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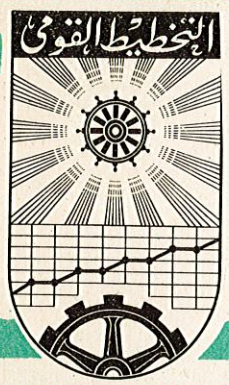

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INDUSTRIAL LOCATION PROBLEMS

by

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INDUSTRIAL LOCATION PROBLEMS

or

Economic Aspects of Regional Location of Industry

Contents

Industiral Location Problems or Economic Aspects of Regional Location of Industry

I. Introduction

The role of industry in economic development depends on:

a. natural resources
b. comparative costs
c. the size of the market.

In less developed countries, however, a further factor must be named. In those countries it is, in the long run, industrial development, which may be expected to contribute most to the creation of new and permanent jobs, both directly and through the promotion of complementary tertiary activities.

The question of regional location of industry thus becomes vitally important from the point of view of the full utilization of un = or under employed labour.

Of course, problems of manpower are playing an important role in developed countries, too. Measures of location are essentially influenced by this problem. But there are some substantial differences between less developed countries and industrially developed countries.

At all, it must be said, the locational pattern of industrial development has to be worked out according to the particular conditions of each country, including the geographical distribution of its known natural resources, manpower resources, and regarding the latter, including the diffusion of industrial knowledge and skills.

All these are points of view to be considered in connection with location problems. And it must be stressed, regarding less developed countries, the location problem of industry is not only a pure economic one but a vitally social problem. And I may say the fundamental objective of regional industrial planning is, therefore, to leave no important fraction of the country's population untouched by the process of industrial development.

Generally speaking the solution of the location problem of industry has to be aimed at:

1. economizing the social production at all,
2. diversifying the economy by considering certain economic conditions,
3. providing adequate employment opportunities for the present unemployed and underemployed and creating new employment for the future growth in the labour force.
4. improving the standard of living of the masses by increasing production.

Proceeding from that, all the location problems must be solved.

Let us go deeper into the single problems.

2. Regional location problems in general

The regional distribution of production is reflected by the location system in every country. All the countries are subdivided into so-called blocks or complexes of location, that means, economic regions. The location of the certain regional special productions are forming the economic basic structure; they are stamping the economic profile of the single regions. The regional

special productions, again, are forming the physcial and technical basis of the formation, existence and development of the single regions within the concerned economic territory as a whole. They are determining the main functions of the single regions within the whole national economy.

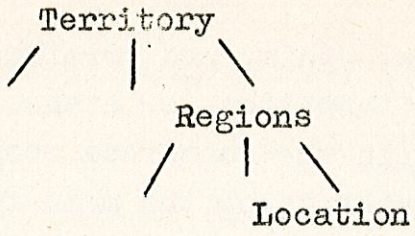
Since, the elementary ingredients of economic territories are formed by the location of enterprises, and since these economic territories, again, represent larger ingredients of the whole territorial structure, and since, further more the economic development of the single regions is determined by the concerning special production, the substantial elements of the territorial structure are mainly represented by the concerning special productions and there location respectively.

When building a rational territorial structure they have to consider these main elements.

Summarizing, there should be distinguished between three levels of location pattern:

I. the territorial structure (The territory)
2. the economic regions (The region)
3. the location of production (The location)

Or, in form of another sketch:



When developing a planned location of industry, it should be vitally important to consider:

a. optimal conditions regarding the special productions
   - at the localities,
   - within the economic regions, and
   - within the territory as a whole.

b. optimal interlacings within and between the economic regions as well.

That can be realized

- by teritorial distribution of investment,
- by corresponding territorial distribution of production programmes,
- by fixing a certain rate of growth regarding the productive enterprises producing within the economic regions on the conditions of social division of labour.

The development of the territorial structure of a country depends on the development of the productive forces, on the character of relations of production, on the historical development, on natural conditions, and on the density and structure of population.

Under non-planned conditions this structure is formed spontaneously, so that it is marked by significant disproportions. Especially under capitalistic conditions the economic and territorial structure is formed only from the point of view of

profit. One of the main features of location policy, represented by an equal growth of the standard of living of all people, is neglected.

Look, for instance, at the GDR's example. Resulting from the capitalist way of industrial or economic development we have to distinguish between:

a. the southern region.
b. the northern region.

