and the conclusions deal with those aspects of von Thünen's theory which may have a bearing upon the views expressed in them.

## INTRODUCTION

An economic geographer reviewing recent methodological papers in American journals can hardly fail to be impressed with the large number of articles suggesting that he devote more of his ingenuity to the formulation of theories and laws. In some instances the authors express dissatisfaction with the empirical and descriptive research conducted by economic geographers in the past and at present.<sup>1</sup> One must agree that the abundant descriptive material accumulated thus far is so diversified that it is difficult to relate many individual studies to any general lines of investigation. The present writer knows

<sup>1</sup> Maurice B. Ballabon: "Putting the 'Economic' into Economic Geography," *Econ. Geog.*, Vol. 33, 1957, pp. 217-223; John Q. Stewart and William Warntz: "Macroeography and Social Science," *Geogr. Rev.*, Vol. 48, 1958, pp. 167-184.

of only one book which successfully integrates a consistent series of empirical, microgeographic studies into a pattern of continental dimensions and shows the method by which this was accomplished. This is Professor Platt's book on Latin America;<sup>2</sup> in the opinion of this writer, his achievement is practically unique.

A greater effort by economic geographers to generalize the results of their detailed studies might indeed result in a better appreciation and understanding of large, significant patterns. But such efforts would not necessarily result in the creation of theories and laws. Generalizations are derived from observed facts and coincidences. For example, to say that a large proportion of Americans prefer to live in one-family suburban residences rather than in apartment houses near the center of the city is to make a valid generalization. Theories are something different. They consist of propositions which if applied to specific phenomena explain their existence or characteristics. A "proposition" as the term is used throughout this paper may be any statement which within the framework of a theory is considered to be true; actually such propositions may be factual, presupposed, or assumed.

In Burgess' well-known concentric zone theory, for example, one of the

<sup>2</sup> Robert S. Platt: *Latin America: Countrysides and United Regions*, New York, 1942.

propositions is the generalization mentioned above;<sup>3</sup> cities are the phenomena to which his propositions are applied; and what is explained is the formation of concentric rings of urban land use and expansion. Laws, if derived from theories, state the consequences which ensue from the propositions and their application. Thus, Burgess' law is that in American cities land use and urban growth take the form of concentric zones. A theory is applicable only if its propositions are applicable. Burgess' theory, for example, would not be applicable if nearly all Americans preferred to live in apartment dwellings near the center of the city.

Most geographers are acquainted with various theories which they accept as useful. So far most of them have been formulated by scientists in other fields. But if the trend heralded by our recent methodological writings bears fruit we may soon have more and better theories by geographers. Yet the present writer would not wish the empirical, micro-geographic approach discarded or forgotten. He believes that facts actually observed and generalizations derived from them are likely to be more valid than theories, because they do not rest upon propositions and therefore their relevance to reality cannot be doubted. Besides, he just cannot understand why it should be the aim of all science to establish theories and laws. The term "science" is derived from the Latin word *scire* which means "to know." Presumably the aim is to know the truth. Just why must theories yield more or better truths than an unbiased and thorough analysis of empirical data?

Even he who follows the traditional approach of gathering and analyzing

<sup>3</sup> H. H. McCarty: "An Approach to a Theory of Economic Geography," *Econ. Geog.*, Vol. 30, 1954, pp. 95-101, explains how generalizations may become propositions of theories.

empirical facts may find it necessary to concern himself with theories. The reason for his concern may be the desire to convince his theory-minded colleagues that conclusions based upon field studies and other empirical evidence are truthful and valid even though they do not conform to any one of the existing theories, or to a combination of them, and do not necessarily lead to the formulation of new theories and laws.

