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INDUSTRIAL LOCATION AND REGIONAL DEVELOPMENT

Proceedings of Interregional Seminar
Minsk, 14-26 August 1968

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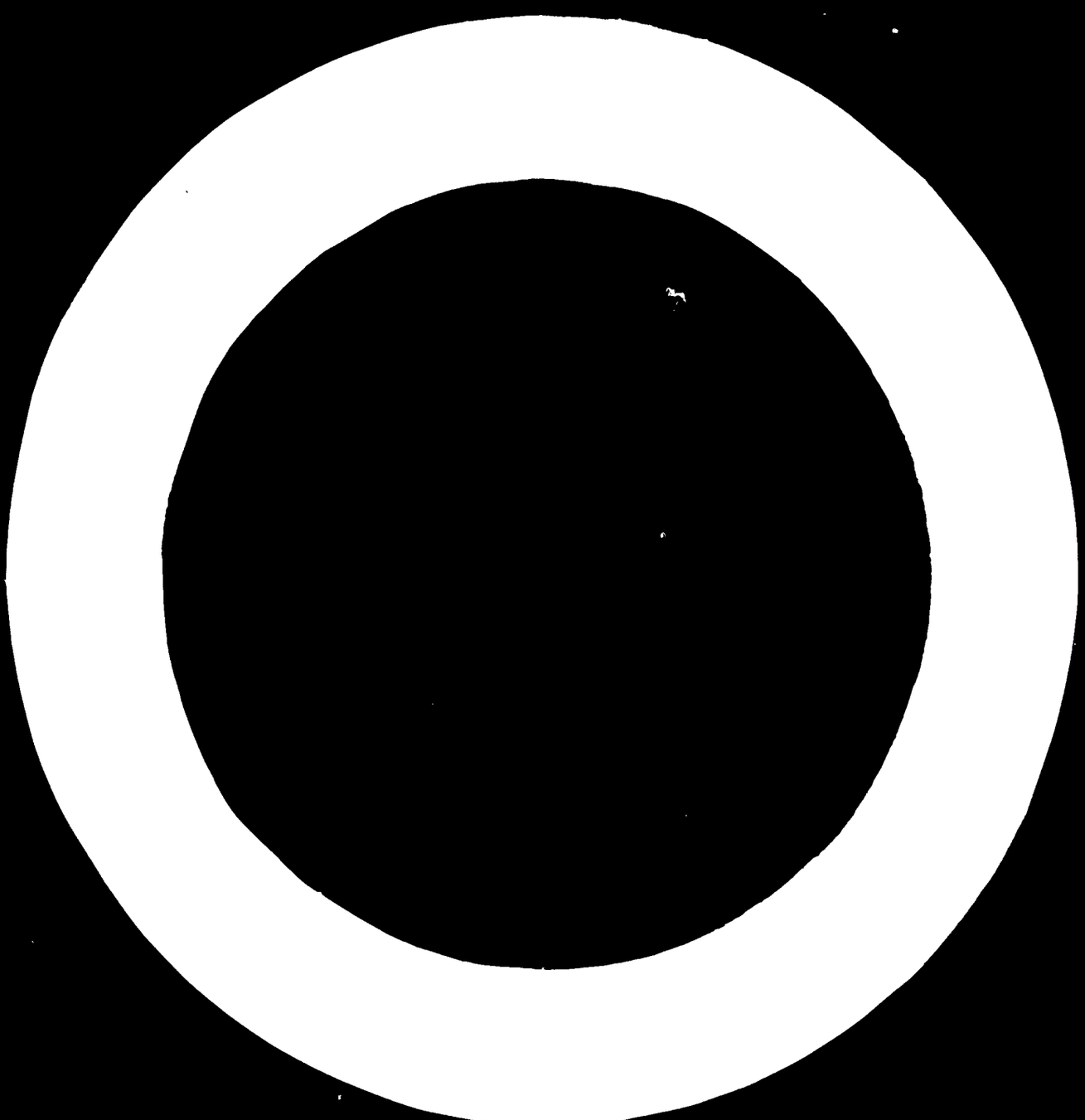

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INDUSTRIAL LOCATION AND REGIONAL DEVELOPMENT

Proceedings of Interregional Seminar

Minsk, 14—26 August 1968

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Preface

The Interregional Seminar on Industrial Location and Regional Development was organized by the United Nations Industrial Development Organization (UNIDO) and held in Minsk (Byelorussian SSR) from 14 to 26 August 1968.[1] Most of the papers presented at the seminar have been published in Volume I of the proceedings.[2]

The present volume of proceedings presents selected highlights of the papers devoted exclusively to regional development and industrial location in the Union of Soviet Socialist Republics. The USSR is divided into the large economic regions shown on the map on page viii. The economy of each region displays unique historical, geographical and national features that affect development planning and industrial location.

At the same time, and despite the peculiarities which are characteristic for each particular region or republic of the USSR, it is imperative that the following principles be observed in the course of plan preparation for each region:

Deepening of public division of labour among the republics and economic regions of the country on the basis of equality;

Comprehensive development of the economy of regions, in combination with their specialization in those branches for the development of which there are the most favourable natural and economic conditions;

Levelling of the economic development among different republics and economic regions of the country;

Use of the possibilities of the international division of labour among centrally planned economies.

Regional development is discussed with particular regard to technological progress, natural resources and urbanization. The experiences of industrial location and planning in Armenia, Georgian SSR, Uzbekistan and Byelorussian SSR are reviewed to provide further documentation[3] for the use of planners and policy makers in developing countries.

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[1] See *Report of the Interregional Seminar on Industrial Location and Regional Development* (United Nations publication, Sales No.: 69.II.B.22).

[2] See *Proceedings of the Interregional Seminar on Industrial Location and Regional Development* (United Nations publication, Sales No.: E.71.II.B.18).

[3] See *Industrial Location and Regional Development—An Annotated Bibliography* (United Nations publication, Sales No.: 70.II.B.15).

Explanatory Notes

Reference to tons indicates metric tons unless otherwise stated.

Dates divided by a hyphen (e.g. 1955–1960) indicate the full period involved, including the beginning and end years.

The following abbreviations are used in this publication:

AC	alternating current
DC	direct current
km	kilometre
kV	kilovolt
kWh	kilowatthour
MW	megawatt
m	metre

CONTENTS

ECONOMIC REGIONS OF THE USSR

IIIA

Part I

REGIONAL DEVELOPMENT

I. TECHNOLOGICAL INNOVATIONS AND THE LOCATION OF EXTRACTIVE AND PROCESSING INDUSTRIES

by M. A. Vilensky[1]

Technological innovations are unique among the factors that influence industrial location. Their effects are indirect and operate to increase or diminish the role of other factors such as raw materials, markets, labour and transport. The sum of the effect on each factor influences the cost per unit of output.