The southern region is highly developed.

Although this district only comprises 40% of our whole territory,

- 66% of the population,
- more than 66% of the productive population
- more than 75% of all industrial workers,
- about 50% of all agricultural workers,
- nearly 75% of our basic industry,
- nearly 75% of our metal working industry,

is situated in this region. Nearly 75% of our gross national product is produced here. Thus, one can say, the southern region is a developed one. Against this the northern region must be called a less developed district. Consequently it must be one of the most important tasks of our planning authorities to develop even this region.

This is particularly so, since the existing and so called congested areas of the southern part must be investigated or explored from the point of view, if their economic effectiveness can be risen by a further development without national economic disadvantages formed by excessively high expenditures, and formed as

well by unwholesome effects regarding the population concentrated in these areas.

For solving the problem of location of industry the following must be done:

1. An analysis must be elaborated concerning the present location of industry.
2. The technico-economic location demands of the single branches and spheres of industry must be ascertained.
3. The location possibilities of the economic regions must be stated.

The analysis, mentioned above, must be aimed at ascertaining the possibilities of development of the single enterprises at their present location. That is essential for distributing prospectively the means of investment.

In brief, this mentioned analysis has to contain (regarding the single enterprises!)

1. An estimation of the technical and technological level of the enterprise.
2. Ascertainment of locality-conditions of the enterprise, so for instance:

   - possibilities for expanding;
   - present and additionally possible technical provision of the enterprise (total as well as by self-providing);
   - number of hands available and additionally possible manpower resources;
   - present and additional demands on transportation;
   - estimation of the possibilities for expanding the relations of cooperation of the enterprise within the region concerned;

For the single enterprise and the development of this enterprise does not only depend on natural conditions but also on the development of related enterprises, the ascertainment of development possibilities has to take place by close collaboration between the leading anthorities of the single industrial branches and the local organs and must be based on centrally given directives.

This analysis concerning the single enterprise is expected to be the foundation for specified technico-economic demands made on the certain economic regions by the single industrial branches. By elaborating such an analysis by all the branches, at last the central planning authorities are getting a reliable survey regarding the technico-economic demands made by the economic branches on the economic regions.

Thus, the planning authorities are not only able to estimate the demands resulting from possible or planned expansions of existing enterprises, but also they are able to decide which branches or enterprises have to be errected within the economic region in question in order to make the social reproduction process go smoother, i.e., in order to optimize the social reproduction process within the economic region and as a whole as well.

The following points of view have to be taken into consideration when determining the direction of economic development in economic regions:

1. Every region has to be developed rationally specialized and complex as well.

2. Within one region not enterprises of all economic branches and spheres can be developed, but only

those, finding favourable conditions in view of natural and economic possibilities.

3. For avoiding one-sided regional structures in all the larger economic regions enterprises of the two national economic main sectors should be errected. Of course, it cannot be possible to ensure within the region in question the national economic main proportions between sector I and II in full measure.

4. The enterprises of one region must be connected by close cooperation with the region in question. Enterprises insufficiently connected must be transferred into other regions.

5. In connection with it (with point 4!) the so-called warehouse programmes are to be removed; i.e., within the single regions a concentration of certain kinds of production has to take place in accordance with natural and economic conditions predominating in that region.

6. For all the economic regions long-term prospectives should be elaborated fixing the rational degree of congestion within the region in question.

7. Peculiar attention must be paid to one-sidedly and less developed regions for developing them comprehensively or more rapid than the others.

Since spheres and regions of national economy are forming a dialectic unit, planning and management of national economy has to coordinate the development of the spheres and the development of the regions for developing national economy as quikly as possible.

For the sake of coordinating spheres and branches with economic regions the following scheme can be established:

1. territorial coordination
   1.1. international coordination; for instance (regarding socialist countries!), all socialist countries are coordinating the development of their national economies as well as the development of ~~their national economies as well as the development of~~ single spheres and branches in accordance with the natural, historic, and economic conditions given in the single countries. By this way, both a more rapid development of the single countries and of the whole socialist system and a higher effectiveness of the single national economies can be guaranteed.

   1.2. national coordination;
   i.e., coordination of the single economic regions within the territory of one national economy.

2. regional coordination
   i.e., coordination of the single spheres and branches within a certain economic region of national economy and coordination of the single subregions to each other .