The present writer found himself in such a position. While dealing with recent changes in land use and agricultural production near Kansas City and St. Louis he noticed a general decline in the cultivation of perishable and bulky commodities and a decline in intensive types of farming. This situation was not unique; the Chicago area showed basically the same trends. According to the censuses of 1950 and 1954 the commercial vegetable acreage had decreased in the standard metropolitan areas of each of these three cities; so had the area used for the production of flowers in the open and under glass.<sup>4</sup> Such trends are contrary to the common interpretation of von Thünen's theory. The writer had heard and read repeatedly that, according to von Thünen, farmers near the market must use their land intensively and produce commodities which are perishable, yield a great bulk per acre, and require high transportation costs relative to their value; whereas farmers at a greater distance from the market must use their land less intensively and produce less

<sup>4</sup> U. S. Bureau of the Census: *United States Census of Agriculture: 1954*, Vol. I, Parts 4, 5, 10, and 13, Washington, 1956, County Tables 8 and 9. The Standard Metropolitan Area of Chicago included Cook, Lake, Kane, DuPage, and Will Counties in Illinois, and Lake County in Indiana; that of St. Louis included St. Louis and St. Charles Counties, and the City of St. Louis in Missouri, and Madison and St. Clair Counties in Illinois; that of Kansas City included Jackson and Clay Counties in Missouri, and Wyandotte and Johnson Counties in Kansas.

perishable and bulky commodities. The following analysis of von Thünen's theory was made to discover the reason for the obvious discrepancy between the theory and the recent trends in urban-fringe farming mentioned above.

#### THE THEORY

Johann Heinrich von Thünen lived in Germany from 1783 until 1850. He contributed to modern science the first theory of the location of agricultural production.<sup>5</sup> His interest in the economics of agriculture had been inspired by the study of such earlier economists as Adam Smith and Albrecht Thaer. At the age of 27 von Thünen acquired the estate "Tellow" near Rostock in Mecklenburg which he operated for 40 years until his death. Most of the data used in explaining and amplifying his theory were obtained by him through practical experience, including detailed cost accounting, on that estate.

According to von Thünen's own appraisal of his work his most important achievement is the concept of the *isolierte Staat*. This is the idea of an "isolated state" in which there is only one central city, the market, and around it an extensive plain of tillable land, uniform in its physical characteristics, served by only one mode of transportation, and inhabited by farmers supplying the central city and having no difficulty in adjusting the use of their resources to any economic condition that might evolve. Thus, several factors normally contributing to a considerable regional diversity of land uses and agricultural production were assumed to be constant or nonexistent.

#### Land Rent

Within the setting of the *isolierte Staat* von Thünen considered the relationship among (1) distance of farms from the market, (2) prices received by

farmers for their products, and (3) land rent.

The relationship between the first two factors was very simple. The price which a farmer obtained for a given unit of commodity was equal to its price at the market minus the cost of shipping it to the market. The cost of transportation increased with distance from the market. Thus, any given product—a bushel of rye, for example—represented a greater value to a farmer living within two miles of the market than to a farmer living at a distance of 20 miles.

The third factor, land rent, was defined as the return from the investment in the land.<sup>6</sup> In the *isolierte Staat* land rent depended upon location relative to the market. This can be explained most easily by a history of settlement. When the *isolierte Staat* was small, only a little land around the city was needed to supply it with agricultural products. As settlement expanded and the demand for agricultural products increased, land at a greater distance had to be taken under cultivation. As a result of the increased cost of shipping from this outer zone to the city, market prices for agricultural products had to increase. Farmers in the earlier settled area benefited from such higher prices. Compared to farmers in the more recently settled, outer zone they obtained the differential advantage of lower transportation costs to the market; thus their land provided a rent and increased in desirability and value. Eventually, settlement expanded still further and a third zone, even more remote from the

<sup>5</sup> His complete works are contained in Johann Heinrich von Thünen: *Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie*, 3rd ed., Berlin, 1875. This book consists of three parts. An earlier edition of Part I had appeared in 1826.

<sup>6</sup> The following discussion of land rent is not paraphrased directly after von Thünen's book. But the definitions given are synonymous with von Thünen's. See *ibid.*, Part I, pp. 14-16, 227-229, and 350-353.

city, was taken under cultivation. At this stage prices for agricultural products in the city had to increase even further. Consequently, the second zone of settlement began to provide a land rent, and in the first settled area the rent increased.