Technological innovations are evident in all industries and production processes although the introduction of new techniques varies in different sectors of the economy. An improved technology in a production process may permit an industry to be located in another region. However, if the total labour costs per unit of output are higher there, the change in location will not be reasonable.

The introduction of new techniques at a plant will reduce labour costs per unit of output as well as the expenditures for raw materials, fuel and amortization. A comparison of these savings with the necessary investments for new equipment will give an estimate of the economic efficiency of the new techniques.

However, the influence of technological innovations on the location of industry is greater than their influence on the economics of an individual process at one plant. The input costs of the production process are determined by activities in other sectors of the economy that are independent from an individual plant.

The following expenditures must be taken into account in planning industrial relocation:

(a) Production costs at the plant;

(b) Costs of extracting and processing raw materials, fuel and power for the plant as well as the costs of geological surveys;

(c) Delivery costs of all input necessary for production and transport costs of the output to the consumer;

(d) Expenses of regional development (creation of a housing complex, transport facilities and other infrastructure).

Improvements in geological prospecting and surveying have made possible the discovery of mineral reserves (coal, ferrous and non-ferrous ores etc.) in many regions of the Union of Soviet Socialist Republics. Mining of these newly discovered deposits may entail larger labour costs per unit of output than the costs of expanding operations at the older mines. Some of the difficulties in exploiting the new reserves are caused by low-grade ores, unfavourable geological and mining conditions or remote location from transport facilities.

Improvements in engineering and mining technology have made possible the mining of low-grade ores and inaccessible deposits. The geographical locations of the extractive industries have thus been increased. However, the development of mining at these deposits will generally require larger total labour costs per unit of output than the total costs of mining under more favourable conditions. The transition to the exploitation of the less favourable deposits will not be the result of innovations in mining techniques but will be a consequence of the exhaustion of the more favourable deposits or the increased national demand for a mineral that cannot be satisfied entirely by the output from the older deposits.

Mining at the more favourable deposits likewise benefits from improved techniques. If the resources in these deposits are sufficient to satisfy the national demand for a mineral, the unfavourable deposits will not be mined despite the availability of highly effective techniques for the purpose. Moreover, improvements in engineering provide the basis for economical, long-distance transport.[2] In this case, technological innovations increase the dependence of the extractive industries on particular mineral deposits.

The dependence on particular mineral deposits is a similar phenomenon in the processing industry for primary resources. Engineering improvements in the generation of electric power have made possible the erection of large power stations with 300–800 MW units and the long-distance transmission of 400–500 kV AC and 800–1,200 kV DC. The resulting lower costs of generation and transmission of electric power bind

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[2] The distances will be determined by the savings derived from the exploitation of the older deposits.

the location of the power stations to particular coal deposits that have large, useful reserves and the possibilities for low-cost mining.

The location of other processing industries is not as closely related to local natural resources as the location of the extractive industries. Their locations are more dependent upon economic factors such as the availability of labour and the demand for the industry's product.

Comprehensive mechanization and automation of production processes reduce the necessary labour per unit of output. Therefore plants may be situated in regions with small labour resources even though the total labour costs per unit of output are not necessarily lowered. The unit net cost will be lower since the proportion of wages in the production costs will decrease. The efficiency of new techniques and of opening plants at new sites cannot be measured only by the reduction in net cost. It is equally important to take into account the costly capital investments for mechanization and automation. These investments should be repaid in economically acceptable terms by the savings in the operation costs of production. Until the investments are amortized, they are a burden on the national economy and therefore should be carefully considered prior to locating industries in regions with small labour resources.

Mass production, as the result of technological improvements, increases the dependence of plant location on the fuel and raw material resources that are necessary for the operation of large plants with high fuel and raw material consumption rates in some branches of the processing industry. In other branches it increases the dependence of plant location on the availability of large labour resources and of transport facilities for products that present special problems. The optimum concentration, from the technical point of view, always reduces the labour costs per unit of output, partly as the result of savings due to mass production and partly as the result of other favourable factors such as raw materials, fuel or labour. However, it is possible that labour costs are not reduced through mass production since the favourable factors are present in varying degrees at different locations in the country. The best location is indicated by a comparison of the economy in costs from the technical and economic advantages of large-scale production with the additional costs of production that result from unfavourable factors.

THE EXTRACTIVE INDUSTRIES

The extractive industries have benefited from innovations in geological prospecting and surveying. The number of regions with surveyed deposits of commercial value has increased. There are coal reserves in 12 of the 19 large economic regions of the USSR; 7 of the regions have rich coke deposits. Petroleum reserves have been surveyed in 11 regions; they are exploited in 9 regions. Natural gas deposits have been surveyed in 11 regions; they are exhibited in 9 regions. Natural gas deposits have been surveyed in 10 regions and ferrous ore deposits in 12 regions. The surveyed reserves of non-ferrous and rare-earth metals in various regions of the country have increased as well as those of non-metallic, mineral resources.

Thus there are additional potential locations for the extractive industries. In planning the location of industries at these new deposits, the costs for geological prospecting that fluctuate from region to region must be considered. From 1959 to 1965, the costs of geological prospecting and surveying for petroleum and natural gas was 6.0 billion roubles, which was 45 per cent of the total investments for the exploitation of these resources. In some regions, the cost per ton of prospecting for petroleum is 10 to 50 times larger than the average national cost. Technological innovations cannot overcome the regional diversities in prospecting costs per unit of output.

Specialized machinery and mining techniques have been developed for specific mining and geological conditions. An example is equipment for underground mining of coal from seams of varying thickness. The mining technology for coal, and ferrous and non-ferrous ores has been enhanced by the widespread adoption of open-cut and hydraulic underground mining.

The use of turbodrills and electric drills with superhard alloy bits enables operational drilling of deep wells in any kind of rock and extraction of petroleum from Devonian deposits. High-pressure and hydraulic drilling increase the petroleum yield. Small reserves of petroleum and low-pressure reserves may likewise be exploited by using these techniques.

Although these innovations permit some freedom in the choice of industrial locations, economical mining is dependent not only upon the level of technology but upon the following regional factors as well: the size of the reserves, the quality of the ore, and the mining and geological conditions. In some instances technological improvements equalize mining prospects in different regions, while in others they increase the differences between regions. The regional factors cannot be affected by the equalizing tendency of improved technology.