For coordinating spheres and regions most efficiently the connections and correlations between these two categories must be known.

Let us deal with, therefore, some special problems regarding connections and correlations ~~and correlations~~ between industrial branches and economic regions.

2.1. Technico-economic demands of industrial branches on economic regions.

In order to make the reproduction process go smoother the continuous delivery of elements of production process is urgently necessary; that means, as known and above all, workers, raw materials, energy, water, transportations, etc. Simultaneously, the produced goods must be sold. For economizing the whole reproduction process these demands regarding sale and purchase must be realized be means of the lowest - possible expenditure of transportation; that means, they have, as far as possible, to be realized within the own or the surrounding regions.

These specific demands of enterprises on the regions concerned or on certain locations are coming into existence in connection with establishing new enterprises as well as in connection with the expansion of now adays already existing enterprises. They are resulting from the technico-economic requirements of the branches and they are, therefore, an expression of the economic conditions and requirements of the branch in question. In turn, the specific demands of economic regions on enterprises are an expression of the economic conditions and requirements of the economic regions concerned.

What are the crucial points to be considered?

1. Different degrees of concentration are conditioned by technico-economic pecularities of the single branches and spheres.

That means, for instance, within the heavy industry (or basic industry at all) only strong concentrated enterprises can be rational from the economic point of view as well as from the economical one. Accordingly, the regions of purchase and sale must differently be extended.

2. Different demands are made by the several branches regarding mineral wealth.

The extractive industry (mining etc), for instance, makes other demands on economic regions (mineral wealth etc) than the working industry, not so closely bound to raw-material sources.

3. Differences are existing, too, between material intensive and labour intensive branches.

Enterprises marked by material intensive production require regions either signed by large supply of materials or by very good conditions of transportation. Labour intensive enterprises, in turn, make pecular demands on the regions regarding highly qualified hands or workers.

4. The branches differ from each other on the strength of their technico-economic pecularities regarding energy, water, etc. Often even the quality of water is playing an important role. So, for instance, chemical industry, textile industry, and power producing enterprises depend on a high quality of water.

On the other hand, also the economic regions are making demands on industrial branches.

That will be our next problem.

2.2. Demands of economic regions on industrial branches

These demands are resulting from natural conditions within given regions.

Out of certain and favourable natural conditions for production the possibility is resulting for a further specialization of the region; for instance, on behalf of the extractive industry - as:

- minning,
- agriculture,
- forestry,
- wooden industry,
- paper industry,
- glass - and ceramics industry,
- energy or power industry,

On the other hand, by favourable natural conditions of a smaller scale the possibility for strengthening the aggregate development of certain regions is given.

That means, if there are no special conditions for one or the other branch, the region would be predestinated to be developed comprehensively. A favourable economic situation, for instance, regarding transportation, provided, of course. Generally speaking, one can say:

On the strength of certain favourable natural conditions existing within a certain region, this region should be predestinated for localizing the corresponding industry. Thus, the natural conditions can be utilized maximally and the regional economic effectiveness can be an increasing one.

If there are no special conditions, the region should be developed comprehensively. Provided, of course, that its general conditions are favourable enough for solving all the problems resulting from such a comprehensive development.

I am thinking, for instance, of the capital of the single countries or the territory in question and of the capital of the economic regions. There, usually, the best conditions are given for developing industry comperhensively.
Why that?

1. The capital, ussally, represents the greatest town of the country. With this fact a lot of other conditions are given. So for instance :
   a. by the great number of inhabitants there are ensured :
      - a great number of shilled or shillable workers,
      - by the great number of inhabitants a certain local sale will be ensured ;
   b. The capital, usually, is fully disclosed regarding traffic and transportation; this fact, again, makes possible :
      - convenient deliveries of raw materials
      - convenient forwarding of finished products to all the other parts of the country.
2. By the capital , usually, the cultural center of the country is represented. Thus, the scientific centers as well as the economic research centers are situated here; a question most important for industry regarding technical progress which only can be realized by close collaboration between science and practice.