The formula given below indicates how land rent for any one product can be derived:

$$R = Yp - E - Yfk.$$

In this formula,  $R$  = land rent per acre;  $E$  = production expenses per acre, including labor, supplies, and equipment;  $Y$  = yield in units of commodity per acre;  $p$  = market price per unit of commodity;  $f$  = freight rate, i.e., the cost of shipping a unit of commodity over the distance of one mile; and  $k$  = number of miles from the market.

The value of land was determined by the rent it yielded. Land nearest the city was most valuable because it yielded the highest rent; land near the outer limit of cultivation was of little value because it yielded a low rent.

#### *Agricultural Production*

Within the *isolierte Staat* areal differences in land use and agricultural production were the result of three forces. These were (1) the types and quantities of agricultural products needed in the city, (2) the technology employed in the production and transportation of such commodities, and (3) the endeavor of each farmer to maximize his land rent by producing commodities for which the location of his land relative to the market offered the greatest advantage. These three forces created the pattern of land uses shown in Figure 1A.<sup>7</sup> The

<sup>7</sup> Figure 1 was copied from *ibid.*, Part I, pp. 390 and 391. Some of the terms used by von Thünen to describe types of farming have no equivalent in the English language. An attempt had been made to translate their meaning as closely as possible.

following is an interpretation of this pattern.

It has already been mentioned that von Thünen relied upon empirical information in defining the commodities needed in the central city and in calculating for such commodities the production expenses, yields, and market prices. His model of the *isolierte Staat* reflects the needs of Rostock city dwellers and the state of technology in Mecklenburg well over a hundred years ago. Writers who have since described von Thünen's theory or elaborated upon it have frequently overlooked these circumstances, and such neglect has resulted in false interpretations and unjust criticism of his theory. Naturally, von Thünen took the conditions of his time for granted. Today, however, such conditions must be stated as definite propositions of his theory. One of these is that in the *isolierte Staat* there was only one form of transportation, the horse and wagon, operated by the farmer at his own expense. There were no multiple freight rates depending upon the commodities shipped. Refrigeration in transit had not yet been invented.

Under such conditions the land nearest the city was used for the production of fresh milk and vegetables. Here cattle were kept in stables throughout the year. The fertility of the land was maintained through manuring, and if necessary additional manure was bought from teamsters in the city. The reason for the existence of this zone so close to the city is to be found in the state of technology. The slow speed of transportation and the absence of refrigeration made it impossible, or at least precarious, to ship fresh milk and vegetables over greater distances. In the location of this particular zone the cost of transportation was not a pertinent consideration. Since fresh milk and vegetables were required in the city, prices for them