The tendency to equalize the basis for coal mining in different regions was manifest during the initial mechanization of the industry prior to the Second World War, in which hand tools (picks and hacks) were replaced by simple power tools (air hammers and coal cutters). The adoption of simple machines and new mining techniques was necessary for rentable coal mining.

However the decisive conditions for rentable mining were dictated by the regional factors that prevented the most economic use of the machines and new tech-

niques at some mines. Consider labour productivity as one example. If the level of labour productivity in the Donets coal basin is assigned the index 1, the 1940 data from eight coal-mining regions showed variations of labour productivity from 1.3 (Far Eastern region) to 2.6 (Eastern Siberian region). The 1965 data for these respective regions range from 2.0 to 5.0.

Regional differences in the rentability of operations are exhibited by the petroleum industry to a larger degree than by the coal-mining industry. The industrial locations are likewise influenced by new techniques as well as by the regional factors.

However, the use of chemicals as basic materials in industry has been one of the most important technological innovations. It provides large potential for extending the base of industrial raw materials by substitution of man-made materials for natural raw materials and thereby reducing the total requirements of the national economy for natural raw materials. In addition, the dependence of industrial location upon particular deposits of natural resources is lessened; it is possible to locate mines in the richest and most accessible ore deposits in many regions. Furthermore, the locations of the processing industries are not as dependent upon the locations of the extractive industries as previously.

The location of the petrochemical industry is not as flexible as the location of the iron and steel industry The best location for the latter is indicated by a comparison of the location of ore deposits and the locations of fuel reserves to determine the optimal location for metal production at the lowest cost. However, the petrochemical industry is based on hydrocarbons as both raw material and fuel. Therefore it is usually located close to natural gas reserves.

Thus industrial location has been affected by structural changes that resulted from the development of the petrochemical industry and the substitution of synthetic materials for traditional metals and raw materials. Another important aspect of the influence of these structural changes on industrial location has been apparent in the fuel industry in which the per cent of petroleum and national gas in the total fuel production has increased.

These structural changes in the national fuel production represent one of the most significant results of technological innovations. The use of modern equipment and techniques in geological prospecting has increased the surveyed reserves of petroleum and natural gas in all economic regions as well as their potential for industrial extraction. Furthermore, improvements in equipment and techniques for extraction provided access to petroleum and natural gas reserves that are found very deep in the earth or in unfavourable regions. Another favourable result was the development of pipelines for low-cost transportation of petroleum and natural gas to regions without these resources where they replaced the solid fuel (mainly coal) that had been locally mined or purchased from other regions.

The structural changes in fuel production furthermore entailed changes in the location of the fuel industries. Previously coal had been the principal fuel. Coal was mined in all regions possessing coal reserves, regardless of the rentability of the mines and the quality of the coal. Since high-quality and economical petroleum resources were scattered throughout the country and their interregional transport was restricted by the limited capacities of the railways, the use of locally mined, uneconomical coal reserves in many regions was more efficient than transporting low-cost coal from other regions. Coal is still mined in almost all the large economic regions in many coal-fields, although some of the fields are small with insignificant production.

Modern railway equipment, expansion of the hauling capacity of many railway trunk lines and lower transport costs affected the location of coal mines. The use of high-quality coal transported from other regions proved to be considerably more effective in many regions than local mining of small deposits. This is evident in the Central, Middle Asian and Caucasus economic regions. However, substitution of petroleum and natural gas for coal has been decisive in this respect. From 1955—1965, the per cent of coal in the total fuel production dropped from 64.8 per cent to 42.9 per cent. Although there was a 47 per cent increase in the total coal production during this period, mining ceased in those areas where the locally mined coal could not compete with petroleum, natural gas and high-quality coal transported from other regions.

The trend to close unrentable coal mines will continue with the development of additional petroleum and natural gas reserves. The process is not clearly evident in the eastern regions because *(a)* no large petroleum and natural gas reserves are exploited in the Far Eastern and Western Siberian regions; *(b)* very low-cost coal reserves are available in Eastern Siberia; *(c)* the development of natural gas production in the Middle Asian region is slow. Thus, the location of the coal mining industry has changed in a selective rather than uniform manner.

The substantial structural alterations in the total fuel production affected not only the location of the coal mining industry but the location of the petroleum and natural gas industries as well. In contrast to coal mining, petroleum and natural gas industries are developing in all regions with surveyed reserves, although the transport of petroleum through pipelines creates a basis for locating a petroleum refinery in each large economic region to satisfy the regional demand regardless of the local availability of petroleum reserves.

Thus, the change in the location of petroleum refineries tends to be uniform. Previously liquid fuel was insignificant in the total fuel consumption, especially in the fuel consumption of large, stationary power plants. Consequently, the location of petroleum refineries throughout the country was economically less effective because of the comparatively small consump-

tion of light oil products in many regions and the large expenditures for pipelines could not be amortized by the savings in production in a single region. Therefore petroleum refineries were constructed mainly in the regions where it was extracted, and the petroleum products were transported to other regions. The considerable growth in consumption of petroleum products, especially by stationary power plants, will provide the savings to amortize the investments for construction of pipelines and petroleum refineries in most of the large economic regions within a short period of time.

The change in the total fuel production furthermore influences the location of fuel-consuming industries and the general industrial development. Some economic regions in the USSR lack energy resources which can provide a basis for modern industrial development; other regions have small, uneconomical, solid-fuel reserves. They are Central Chernozem, Southern, Central, Volga-Vyatka and Eastern regions as well as a considerable part of the Northwestern region. Their economic development was based mainly on transported fuel, chiefly Donets and Perchersk coal; lignite from the Moscow region played a role in the development of the Central region. However, these coal resources proved to be expensive because of the long-distance transport (Donets coal) or its uneconomical mining (Moscow coal). Thus the absence of adequate fuel supplies hindered the development of these regions and the use of their natural resources.

The best economic solution of this fuel problem is provided by the national fuel production. Although the economic development of these regions will inevitably continue to be based mainly on fuel transported from other regions, petroleum and natural gas will provide opportunities to use the natural resources and to achieve the planned production in many European regions of the USSR.

However, the energy factor cannot be omitted in planning the industrial development of certain regions. Since the price of transported fuel must include the transport costs, the location of industries with large power requirements is determined by other factors such as the degree to which local raw materials that are difficult to transport are processed, the availability of hydrocarbon resources as a result of the construction of natural gas pipelines and petroleum refineries, or a sufficient volume of local demand for the products of the industry to justify the economic construction of optimum-size plants. It would be unreasonable to market the products of these industries in other regions because the retail price would have to include the transport costs of the fuel as well as the transport costs of the product. Hence, the changes in the structure of fuel production strengthen the regional specialization of areas with rich fuel reserves (especially petroleum and natural gas) and limits the economic development of other areas that are deficient in fuel reserves.