In brief, we can say :

The interlacing of enterprises within economic regions is marked by the following facts, which must be concidered and investigated unconditionally, when projecting and realizing location policy :

convenient conditions and interlacings must be given regarding purchase and sale for :

1. deliveries of raw materials, auxiliary materials etc.
2. construction materials
3. water resources and conditions of water supply
4. situation in the fields of power
5. transportation
6. manpower supply

Within less or underdeveloped countries the latter point is not only a passive one, but even one of the most active ones. Usually, underdeveloped countries suffer from loss of employment. Usually, there is a considerable number of un-or under-employed workers. Thus, the question of regional location of industry becomes vitally important from the point of veiw of the full utilization of under employed labour. Thence, for social reasons, heavy public investment must in any case be undertaken particularly in those regions where there is much underemployed labour.[1)]

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1) c.f. International Labour Office
Employment Objectives in Economic
Development, Geneva, 1961, P. 8,9,49,108,109;110.

Many of the regions with a heavy concentration of underemployed agricultural labour, for instance, may not be defficient in mineral resources and most of them do produce agricultural products which can be further processed. Thus, local resources may provide a basis for industrial activity within those regions to raise the level of employment and income for the local population.[1)]

But the following have to be considered regarding location policy in underemployed regions.

Regions in which industry is expected to make a major contribution to employment-creation will need, at least, some units of manufacturing industry with a nation-wide market and with prospects of higher than average rates of growth. These industrial units will tend to be of a largescale character and will usually need, regarding underdeveloped countries, an initial provision of public incentives and initiative.

In any case, the government is in a favourable position for influencing many important aspects :

1. the public sector could be strengthened,
2. the government can prevent uneconomic duplication of regional enterprises,
3. it can promote a larger recruitment of local labour and encourage a policy of putting-out or subcontracting with local small - scale industries.

The general criterion, however, will be to try to reconcile the objective of creating one or more industrial centres within the most important economic regions.

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1) ibid

In these conditions each region should then be able to develop with less difficulty a substructure of small - scale industry, which might be secondary producers of the leading and public enterprises.[1)]

The development of such local small - scale idustry could be integrated into the national industrial development program, still leaving a major portion of available capital for investment projects aimed at long-term economic growth.

All these are - or should be - viewpoints to be considered when drawfting development programmes with due regard to location problems.

Now we will try to explain these problems by dealing with an example.

What has to be done, when projecting a new plant? At first, the capacity, to be estabiliched, must be explored. What is the contents of this complex of investigation?

The complex is expected to give an answer upon the position of the planned plant within the national economic and aggregate development of that kind of capacity.

For this reason the long-term statements regarding the national economic and necessary capacity are to be proved under the points of view of the circumstances concretely existing at the time the project is being prepared.

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1) c. f. International Labour Office, p.a.s.

This mentioned task of planners must be solved proceeding from the following basic questions:

1. which production volume will be necessary for the products in question?
2. are there other productive capacities possible to be utilized for the production concerned?
3. in what size have new capacities to be errected?

After fixing the necessary volume of production the existing capacities must be analysed. That can happen by analysing the following aggregate indicators:

a) capacity possible to be reached within the coming years
b) possible utilization of the capacity within the current or the coming plan year.
c) the real utilization of capacity at present.

Therefore, the following indicators should be used:

a) the so-called <u>shift-cofficient</u>
formulas for calculating:

1) $$\frac{\text{machines (1. shift)} + \text{machnies (2. shift)} + \text{machines (3. shift)}}{\text{Number of used machines}} = X_1$$

2) $$\frac{\text{Productive workers}}{\text{working places for prod. workers}} = X_2$$

3) $$\frac{\text{average number of productive workers in the seperate shifts}}{\text{average of productive workers at all}} \times 100 = X_3$$

b. the so-called profile of capacity; that means, utilization of the most essential machine groups or equipments.

Formulas for calculating:

1) $\frac{\text{actual working hours (h) of a certain groups of machines}}{\text{possible working hours (h) of this group}} = X_1$

2) $\frac{\text{used energy (KWH, Kcal h) of a certain group of machines}}{\text{energy installed in this group of machines}} = X_2$

By doing so, we will get a reliable survey upon available capacities. But that will not yet be enough. Furthermore, we have to estimate:

a) What are the effects of physical and moral wear and tear of the available equipments regarding the quality of products? Will the available machines be able to produce qualities demanded on the long run?

b) What about the present utilization of capacity and its effect on prime cost, labour productivity, and accumulation?

c) Are there possibilities for an increasing and possible use by specialization, standardization, concentration, and cooperation?

