

KREVIEW OF CLASSIC MODELS OF OPTIMAL PLACEMENT OF ENTERPRISES

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Geographical location of a company impacts its performance metrics. Badly chosen location for a production chain can turn it from a promising one into unprofitable and impractical. The problem of optimal placement of enterprises has been studied by numerous scientists: Isotov D. O. [1], Stanitskiy Y. I. [2, 3], Kachan E. P. [4], Kovalevskiy V. V. [5], and others.

In this paper we review models proposed by scientists who studied optimal placement problems, analyse strengths and weaknesses of those models, and justify the need for an update and adaptation of historical models to new economic realities.

Profit is the ultimate goal of any enterprise. Maximum profit can be achieved by minimising costs and maximising income.

The problem of optimal placement of enterprises is studied even today. In 1826, Johann von Thünen developed his theory of agricultural standard [6].

Since then it is widely believed to be the basis for the development of the enterprise placement theory. Thünen's model is based on the following principles:

- farm specialisation is based on the assumption that intensity of land use decreases as they move further away from the center;
- produce from the outstrips of the farms is cheaper due to cheaper rent as well as because of the reduced land utilisation there;

- production efficiency in all rings is approximately the same, with reduced rent costs balanced by increased transportation costs, hence the price tends to equalise for all farms.

In 1885, Wilhelm Launhardt extends Thünen's model with an additional observation: production of perishables as well as heavy and bulky products tends to be located near the city. This is formulated in «Thünen's Model Diagram» [7].

The diagram illustrates Thünen's theory of choice under the following assumptions: production function is linear and homogenous; productivity per unit area stays constant; production factor prices are the same; transportation costs are linear based on the distance to the center.

If any of these assumptions is violated, there is an intersection of rental functions which means that it is possible to produce one type of product in multiple rings [7].

Wilhelm Launhardt presents his model as a problem of enterprise placement (the three-point problem), with a single type of product, constant manufacturing costs per unit, and a single market and a single source of raw materials [7].

The optimal placement then requires minimal transportation costs per unit of product, including expenses to transport raw materials to the production site as well as expenses to transport products to the point of sale. The exact location of the optimal placement depends on the weight coefficients for transported goods and distances. This problem can be solved using geometric approach by constructing the location triangle. On each side of the location triangle, construct a weight triangle, congruent to the location triangle. Then construct circumcircles around weight triangles. The point of intersection of the circumcircles is the point with minimum transport expenses. Each point of the triangle attract production capacities proportional to the assigned transportation weight [7].

Additionally, Launhardt has identified optimal sales area for competing manufacturers. They are expected to have fixed locations and serve evenly distributed consumers. Launhardt defines the price of product delivery as a function of fixed production cost and variable transportation costs, which are proportional to the distance to the market. Demand is proportional to the local delivery price. The number of goods sold by an individual manufacturer is proportional to the cube of the transportation expenses and inversely proportional to the square of transport tariffs.

Launhardt's model assumes labor costs to be the same at any point. Alfred Weber proposed to supplement this model by minimising the total cost of production,

depending on geographical location and including the cost of hired workers, transportation, cost of raw materials and supplies [7].

Transportation costs are affected by the weight of the cargo and the distance of transportation. Places with minimal transportation costs are more attractive and attract manufacturers. Manufacturers also have a material consumption index defined as the ratio of the weight of individual materials (limited sources of extraction) to the weight of the final product. Enterprises with a high index tend to be located closer to the point of extraction of the necessary resources. Those with a low index are usually located closed to the points of sale of the final product.

Businesses gravitate to places with low labor costs until the increase in transportation costs exceeds labor savings. Relocation of manufacturing causes uniform increase in transportation costs, regardless of where you relocate.

Weber later supplemented the model with agglomeration – concentration in one place of many industrial enterprises, which reduces the cost of building new plants. Concentration of industrial facilities at a certain point, typically a city center, closest to the markets, with cheap labor and the proximity of ancillary industries cause the effect of agglomeration. Centralisation of production increase the labor costs, prices for raw materials, rents, which in turn causes the effect of degglomeration. In the case when additional transport costs and wage costs do not exceed the reduction of costs due to agglomeration, enterprises with transport and work orientation tend to deviate from their optimal locations. Agglomeration can be described by the follow formula:

$$f(M) = A \cdot S \sqrt{\frac{M}{\pi p}}$$

where $f(M)$ is the agglomeration function which reflects the attraction of large-scale production relative to small scattered industries,

M is the mass of large production attracted to the center of the agglomeration,

A is standard weight, S is the cost of transportation per one ton of product (t/km),

p is the volume of production per unit area with radius R , in the case of uniform distribution of production in this area.

August Lösch defined the ultimate goal not as minimising costs but maximising profits. The most efficient location of the enterprise will be at the point where the profit is maximal. Lösch extended the theory of enterprise placement with such components as scientific and technological progress, international trade and the

taxation system. He moved the doctrine of the optimal placement to the macroeconomic level. According to Lösch's theory, each product of the manufacturer has its own sales radius, limited by profitability. Thus, the sales area can be represented as a cone, where the distance from the base to the point of intersection with the surface of the cone is the net profit from sales. If you go beyond the radius of the cone, the profit becomes negative and becomes a loss. In addition, at the intersection with the cone of another manufacturer there is a conflict with competitors, causing a change in the shape of the base of the cone to an irregular shape in order to balance demand and price [8].

After analysing the above information, we conclude that use of these models in modern conditions requires their modernisation and adaptation. It is also necessary to supplement the models with a factor of uncertainty in determining the optimal location of the enterprise, which will lead to the possibility of more flexible use of models in modern times.

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