The processing industry

The effect of technological improvements on the location of different branches of the processing industry is dependent on the unique technical and economic conditions of a branch and on local factors. The effects may be parallel, but often they intersect and are polarized. The electronic computer is able to take these multiple effects into account.

There are two major branches of the processing industry. One branch is concerned with the primary processing of raw materials from the extractive industries; the other branch includes secondary processes for manufactured goods.

Industries in the first branch usually are located in regions with raw-material resources and rentable extractive industries. The location of the second branch of processing industries is dependent upon the availability of stock, labour and markets.

The influence of these factors is not uniform in all industries of the group. Some industries are attracted by sources of stock, for example, the heavy-machine industry. However, the location of the majority of industries in the branch is more influenced by markets and labour reserves. Some food, machine, woodworking and light industries favour areas with consumer markets for their products. Some metalworking and machine industries are attracted by areas with labour resources. Technological improvements affect all these factors and weaken their special importance for industrial location.

The improved, low-cost transport facilities provide a basis for alternate locations of those processing industries that otherwise favour locations near sources of stock.[3] The savings in transport costs enable the processing industries that consume large quantities of stock to shift their locations to areas with consumer markets or labour reserves. In this case, added impetus is given by production of product groups that are in demand or by full use of the available labour reserves. Furthermore, the location of these processing industries is influenced by the substitution of synthetic stock and materials for natural raw materials.

The importance of the stock factor is reduced by technological improvements in production and process technology since the stock costs per unit of output are lowered with resulting lower rates of material consumption. However, the lower stock costs may be cancelled as a result of technological improvements in stock-producing industries. The stock production costs determine the rentability of its long-distance transport.

The economic effect of alternative locations for these industries will depend on the extent the savings in stock transport costs balance the transport costs of the finished products to the consumer areas. The industries

[3] Exceptions are industries that process transportable stock and produce goods which lose their value during lengthy transport.

which had previously been oriented towards locations in the consumer area will expand production and could fill the consumer demand of several regions. However, large-scale production could further the economic development of the eastern regions of the USSR with a sufficient raw-material base.

The locations of processing industries requiring large labour reserves are influenced by technical and economic changes in the production process that decrease the labour consumption. The index of labour costs per unit of processed stock or per unit of output is large as well as those of the total manpower employed in a particular plant and at an optimum-size plant. Therefore, the development level of these industries should be in the western region of the country and not in regions with small labour reserves such as Siberia and the Far East.

The electrification of techniques in the processing industries that are located in regions with large labour reserves increases the productivity of labour and, thus, decreases the labour costs per unit of output. Examples are the electrification of the forges, foundries and heat-treatment shops in machine factories and the electrification of drying and evaporation processes in food and light industries. Additional prospects for the reduction of labour consumption are offered by the change from mechanical processing of materials (especially metal cutting in machine building) to electrical processing. Complete mechanization and automation are decisive in this regard.

However, negative tendencies must be taken into account. Although the rate of labour consumption is decreased, the labour requirements of the industries remain large; it is easier and less costly to satisfy them in the western regions than in Siberia and the Far East. In the European part of the USSR, the wider application of electrotechnology will be restricted by the higher costs of electricity; on the other hand, the development of this important innovation in the processing industry will be stimulated in the Siberian and Far Eastern regions by the availability of very low-cost electricity that partially compensates for the larger labour costs. In addition, technological improvements in transport and reduction of costs increase the efficiency of shipping manufactured products from processing industries (mainly machinery and a number of light-industry products) to Siberia from western regions, especially the Urals region. Therefore, labour-consuming industries should not be located in regions with limited labour resources. The development of these industries in such regions should be restricted mainly to the regional requirements for their products.

Thus, the significance of local factors in determining industrial location is changed by technological improvements. In planning industrial location, the factors must be considered in the context of the changing conditions fostered by technological innovations.

2. NATURAL RESOURCES AND REGIONAL DEVELOPMENT PLANNING

by A. A. Mints[4]

Considerable attention has been devoted to regional aspects of economic planning. The presence of natural resources is foremost among the essential factors in regional development.

The quantitative and qualitative effects of natural resources on regional specialization are illustrated by sharp geographical differences. The complexity of the regional economy and its intrinsic integrity are always influenced by the local natural resources.

The research of Soviet economic geography has contributed to the regional organization of the national economy. In addition, modern geography provides evaluation and research of methods for exploitation of natural resources. These studies are supplemented by economic studies of the significance of natural resources for industrial location. Although the importance of natural resources has been indicated for the location of certain sectors of the economy, a detailed consideration of the natural-resource factor contributes to a better understanding of the relationship.

A central idea in Soviet economic theory and planning treats the national economy as a system of interrelated, industrial complexes in different regions. In planning their development, all local conditions in each region are carefully considered. The development and use of natural resources found in a single region or in several regions is one of the most important processes in the regional structure of the national economy; the Geographical Institute, Academy of Sciences, has estimated the scale and dynamics of the process.

However, in the literature of economic geography, the role of natural factors (especially local resources) in determining industrial location tends to be overestimated. The mere presence of natural resources in a given region has often been considered as a crucial argument favouring the establishment of extractive and processing industries.

These erroneous conclusions result from neglect of their economic efficiency. Frequently consideration is not given to the problem that while the development of the extractive and processing industries requires large capital investments, two conditions that are prevalent in many regions are not alleviated by this development; namely, underemployment of the labour reserves and the over-all, low economic development of the region. Furthermore, the costs for a single plant and the costs per unit of output are higher for these industries than for other sectors of the economy.

Industrial development planning must take into account structural changes in the national economy; there is a decrease in the per cent of primary processing in the total volume of production as a result of the increased complexity in processing raw materials and manufacturing finished goods. Furthermore, the type of natural resource exploited in a region affects the regional development. The physical area of a region is a universal type of resource. The extraction of ore provides a basis for single, specialized plants that are weakly related to other sectors of the regional economy in contrast to the exploitation of agricultural, timber, fuel and power resources that strongly affects the structure of the regional economy.

Kolossovsky has developed a scheme of energy and production cycles on the basis of groups of production processes that correspond to specific natural and economic conditions in a region. An elaboration of the scheme would indicate the relative importance of the natural-resources factor in the development of an industry as well as the technical and economic relationships between production and the raw material basis.

Industries that process natural resources can be located in regions where they are not extracted as the result of increased transport facilities that permit the selection of the optimum location by carefully weighing the effects of socio-economic factors, such as labour resources, markets and infrastructure. However, the industrial branches that initially exploit natural resources are closely linked to the regions where they occur. Examples are the extractive industry, hydroelectric power stations, timber cutting and agriculture. Although these industries do not always provide a local basis for secondary pro-

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cessing industries, the regional development can be enhanced by the economic relations between industries located within its area, even in the absence of direct technological connexions.