The results of this investigations and analysis we have to compare with the national economic capacity, necessary to meet the demands calculated earlier by means of another analysis.

Our next task would be to decide whether the necessary extension of capacity shall be achieved by establishing a new enterprise or by reconstructing enterprises already existing.

In respect of less developed countries this question will not play an important role. Therefore, we are allowed to neglect it. Let us assume, however, that we are forced by the very facts, to establish a new plant. Thus, we have to decide the question of location.

In our example there shall be determined the "local locality" as well as the "overlocal locality". Overlocal locality, that means, a more or less limited region, as, for instance, a town, a county, a district, or a geographically bordered region.

The investigations shall be resulting in a location ensuring the development of the region in question,
- guaranting the special demands of the projected plant on the natural conditions,
- minimizing the costs conditioned locally and concerning the costs for the implementation of the project as well as the costs resulting from the transport of raw materials and finished products.

The point of view to be investigated are different ones and depend on the kind of production.

The location of power plants, for instance, depends on the local fuel deposits or on the centers of main consumption, water plant on the water deposits, etc. Regarding engineering plants not the distance between plant, supplier of material and purchaser will be decisive, but the conditions of manpower and

traffic. Concerning trading plants the location is determined by the district to be provided. In particular, the following questions must be clarified:

a) <u>What conditions must be given at the location?</u>
Above all, there are to be investigated:

1. the guaranty of minimal distances of transport, including minimal costs of transport;
2. regrading extractive industry, especially the demands on the deposits of raw materials;
3. the problem of manpower;
4. the possibility to provide the projected plants with electric energy, with gas, water steam, and to ensure the removal of used water (waste - water);
5. the possibility to connect the projected plant with the local communication system by using the lowest possible expeditures;
6. the requirements of the projected plant regarding the other mediately and immediately following establishments (as there are; dwellings, public, cultural, social - and medical establishments).
7. the possibility to utilize following establishments already exsiting;
8. the requirements regarding the bulding ground;
9. finally, the technico - physical requirements must be investigated.

That is the first circle of problems which must be investigated before fixing the location.

The second circle contains the question:

b) which are the effects of the projected plant concerning the surroundings and the other economic branches?

In this direction there are to be investigated the following questions in detail:

1. the possibilities for developing the region concerned;
2. sundry interests regarding national trust of nature and historic monuments;
3. the possible factors of disturbance resulting from the plant and their effects towards the surroundings, as, for instance, atmospheric pollution, water - contamination; molestations by noise and odour.

After investigating all these question the planner or the planning authority will be able to answer the question:

Which demands must be made on the location concerned?

Now, the next step can be done.

a) the "over-local location" and its determination

In this direction the following tasks must be solved:

1. the single programmes of developing separate regions must be evaluated;
2. proceeding from the theoretical investigation, explained above, the factors determinign the location must be stated.
3. proceeding from these factors and considering the development programmes of the single economic regions,

those regions must be fixed, able to serve as location for our projected plant.

If there are several possibilities, an economic comparison will be necessary containing such indicators as:

- investment costs for establishing the plant
- probable prime cost of one unit of products to be produced in future.

Therefore, the following locally-conditioned facts influencing these costs have to be analysed:

3.1. the distance between the location in question and the concerning deposits of raw-materials or between the location and the supplying plants;

3.2. the distance between the location and the centers of consumption;

3.3. the distance between the location and the dwelling-places of the workers;

3.4. the necessary property development costs including the necessary social establishments.

b) <u>The determination of the virtual location</u>

After finding the economic region (the so-called over-local location) the narrowly - limitted location must be fixed.

For doing so, the following working steps will be necessary:

1. the regional development plans of the over - local location in question must be evaluated with due regard to the building plans as well as to the geological conditions given within this special region;

2. The possible building grounds must be found out. If there are two as more possibilities the most favourable must be taken. For finding the most favourable, the following questions must be cleared:

2.1. the special property development costs in respect of the certain building ground;
2.2. the adjustment of the plant with the surroundings;
2.3. the local traffic - conditions and the distance between the building ground and the communication system;
2.4. the conditions regarding drinking = and otherwise used water;
2.5. the property relationships regarding the building ground;

All these single things must be done before being able to determine the actual or virtual and narrowly - limited location.

3. Practical examples

And now let us translate these theoretical statements into a practical example.