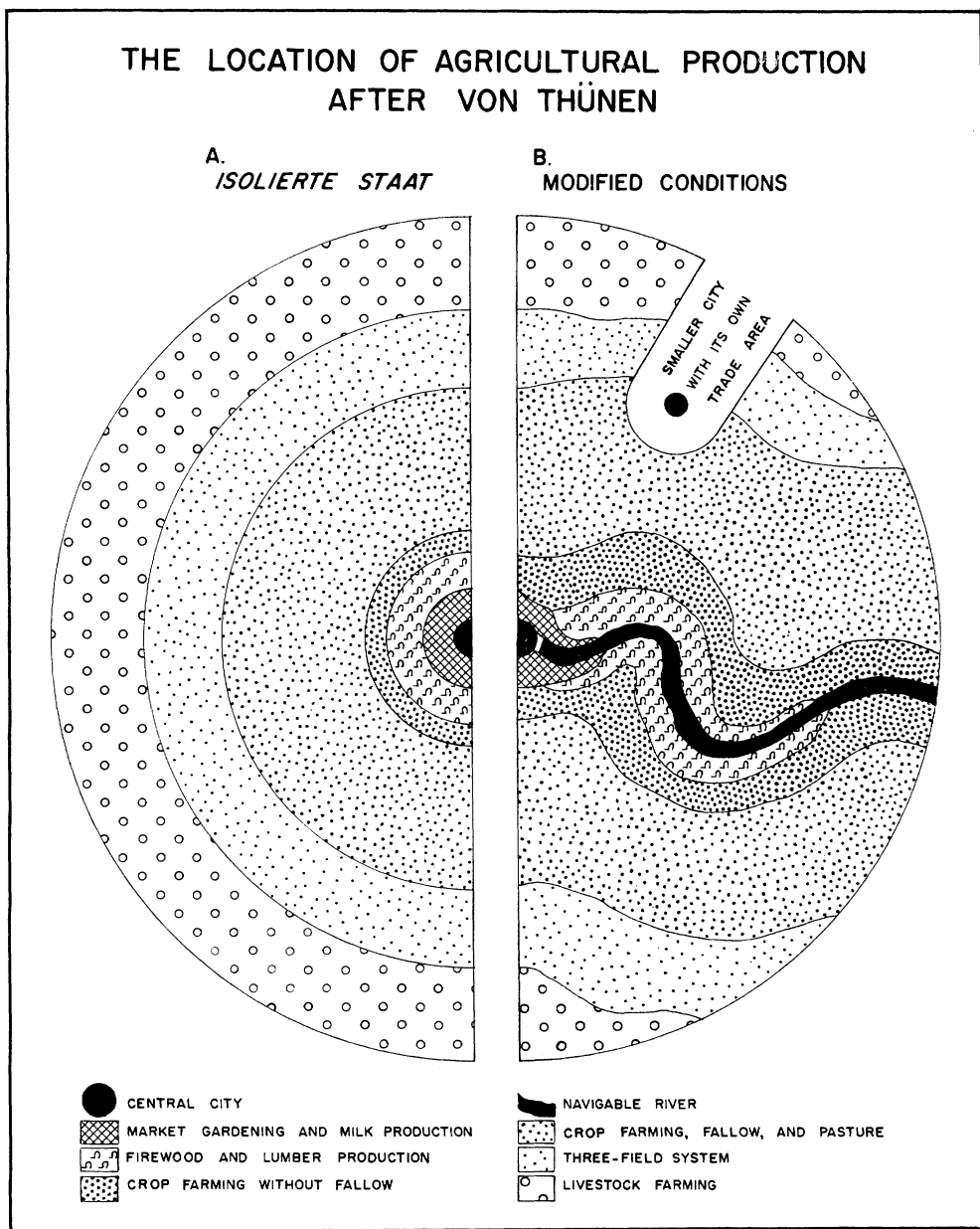


FIG. 1.

had to be so high that no other use of the land would have yielded a higher rent.<sup>8</sup>

The second belt was used for the production of wood. Von Thünen has shown, on the basis of his empirical

<sup>8</sup> *Ibid.*, Part I, p. 3.

data, that forestry yielded a higher rent on this land than any other use. The following is a simplified version of his argument.<sup>9</sup>

Forest land produced not only lumber but, more important, it was the source

<sup>9</sup> *Ibid.*, Part I, pp. 172-184.



of firewood required in the city. The physical volume of all wood obtained from an acre was quite large; let us assume that it was three times as large as that from an acre of product D. In addition, let us assume that for each commodity the production expenses and yields were the same in all parts of the *isolierte Staat*.

Figure 2 illustrates the competition for the land between wood (thick lines) and product D (thin lines). The dashed lines ( $Yp$ ) represent the prices of produce per acre at the market. The dotted lines ( $E$ ) show the production expenses per acre. The solid lines ( $Yp - Yfk$ ) represent the market prices of produce per acre minus the cost of shipping them to the market, i.e., the per acre values of the respective commodities at the site where they were produced. Obviously, these values decreased with distance from the market. In our example the rate of decrease per unit of distance was three times as great for wood as for product D. All land owners in the *isolierte Staat* selected the land use which would give them the highest land rent ( $R$ ). Figure 2 shows that wood yielded a greater rent up to the distance of  $k_2$ ; beyond that the rent was higher for product D. Thus, wood was produced closer to the market than product D.