Methodological difficulties have prevented the definition of the quantitative indices of the relations between industries. The indices of industry and agriculture cannot be compared because there is a large differential in the productivity of labour in these branches. There are considerable regional differences in the level of agricultural development and in its significance in the national economy.

Therefore, quantitative indices are restricted to industry. The Geographical Institute, Academy of Sciences has estimated that the extractive industries employ approximately 15 per cent of the total industrial labour force. However, regional differences in the magnitude of the index reflect the degree to which the regional economies are affected by natural resources.

The location of extractive industries is more closely connected to the national economy than to the regional location of important natural resources. The eastern region of the USSR is an example of this tendency; although the region has rich reserves of fuel, timber, water and other mineral wealth, only about 30 per cent of the total labour force in the extractive industries is employed there.

The role of natural resources in the development of regional specialization is defined by the nature, quality and quantity of the reserves, the level of economic development and the position of the regional economy in the national economy. There are two alternative consequences of natural resources for regional specialization; either it takes places on the basis of local natural resources, or in its absence, the output of its primary processing industries is shipped to other regions for further processing.

The latter conditions are evident in recently developed regions in which the primary processing industries play a pioneering role as in the newly exploited timberlands of the North European and Siberian regions. Interregional transport of raw materials from industrially developed regions takes place within the context of the national economy; iron ore is shipped from the Dnieper region and Chernozem Centre where the iron and steel industry is well developed and natural gas is supplied from the North Caucasus, Ukraine and Middle Asian regions where there is large-scale industrial consumption of natural gas.

The exploitation of natural resources provides impetus for regional specialization when the output is necessary for the national balance of supply and demand. This condition is the basis for extraction of some non-ferrous and rare-earth ores in the Siberian, Far Eastern, Kazakhstan and Middle Asian regions, iron ore in the Kursk Magnetic Anomaly region and petroleum in Western Siberia and Mangyshlak, as well as the development of large-scale grain production in the virgin lands of Kazakhstan and West Siberia.

Otherwise, the regional development can be furthered by the substitution of high-efficiency petroleum and natural gas fuel for less-efficient solid fuels. This condition led to the development of natural gas reserves in the North Caucasus, Ukraine, Middle Asian and West Siberian regions; the fuel is transported to regions in the Centre, Urals, Northwest and Baltic Republics that lack this resource. In a number of cases, however, higher production costs or transport costs of the product to the areas of consumption prevent marketing at competitive prices. Thus there is no regional specialization based on these resources.[5]

The manufacture of semi-finished and finished goods based on the local resources is decisive in the specialization of the Urals, Donetz-Dnieper, Volga, Western Siberian, North Caucasus and Transcaucasus regions. This development is sometimes a necessary prerequisite for large-scale exploitation of the natural resources when long-distance transport is uneconomical. Eastern Siberia is exemplary; reserves of coal, water, ore and timber are exploited there for the development of metallurgical, chemical and other industries that consume large quantities of power.

Although the primary processing industries employ about 23 per cent of the total number of industrial workers in the USSR, other indices are important in relation to the processing industry and local natural resources. In addition to the transport factor that has been previously mentioned, costly capital investments are necessary. Consider the Bratsk power stations. The necessary investment per 1,000 kWh is estimated to be 28 roubles. However, the estimate for development of industrial plants to use their power output varies from 30 to 70 roubles for industries that consume large quantities of power to 400 to 700 roubles for other industries that consume small quantities of electric power.

Regional specialization must be appraised in the context of the national economy. The ability of a region to satisfy its internal demand on the basis of its own resources deserves close attention.[6]

The classification of natural resources into categories that determine regional specialization and those that are used to satisfy the intraregional demand is relative, for the demarcation between them is not clear cut. A resource may be used in both kinds of development in a single region. Furthermore, as the general economic development proceeds, the relation between the groups changes as the intraregional consumption increases. In addition, a particular resource may play a dual role; the resource

[5] Exploitation of these resources to supply the intraregional demand is expedient only when the total costs of production and transport are lower than the price of a given product shipped from another region.

[6] Although there are methodological difficulties in the determination of the specific industries that are most suited to fill the intraregional demand, guidelines can be obtained from interbranch, regional balances.

can be of secondary significance in the regional economy although it results in specialization for a subregion.

An indirect effect of natural resources is the establishment of auxiliary industries. Large-scale coal mining in the Donets, Kuznetsk and Moscow fields was accompanied by the development of processing centres and auxiliary industries; they in turn furthered the development of urban areas and tran port networks. However, the latter developments have not been necessary for the exploitation of resources in southeast Tatar ASSR or in the natural-gas regions of Stavropol Province and Ukraine.

On the other hand, the mining of non-ferrous and rare-earth ores usually is associated with a single, medium-sized plant. When rich ore deposits are located near sources of auxiliary raw materials and the local processing of the metal proves to be economically efficient, large-scale industry develops as has occurred in Norilsk, Kounrad, Monchegorsk, Leninogorsk and Ust-Kamenogorsk.

Hydroelectric resources occupy an intermediate place for, although their establishment does not require urban centres, large power stations have become centres for industrial development as in Zaporozhye, Togliatti and Bratsk. The exploitation of forest and farm lands demands the convenient location of labour and transport facilities, although the development of these resources does not stimulate the concentration of either industrial or population centres. Recent examples are the northern and eastern lumber regions and the agricultural areas in the Northern Kazakhstan, Southwestern Siberian and Southeastern European regions of the USSR.

The development of new reserves is strongly affected by these structural considerations in the frontier areas of the Northern European, Siberian, Far Eastern, Kazakhstan and Middle Asian regions, where the economic development is based on the regional fuel, power and land resources. On the other hand, the regional insignificance of the structural changes resulting from the exploitation of new reserves has been observed in the older, well-developed regions of the Moscow coal-fields, the Estonian shale basin, the Kursk Magnetic Anomaly in Central Chernozem and the petroleum fields in the Volga region.

The preceding discussion contributes to the assessment of the role of natural resources as a factor in industrial location and planning. The co-ordinated research of several branches of science will contribute to the further knowledge of theoretical and practical approaches to industrial planning.