(1) Example

The location of a coal power station shall be determined.

In this case the following 4 factors are of a determining influence:

1. the transport of fuel as well as the transport of ashes.

This viewpoint has to be considered under the following special points of view:

a) the guarantee of the most economical use of the different kinds of fuel.
That means, the lower heating value as well as the burning-properties of the different kinds of fuel are determining the location.
Therefore, a special indicator "heat-price" has been introduced showing the price of one unit of fuel plus cost of transport for producing one kcal of heat. For instance, lignite or brown - coal is marked by a very low heating - value (1.700 to 2.300 kcal kg) and by a high percentage of ashes and water. For these reasons the economic way of transport is limitted by 50 to 75 km;

2. the transmission of energy produced by the power station.
That means, when establishing a power-sation and choosing the location in question not only the cost of production of the power plant itself, but also the consignment cost must be calculated (cost of forwarding).

3. the supply with cooling - water
This point is very important regarding the choice of location of a power-station, since great quantities of water are needed. For instance, 100.000 m^3 are needed daily by a 400 MW - power-station. If water is not available this size, the fresh - water - cooling must be replaced by the so-called return-movement - cooling.
But when using the return - movement - cooling the heat consumption will be higher about 2%. It is true, the additionally needed water for cooling can be reduced in that case to 30.000 m^3 per day. But, anyhow, fresh-water-cooling should be preferred, when choosing the location of a coal-power-station.

4. The fourth viewpoint is formed by a group of factors: that is:

a) the conditions of transportation between power-station, on the one hand, and the railway-station or the port, on the other. It should be avoided, to hinder the traffic around the power-station. Especially, the utilization of much needed ways of traffic must be avoided;

b) disturbing influences concerning the surroundings have to be avoided. In case of a coal - power-station the main factors of disturbances are formed by atmospheric pollutions, cased by flying ashes and smokes (especially SO_2 - sulphuric - di - oxide). For this reason, coal-power-stations should be situated at wind-shadow-sides of towns. Valleys should be avoided, for they are hampering the distribution of flying ashes and of smokes;

c) the need of manpower and the position of dwelling regions of the workers including other following cultural and social establishements. This is a very important factor, since in case of great distances between power - station and dwelling - region, either new dwelling complexes must be established in the neighbourhood of the station or new and extensive local traffic communications must be shaped. Both the measures would highly be influencing the costs of following investments.

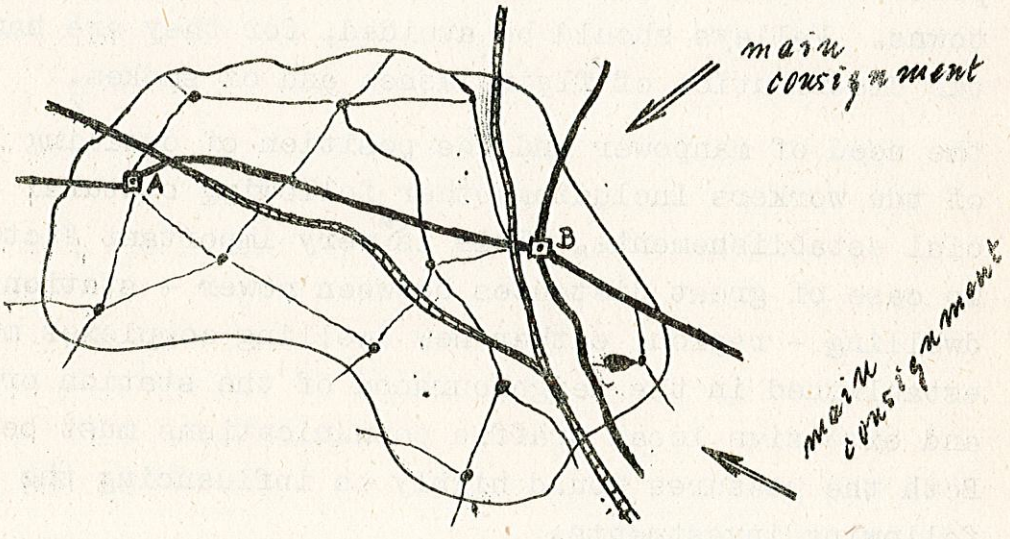
2. Another example

The location of a warehouse shall be chosen. The thoughts must be as follows:

1. The supply area is represented by the county A, comprising the two larger towns x and y and some villages. Proceeding from that point of view that the warehouse should be erected at the locality marked by the highest density of population, only one of the two towns could be chosen.