Some authors have stated as a general law that, according to von Thünen, the product with the higher yield per acre must be produced closer to the market. Von Thünen had indeed arrived at this conclusion and stated it in his book.<sup>10</sup> But it is misleading to repeat this statement outside its proper context. It held true only if the competing commodities were equally resistant to spoilage and if the higher cost of shipping the more bulky product could not

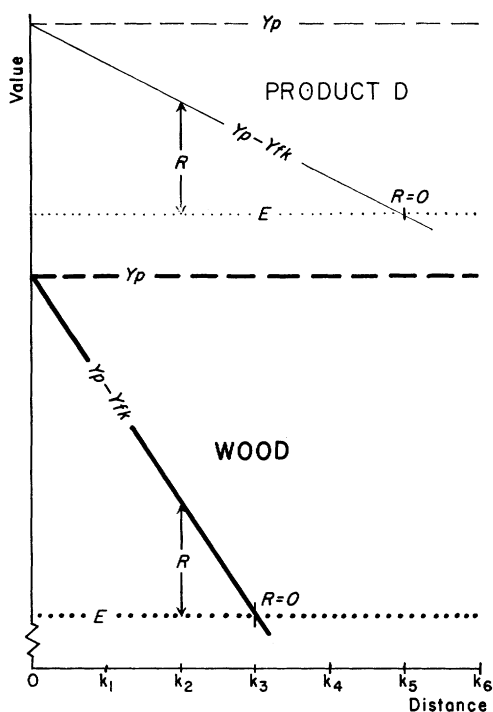


FIG. 2.

be compensated by lower freight rates or by a reduction in the production expenses.

According to von Thünen the production expenses for wood were fairly equal in all parts of the *isolierte Staat*. This, however, was not so for all commodities. His model of the *isolierte Staat* (Figure 1A) shows behind the forest belt three zones where rye was an important market product. The essential difference among these three zones was in the intensity of cultivation. With increasing distance from the market the production expenses for rye were lowered with a consequent reduction in yields.

In the first of the three zones farmers followed a six-year crop rotation. Rye occupied one-third of the land; the other two-thirds were planted to potatoes, barley, clover, and vetch.<sup>11</sup> Potatoes,

<sup>10</sup> *Ibid.*, Part I, p. 2.

<sup>11</sup> *Ibid.*, Part I, p. 90.

like rye, were sold in the city. Vetch was used as a soil builder and for green fodder during the summer. Cattle were kept in stables most of their lives. The soil fertility was maintained through manuring. There was no fallow land.

In the next zone the land was used somewhat less intensively. Farmers applied a seven-year crop rotation wherein rye occupied only one-seventh of the land; it was followed by one year of barley, one year of oats, three years of pasture, and one year of fallow.<sup>12</sup> The market products consisted of rye, butter, cheese, and possibly live animals to be slaughtered in the city. Such products did not spoil as quickly as fresh milk and vegetables and could be produced at a considerably greater distance from the market.

In the most distant of the three rye-supplying zones farmers followed the three-field system. This was a rotation scheme wherein roughly one-third of the land was used for field crops, another

third for pasture, and the remainder left fallow.

Beyond this zone, in the area of livestock farming, the distance to the market was so great that even the most extensive and cost-saving method of rye production could not have yielded a higher rent than the production of butter, cheese, or live animals. Consequently, the production of rye was limited to the demand on the farm. Only animal products were marketed.

Figure 3 illustrates the effect of decreasing production expenses and yields upon the areal extent of rye cultivation. Rye A (thick lines) represents rye cultivation as it was described by von Thünen; production expenses and yields decreased with increasing distance from the market. Rye B (thin lines) is a hypothetical projection of rye cultivation as it was carried on near the market into areas at some distance from the market. At the market the rent for rye A and rye B was the same. From there outward, however, the rent decreased less steeply for rye A than for rye B. At the distance of  $k_4$  the rent for rye B would have been zero whereas for rye A it was still positive. Thus, through less intensive cultivation the rent which rye yielded at greater distances from the market was increased, and rye could compete with other products over a wider area.