3. MODERN URBANIZATION AND ITS INFLUENCE ON INDUSTRIAL LOCATION

by L. N. Karpov[7] *and V. M. Gokhman*[8]

The twentieth century is the century of urbanization; the process can be observed almost everywhere in the world. Population growth is twice as rapid in urban areas as in rural areas, and the per cent of urban dwellers is rapidly increasing. In 1900, 13 per cent of the earth's inhabitants was estimated to live in urban centres with populations exceeding 5,000. In 1950 and 1965, the per cent of urban dwellers was estimated to be 28 per cent and greater than 33 per cent, respectively. By the year 2000 more than one half of the total population of the world (i.e. more than 3 billion people) will be concentrated in urban centres. This urbanized population will be larger than the total world population in 1960.

The rapid growth of population, especially in the developing countries, poses a number of acute problems. One of them concerns the necessity of providing the growing population with material wealth and first of all with food. Another problem, which also attracts considerable attention, is connected with the geographical location and distribution of population.

Urbanization is the most important aspect of the latter problem. Urbanization is especially significant because industrial development and the industrialization and intensification of agriculture, which are vital for the increase of food production, are closely connected with it.

The scale and the character of urbanization are determined by many socio-economic, natural and historical factors. In turn, the growth of urban population and urban centres greatly influences the national and international division of labour and the formation of different types of economic regions

Two aspects of urbanization are defined to avoid confusion. The first aspect is the process of increased urban influence on the life of a county or an economic region. The process of urbanization is generally reflected in the rates of growth of the urban population. The second aspect refers to the development of urban life, which can be expressed by the per cent of urban dwellers and the degree of development of urban systems. This situation, which is attained through urbanization, is termed the level of urbanization.

Urbanization and the level of urbanization may be (and very often are) significantly different. A low level of urbanization often opens rather broad possibilities for high rates of urbanization as seen in most developing countries.[9] At the same time, the approximation to the maximum level of urbanization is inevitably connected with a sharp decrease in the rates of general urbanization, or its almost stagnation, as in several highly industrialized countries. But even the complete stabilization of the per cent of the urban population is connected with a permanent absolute increase in the number of urban dwellers.

When the level of urbanization is very high, almost all the population increase is concentrated in urban centres, as has taken place in the United Kingdom, the United States and other industrialized countries, where the urban population centres are inhabited by 70 to 80 per cent of the national population. Moreover, the qualitative aspects of urbanization continue to develop when the percent of urban population can no longer increase. Some of the qualitative aspects of urbanization are the growth of the economic influence of urban centres, the increase of their size and its effect on life in rural areas.

One of the most typical features of modern urbanization in industrialized countries is the formation of urban agglomerations in connexion with the thriving of suburban areas and the population decrease of the central city. Similar processes occur to an ever increasing degree in developing countries. Therefore, for correct determination of the number (and per cent) of the urban population and the size of urban centres, the designation of urban boundaries is of primary importance. In a market

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[9] In many countries of Asia, Africa and Latin America, there was a hypertrophied concentration of population and economic activity in one or several main centres. The population of the main centre was sometimes larger than the combined population of all the other centres. In such an urbanized country as Uruguay, the criterium of per cent of urban population indicates the capital Montevideo accounts for three-quarters of the total industrial production.

economy, there are many difficulties in extending the area of an urban centre, especially when independent settlements are to be absorbed in the larger unit. Often the formal incorporation never takes place and there is a disparity between the administrative boundaries and the actual, practical boundaries. The disparity can be large and has a tendency to increase. Therefore the actual and not administrative boundaries are used in several countries in compiling statistical data. In the United States, three types of data are published for cities with a population exceeding 50,000 inhabitants. They represent the following city boundaries:

(a) The administrative boundary;

(b) The urban boundary, which includes the surrounding, developed area;

(c) The standard metropolitan statistical area (SMSA) boundary, which includes the city and the suburban zone of countries closely related to the central city of the SMSA.

The importance of this distinction is illustrated by data from the United States Census Bureau. In 1960, the combined population of 212 SMSA was 113 million, or 63 per cent of the total United States population; the combined population of the central cities of these SMSA was only 58 million or 32 per cent.[10]

In addition, the distinction is important to determine correctly the population of very large cities. For example, in 1960 New York had a population of 7.8 million in the administrative boundaries and of almost 15 million in the real boundaries. The respective figures for Los Angeles were 2.5 million and 6.7 million; for Chicago, 3.5 million and 6.8 million; and for Washington, D.C., 0.7 million and 1.8 million. The disparity may be seen in other countries; the corresponding figures for London were 3.2 million and almost 10 million in 1961; for Paris, 2.8 million and 7.4 million in 1962; for Buenos Aires, 3 million and 6.8 million; for Mexico City, 2.8 million and almost 5 million; for Ankara, 0.5 million and 1.3 million. Thus, when comparing the per cent of urban population in different countries and grouping them according to size, it is important to obtain data concerning not only the population within the administrative boundaries, but also the population within the real boundaries, including the suburbs.

The increasing population concentration in urban centres is a result of several socio-economic factors. For different levels of development and for urban centres with different functions, there are various dominant combinations of factors. In industrialized countries, the growth of industrial production was a leading factor in urbanization at one stage of their development. It remains a very important factor for many developing countries,[11] although in several industrialized countries it is now only of secondary importance. The increased urban growth of industrialized countries is connected with the development of service industries for commerce, transport and maintenance, as well as institutes for research, education and administration. The rate of increase of industrial employees is slower than the growth rate of the total population and considerably less than the rate of urban growth.

The technical revolution fostered a greatly increased industrial output, the expansion of scientific research and the need for highly skilled labour. Thus the importance of industry as a factor in urban development in industrialized countries was diminished. For example, from 1950–1965, the number of industrial workers in the United States was rather stable, although the per cent of industrial workers in the total active population is continuously decreasing.

The migration from rural to urban areas resulting from the lack of job opportunities and low income levels may be an important factor of urban growth, especially in developing countries. Urban population growth through natural increase, rural migration and to some extent the incorporation of large rural settlements as towns affect all the urban systems of a country or a region.

Complex urban systems with centres of various sizes and functions have evolved in industrialized countries and regions. Improvements of these systems are integrated with the changes in the structure of the regional economy. In some developing countries, urban systems evolve around the largest centres in a few important regions where population and economic activity are concentrated.

Various factors are present in the development of urban centres of different sizes and functions. Although the individual features of an urban centre are important, there are three groups of urban centres:

(a) Large cities with a population of 100,000 or greater and urban agglomerations;

(b) Existing medium or small towns;

(i) Administratively independent towns;

(ii) Suburbs of a large city that are integrated in its agglomeration;

(c) New urban centres.

One type of new urban centre built in previously inhabited areas is a result of the decentralization of production and the dispersion of population. Another type of new urban settlement is created in a thinly populated area in connexion with the development of mineral, hydroelectric, timber or land resources. The first type of new urban centres may be either a suburb and satellite town, or an independent settlement beyond the limits of urban agglomerations.