2. The warehouse will obtain its supplies from the yield of of the county, the district, and from the districts situated in the south-east of the district as well as from imports.

   The main consignments will be coming from the north-east and the south-east on rail way. The town B is situated in the eastern part of the country and, accordingly, this town will be predestinated.



3. At present eleven different stores are used; there are, 8 in A, 2 in B, and one store anywhere in the county. Now, and new and central warehouse shall be erected, without considering the existing stores, since all of them are unsuitable for food - turnover.

4. Regarding manpower there are no substantial differences between the two towns.

5. Possibilities regarding communications are somewhat different. In B a building ground will be available close to the railway. In A, however, a developed location could be presented; also it would be possible to establish a siding within the town. The proposed location has been situated in a future, at present undeveloped, industrial district of the town. When establishing the warehouse in this district it would be necessary to install a siding of a length of 3 km and with two bridges.

By comparing the indicators of the two possible locations we can see the following: (for instance!).

	A	B
the length of the siding	3.000 m	800 m
property development costs	1.000 TDL	—
expenditures for establishing the siding	900 TDM	240 TDM
expenditures for building bridges	60 TDM	—
total expenditures	1.960 TDM	240 TDM

Because of the essentially lower costs regarding both property development and siding, the best conditions would be given in B.

But we have to consider the following facts:

in A 30% of the inhabitants of the county are concentrated; in B, on the contrary, only 18%.

By this fact and in case of choosing B as location higher costs of consignment would be conditioned. The difference may be, for instance, 100 TDM.

Which must be the conclusion?

In B obviously a row of advantages are given for establishing the warehouse in that town.

Lower prime cost, howevern are accompanied with relatively higher investment cost regarding property development and communication.

The real effectiveness can be calculated by a formula:

$$E = \frac{C_1 - C_2}{I_2 - I_1} = \frac{\Delta C}{I_2 - I_1} = \frac{100}{1.960-240} : \frac{100}{1720} = 0.058$$

The general effectiveness E_0 has been calculated with Eo ≙ 0,15. Accordingly, B is likely to be location of our planned warehouse.

In our formula there stands:

C_1 = consignment cost of town B

C_2 = consignment cost of town A

I_1 = additional investment cost of B

I_2 = additional investment cost of A

E ≙ economic effectiveness

The more E is going towards 0, the higher will be the effectiveness.

3. <u>And now, a last example:</u>

The planning authorities of the UAR have made up their minds to establish a cotton weaving plant. Two spinning plants are existing.

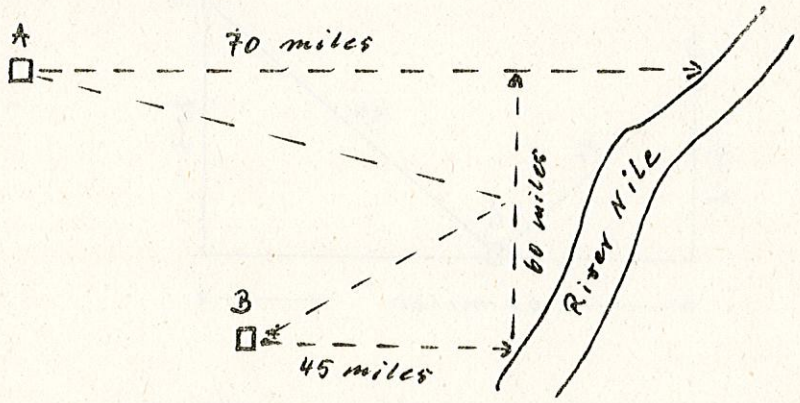
Now it shall be decided

- either to establish a central weaving plant, able for working the materials of both the spinning plants
- or to enlarge the existing enterprises in such a way that both of them are enabled to work up their immediate goods.

After making an analysis, like our examples, mentioned above, after calculating the cost of investment, and by considering the costs coming into existence in connection with the delivery of raw materials, the planning authorities have made up their mind to establish a new weaving plant centrally situated.