On the basis of this argument some writers have stated as a general law that, according to von Thünen, the intensity of cultivation must decrease with increasing distance from the market. Such statements are very irritating if quoted outside their proper context. As is shown in Figure 2, the production expenses for wood were far lower than for product D. Yet wood, the less intensively cultivated product, was

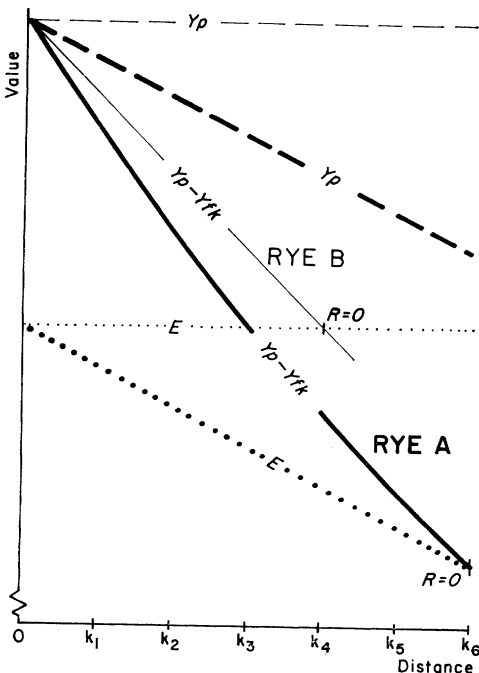


FIG. 3.

<sup>12</sup> *Ibid.*, Part I, p. 89.



grown closer to the market than product D. Even in the case of a single product, such as rye, this law is subject to an important qualification. A reduction in the production expenses is feasible only if the consequent reduction in yields is not so great as to offset the savings accomplished by the reduction in production expenses.

It has been recognized, by von Thünen and others, that the conditions of the *isolierte Staat* were nowhere duplicated in practice. In von Thünen's book one finds a diagram showing the application of his principles to an area traversed by a navigable river where transportation was more speedy and shipping costs only one-tenth as much as on land (Figure 1B). As a practical farmer von Thünen was aware also of areal differences in the productivity of the land and of the fact that farmers differed in ability to manage their land so as to obtain the highest land rent possible. Such facts modified the simple model of the *isolierte Staat*; but they did not invalidate von Thünen's basic principles.

#### CONCLUSIONS

The preceding discussion permits the following conclusions regarding von Thünen's theory:

(1) The theory was based upon propositions. Some of these were empirical facts which von Thünen had observed; other propositions were taken for granted or stated as assumptions.

(2) The importance of the empirical background and the propositions derived from it have been overlooked by many writers who have quoted or interpreted von Thünen's theory.

(3) A modern reader cannot understand von Thünen's theory unless he considers its empirical background. The present writer, who had done so, found it consistent and logical.

Von Thünen's theory was applicable during his lifetime and for many years beyond. The patterns of land uses near European and American cities conformed quite closely to the model of the *isolierte Staat*, and the theory offered a sound explanation for the forces which had shaped such patterns. Even today there are still bits of evidence for von Thünen's theory near cities in Europe and America. The evidence, however, is vanishing.

What has upset von Thünen's theory more than anything else is the development of modern transportation. Lake steamers, river barges, railroads, and even trucks are vastly cheaper means of transportation than the horse and buggy. No longer are the costs of shipping strictly proportional to bulk and distance; much depends upon the means of transport and the commodities shipped. Perishable commodities are moved long distances under refrigeration. Surely, urban-fringe farmers still benefit from lower transportation costs to the market for many products. But the importance of their locational advantage has declined to the point where they cannot compete with distant producers who are favored by better land, cheaper labor, or lower taxes.

Other reasons for the obsolescence of von Thünen's theory are changes in the tastes and demands of city dwellers, made possible by modern technology. Firewood, for example, is no longer an important fuel. Improvements in transportation and the arts of canning, cold storage, and freezing have greatly increased the variety of foods available to consumers. In von Thünen's time people ate lettuce in spring, tomatoes in summer, apples in fall, and sauerkraut in winter. Today, they can select what they like best or what fits their prescribed diet, and this they eat pretty much throughout the year. By and

large the choices made by consumers have not helped the urban-fringe farmer. Many of the desired products, like bananas and citrus fruit, he cannot grow at all. Others, like tomatoes or lettuce, he can supply only for a few months of the year. For example, of the total quantity of lettuce unloaded in St. Louis in 1956 less than three per cent came from Missouri and Illinois; 82 per cent originated in California and Arizona.<sup>13</sup> Of the fresh tomatoes 33 per cent came from Missouri and Illinois; during the month of July these two states supplied 88 per cent, whereas during the winter nearly all the fresh tomatoes came from Florida.