[10] During 1950–1960, the population of all SMSA grew by 26.4 per cent (i.e. it was growing more rapidly than the country's total population, which showed an increase of 18.8 per cent). At the same time the population of the central cities of the SMSA grew by 10.7 per cent, while the suburban zone increased 48.6 per cent. Redistribution of population in urban agglomerations takes place in other countries on different levels of development.

[11] In the majority of developing countries, the rates of growth of urban population are much higher than the rates of industrial production.

The former centre is in an urban agglomeration or in close proximity to it. It permits a certain decentralization of production and population in the urban agglomeration and reflect the expansion of the larger unit. Thus this type of urban centre contributes to the increasing concentration of production in the urban agglomeration as a whole.

The independent new urban settlement often provides industrial locations for plants transferred from the older centres or for newly established plants and subsidiaries. Although it creates a certain regional spreading of production, the per cent of the regional production in the total national production does not necessarily increase.

The large cities in industrialized countries absorb most of the increased urban population. In the United States during 1950—1960, the population of 212 SMSA grew by 23.5 million, while the population increase of all other urban centres was less than 5 million. Moreover, the population of the 24 largest agglomerations that each had more than 1 million inhabitants in 1960 grew by 12 million. Thus these urban agglomerations absorbed more than 40 per cent of the total population increase.

As a result of similar processes in many other countries, the per cent of the world's population concentrated in large cities is growing rapidly. In 1900 it was 5.5 per cent; it increased in 1950 to 12.5 per cent, in 1960 to almost 20 per cent and is expected in the near future to exceed 25 per cent. The number of cities with a minimum population of 1 million inhabitants has increased from approximately 20 in 1900 to 130 in 1960. In 1963, more than 2,000 cities had populations greater than 100,000 inhabitants; more than 100 of these cities were in Latin America and more than 70 in Africa. The growth of large cities in developing countries increased after achievement of political independence. The rapid growth of the capital city is exemplified by Algiers, Cairo, Casablanca, Djakarta, Kinshasa, Lagos and Rangoon.

The majority of manufacturing plants are located in large cities in industrialized countries. However, the decrease in the per cent of the total labour force employed in manufacturing plants indicates the gradual lessening of the industrial factor in urbanization. Furthermore, the scientific, educational and cultural functions of large urban agglomerations acquire greater importance. In capital cities, the trend is towards the increased importance of administrative functions, which leads to the expansion of government employment.

The physical area of large agglomerations is growing even faster than their populations, as a direct consequence of the process of suburbanization. The spreading urban agglomerations in countries possessing a dense urban network begin to adjoin one another, accrete and form immense urban areas extending over many hundreds of kilometers, namely, a megalopolis. The greatest megalopolis extends approximately 1,000 km along the Atlantic Coast of the United States, from the northern suburbs of Boston to the southern suburbs of Washington, D.C. Its physical area of 140,000 km^2 and population of 40 million continue to grow. Similar, smaller megalopolis formations are developing in the United States (in the Great-Lakes region and in California) in several Western European countries (Rhine-Ruhr region, the Midlands area of the United Kingdom, Paris and Randstadt, the Netherlands) and in Argentina (Buenos Aires and Rosario).

The typical features of a megalopolis are its linear, tree-like form and polycentral structure, which distinguish it from conventional urban agglomerations. This form and structure permit the extension of urbanized areas. Within a megalopolis there are urban and rural areas as well as forested areas. It thus includes both congested and relatively thinly populated areas. However, the latter are functionally linked to urban centres and fulfil various functions, especially those for short-term recreation facilities.

In contrast to large cities, the independent, medium-sized and small towns of industrialized countries grow slowly or even stagnate, although as a result of difficulties in defining them, statistics may indicate an increase in the total number of towns. In the United States the number of towns with populations between 2,500 and 49,900 grew during the period 1950—1960 from 3,300 to 3,600. However, their total population increased only by 6.5 per cent; their per cent of the national urban population was reduced from 28.5 per cent to 23.5 per cent.

One group of these towns is within the sphere of influence of large cities; gradually the towns become part of the suburbs of large cities with favourable perspectives for growth. The population of 1,200 small towns in suburban zones of large, United States cities increased by 90 per cent during the period 1950—1960.

A small group of towns possesses the conditions for growth (the development of industry, institutions of higher education, recreation areas etc.). When the population reaches 50,000 inhabitants, the town is classified as a metropolitan centre. During the period 1950—1960, the number of SMSA in the United States was increased by 43; and during the period 1960—1966, the increase was 12.

Under conditions of economic stagnation, most medium-sized and small towns do not grow, and some even lose population when unemployed workers migrate elsewhere. In many countries, the problems of medium-sized and especially small towns have become critical.

The accelerated industrialization and the growth of existing urban agglomerations result in the modern process of urbanization in which a network of new towns is created. The networks of new towns are usually relatively close to urban agglomerations and large cities in industrialized countries. Other networks of new towns and industrial settlements are created in uninhabited areas.

The widespread construction of new towns in most industrialized countries is an attempt to eliminate or

weaken some negative, strategic, social and political features of the growing concentration of population and production in large cities and urban agglomerations. It has been directly reflected in governmental programmes of decentralized production, in subsidies for construction of new towns, and in the direct participation of national bodies in creating many industrial, scientific and residential centres within a 50—100 km range from an urban agglomeration or centre.

Most new towns that have been planned near urban agglomerations have acquired relatively numerous populations and a restricted number of functions. Analysis has shown that in most new towns created since the Second World War in industrialized countries the number of inhabitants surpassed the level of 50,000—100,000 within a short period of 5 to 10 years.[12]

The economic and political significance of the development and settling of new areas is increasing. In the industrialized countries, the development of new regions often provides the existing industrial regions and centres with energy and raw materials. In the developing countries, the development of new regions widens the structure of industry by increasing the number of locations. The economy must be reoriented towards the domestic markets. Since the development and settling of new regions include a number of relatively new and unresearched processes, the problems related to them are considered in detail.

The creation of a network of new outpost towns, which serve as a means of resource development in uninhabited areas, reflects developments in the national economy. In the frontier regions of Alaska, Northern, Central and Western Australia, Northern and Western Canada, Greenland and Northern Scandinavia, 700 new towns and smaller settlements were founded during the last 25 years. In the northern and eastern regions of the USSR, 500 new centres were founded during the same period.