Now, the location of the weaving plant must be found,

The conditions are as follows:

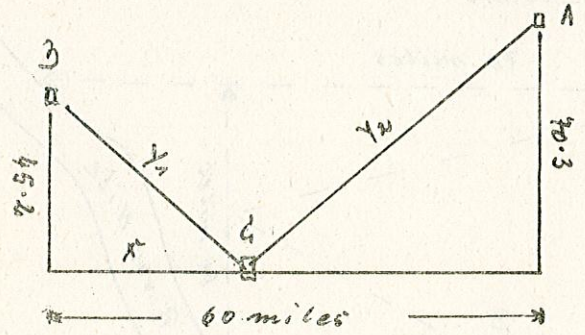


1. The two enterprises are situated near the River Nile. Enterprise A about 70 miles and enterprise B about 45 miles.
2. The thought vertical distance between the two enterprises amounts to 60 miles.
3. The volume of production of the two enterprises is equal to 2 (B) : 3 (A). Conditioned by some factors, this relation will not be changing within the next time.

4. The River Nile would be a good condition for transporting or shipping the soft goods to the ports of the UAR, for a considerable part of the produced goods will be exported, and to Cairo, for Cairo will be the main domestic receiver.

5. Up-to now no one of the enterprises is connected with the River Nile, neither by road, nor by a canal. Thus, in each case a way of traffic must be built.

6. Now, it will be the task of our location planners to determine the location of our weaving plant, considering lowest possible costs regarding the necessary road as well as the highest effectiveness of the road, for the share of the two enterprises in the aggregate volume of production is and will be a different one. As mentioned above, the share is like 2 : 3. The way of calculation should be as follows:



We are able to fix the following equations:

$$y = y_1 + y_2$$

$$y_1^2 = (45.2)^2 + x^2 \; ; \quad y_2^2 = (70.3)^2 + (60-x)^2$$

$$y = \sqrt{90^2 + x^2} + \sqrt{210^2 + (60-x)^2}$$

$$= \sqrt{8100 + x^2} + \sqrt{44.100 + 3600 - 120x + x^2}$$

$$= \sqrt{8.100 + x^2} + \sqrt{47.700 - 120x + x^2}$$

The equation of differentation will be:

$$\frac{dy}{dy} = y' = 2x \cdot \frac{1}{2} (8.100 + x^2)^{-\frac{1}{2}} + (2x - 120) \frac{1}{2} (47.700 - 120x + 2)^{-\frac{1}{2}}$$

$$= \frac{x}{\sqrt{8.100 + x^2}} + \frac{x - 60}{\sqrt{47.700 + 120 + x^2}}$$

The first derivation has to be set equal 0:

$$\frac{dy}{dx} = 0$$

$$0 = x\sqrt{47.700 - 120x + x^2} + (x-60)\sqrt{8.100 + x^2}$$

$$= \sqrt{47.700x^2 - 120x^3 + x^4} + \sqrt{(x-60)^2 (8.100 + x^2)}$$

$$= \sqrt{47.700x^2 - 120x^3 + x^4} + \sqrt{(x^2 - 120x + 3.600)(8.100 + x^2)}$$

$$= \sqrt{47.700x^2 - 120x^3 + x^4} + \sqrt{8.100x^2 + x^4 - 972.000x + 29.160.000 + 3.600x^2 - 120x^3}$$

$$= \sqrt{47.700x^2 - 120x^3 + x^4} + \sqrt{11.700x^2 + x^4 - 120x^3 - 972.000x + 29.160.000}$$

$$-\sqrt{47.700^2 - 120x^3 + x^4} = \sqrt{11.700x^2 + x^4 - 120x^3 - 972.000x + 29.160.00}$$

$$x^4 - 120x^3 + 47.700x^2 = x^4 - 120x^3 + 11.700x^2 - 972.000x + 29.160.000$$

$$0 \qquad 36.000x^2 + 972.000x - 29.160.000$$

$$x^2 + 27x - 810$$

$$x_{1/2} = -\frac{27}{2} \pm \sqrt{\frac{729}{4} + \frac{3.240}{4}}$$

$$= \frac{27}{2} \pm \sqrt{\frac{3.969}{4}}$$

$$= \frac{27}{2} \pm \frac{63}{2}$$

$$x_1 = 18$$

$$x_2 = \text{(useless)}$$

That means, the weaving factory must be established in a distance of 18 km from a thought point vertically located from B.