The flow of dairy products in Missouri is a fine example of the decreasing significance of transportation costs. The city of Columbia, about halfway between Kansas City and St. Louis, has two dairies. These face competition from larger enterprises just outside Kansas City. The latter buy fresh milk from farmers within a few miles of Columbia.<sup>14</sup> From here the milk is shipped nearly 130 miles to Kansas City where it is pasteurized and homogenized; the final product is then shipped back to Columbia where it is sold. An even more striking example is the flow of half-and-half cream and chocolate drinks. A dairy located in the St. Louis area buys its milk from places in the Ozarks which are at least a hundred miles closer to Kansas City. In St. Louis the milk is made into cream and chocolate drinks. These products are shipped about 250 miles to a branch plant in Kansas City from where they are distributed to Columbia.<sup>15</sup>

<sup>13</sup> U. S. Agricultural Marketing Service: *St. Louis, Unloads of Fresh Fruits and Vegetables: 1956* (mimeographed, no date).

<sup>14</sup> Edward L. St. Clair: *Marketing Administrator, Greater Kansas City Marketing Area Bulletin*, Vol. I, No. 5, February 1958, p. 1.

For purposes of farming the urban-fringe areas of American cities have lost much of their high rent-yielding potential. High land values in such areas must be attributed primarily to suburban expansion and to the real estate boom that goes along with it.

Obviously, an explanation of recent trends or a forecast of future developments in urban-fringe farming on the basis of von Thünen's theory could hardly come close to an approximation of reality. The reason for the obsolescence of von Thünen's theory is not to be found in any logical error committed by him. Nor is it that better information has become available since he formulated his theory. Von Thünen's theory is outdated as far as urban-fringe farming is concerned because his propositions regarding the production, transportation, and consumption of agricultural commodities are no longer applicable. Otherwise, there is nothing faulty in the theory.

In commenting on this paper Professor Murdock of the University of Missouri suggested that by substituting for perishable agricultural commodities such "perishables" as services one might find that the basic principles of von Thünen's theory hold true even at this time. This interesting possibility appears to be a promising research topic in urban geography. If it should show positive results it would, in the opinion of this writer, create a new theory. Such theory would be "new" because it would be based upon a new set of propositions (pertaining to the city-dweller's need for services) applied to new phenomena (urban instead of agricultural land) and explain different characteristics of such phe-

<sup>15</sup> Information from Mr. Stephen F. Whitted, Agricultural Economist at the University of Missouri.

nomena (presumably a concentric zone arrangement of service industries).

However stimulating von Thünen's thoughts might be, the fact remains that his theory of the location of agricultural production as presented nearly a century and a half ago is now outdated. Von Thünen's propositions were concerned with man and the creations of man, and these are likely to change. All theories in the social sciences are subject to this limitation. No "law" of economics, economic geography, or any other social science can ever be a "law" in the sense in which the mathematician or physicist is permitted to use the term.

This, of course, does not imply that theories and laws in the social sciences are useless. It merely means that they must be considered within their historical and regional settings. The latter are recorded in the form of empirical, microgeographic observations and facts. Such facts can never be insignificant, sterile, or fail to meet the needs of economic geography; on the contrary,

they are the basic stuff on which all valid theories must be founded and against which the theories must be evaluated. But, of course, even the best descriptions of empirical observations and facts are useless to him who denounces them as insignificant. A disregard for empirical information is not a recommendation for a scholarly paper in economics, economic geography, or any other social science, whether the purpose is to evaluate the works of previous writers or to arrive at new generalizations or theories.

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