The previous neglect in developing these rich regions was a result of the complexity of the process and the large capital investments that were necessary. In addition, serious natural obstacles had to be surmounted, such as extreme temperatures, an arid or very humid climate, irregular terrain, dense forests, marshes or pests. The geographic frontier coincided with the boundaries of regions with a profitable economic development. Exploitation in the frontier regions was usually centred on a particular kind of resource.

However, the discovery of precious and rare metals gave impetus to the sudden, unplanned exploitation of the renowned gold rushes that hampered the formation of an economy that would be viable in the future. Furthermore, the gold rushes were not a basis for permanent settlements in the frontier regions. Ghost towns and neglected roads are monuments to the hasty and rapacious development of resources.

The modern development of resources in frontier regions reflects numerous quantitative changes in international economy and policy, the modern technical revolution, and the regulation and planning of economic development in industrialized market economies. Since the undeveloped territories occupy one third of the total area of these market economies,[13] and more than one half of the total area of the USSR, their development is an important part of modern industrial development.

Since the frontier regions occupy large areas in many developing countries, their development is an important programme of the government. In Mexico, for example, the programme of "a shift towards the sea" to further the development of the south-eastern regions has been carried out since 1947. Future development of the vast, sparsely populated Amazon Basin is planned in Brazil. India's development plans include the accelerated development of the central regions, the Thar Desert and the piedmont distri . of the Himalaya Mountains. The economic programmes of Algeria, Egypt, Nigeria and the United Republic of Tanzania include the development of uninhabited, arid and tropical areas of the African continent. A further goal of frontier development is the alleviation of demographic pressure and land hunger in overpopulated regions.

Although the problem of frontier, regional development is most urgent for the developing countries, considerable success has been achieved in the industrialized countries, where the frontier regions occupy an important place in the structure of the national economy. Food and raw materials produced in these regions considerably influence the structure and geographic distribution of international trade. The development of the frontier regions is characterized by intensive methods based on modern technology, the use of highly skilled labour and the interregional division of labour.

Participation of these frontier regions in the national and international division of labour is usually based on a highly specialized production of raw materials and semi-manufactured goods. Their high technical and economic levels of production are based on the mechanization and automation of production. However, the large capital investments which are required can be amortized only by large-scale production. As a result of the initial orientation of many industries in frontier regions to external rather than internal markets, relatively small towns have an important position in the national production and the subsequent international trade of a product. Examples of this phenomenon are the Canadian

[12] The development of industrial centres in new towns is sometimes the result of difficulties in raw-material and power supplies, and the high costs of land and labour in the large cities.

[13] The areas of these frontier regions are as follows: Alaska, 1.5 million km²; Northern, Western and Central Australia, 6 million km²; Northern and Western Canada, 7 million km²; Greenland, 2 million km² and Northern Scandinavia, 0.5 million km².

towns, Kitimat (aluminium) and Schefferville (iron-ore concentrates), Weipa, Australia (bauxite) and Glomfjord, Norway (chemical fertilizers). Similar centres have begun to emerge for several resources in Africa, Asia and Latin America, as in the Guiana Highlands of Venezuela.

The size of towns and settlements is closely connected with the economy of scale of the industries to be founded in frontier regions. The creation of a new outpost town and the regional development has been preceded by a large, long-term effort to provide the technical and economic basis for the new centre with plans for further development of the industry. Quantitative estimates are important of the relations between *(a)* the available resources; *(b)* the optimum size of a plant; *(c)* the optimum size of a new centre; and *(d)* the present and future demand of internal and external markets.

The development of the majority of new centres in frontier regions of industrialized countries is directly connected with the modern technical revolution that broadened the limits of profitability of investments in the resources of uninhabited regions. Although labour costs are considerably higher there than in populated areas, modern equipment and an economy of scale increase the labour productivity. The substitution of equipment and technology for costly labour permits their more efficient use than in populated regions. Many new mining centres in Canada, the Soviet Union and Western Australia owe their existence to a sharp increase in labour productivity, a decrease in costs of geological survey by approximately 20 times. There has been a substantial increase in the per cent of industrial and agricultural products from the frontier regions in the total world-wide production.

A significant feature of the towns and settlements that were developed after the Second World War is their relatively small size of 5,000 to 10,000 inhabitants. The large frontier region of Western and Northern Canada is an example. Of 400 new centres, only three had more than 10,000 inhabitants in 1966, namely, Kitimat—13,000, Prince George—17,000, and Sept Ils—14,000.

These settlements exhibit patterns of size and function that are quite different from those of the older, urban areas. Usually there are no large cities with trading, distributing, cultural and administrative functions in the entire region or in a group of new towns. With the exceptions of Edmonton, Canada and Anchorage, Alaska, there are no cities in the frontier regions. The activities of all new centres are mainly based on services provided by large cities in the inhabited regions. In Canada, the frontier regions are served by Montreal, Toronto and Vancouver; Alaska by Seattle, Washington; Greenland by Copenhagen and Northern Sweden by Stockholm.

Since the development of frontier regions is primarily connected with the economic use of natural resources, more than one half of the 700 new frontier centres in the industrialized market economies are specialized resource towns. Usually only one or two highly specialized plants are located in a centre.

Detailed preliminary planning of the frontier towns was based on several small areas sharing a common town centre with green belts separating industrial plants. Building codes for private dwelling were a part of many plans; they excluded the erection of primitive structures of waste materials by the poorest strata of the population, which otherwise was a widespread phenomenon.

However, more labour was needed during the period of construction than after operations were begun at automated plants. Furthermore, the development of separate, small deposits precluded the establishment of large permanent towns. Therefore the use of mobile, trailer camps was common.[14] Sometimes these mobile camps were used together with a main, centrally located centre that performed several functions. Thus, it was not necessary to construct permanent settlements near mines and logging camps; after exhaustion of a deposit or a forested area the trailers were moved to another location.

This system allowed profitable exploitation of small, but rich mineral deposits or woodlands without construction costs for special settlements and costly, long-distance transportation of labour. Furthermore, the inhabitants of mobile camps are initially provided with modern housing and necessary services. In some countries many different kinds of trailers are manufactured, including one-family units, kitchens, laundries, dining rooms, hospitals, offices, libraries, club-rooms and storehouses. The mobile camps aided a flexible and effective development of frontier regions, although the new towns have provided permanent homes for a small number of residents.

Future trends in urbanization and industrial location are indicated by the recent formation of settlement networks in both industrialized and developing countries. Practical aspects of the technical revolution, especially in transport, will enable the transfer of some economic functions from regions with high production costs to regions with lower costs. This trend is one of the consequences of increased wages for skilled labour, which has been apparent since the Second World War. It limits production in the frontier regions to large-scale, automated mining and processing of raw materials in relatively small settlements. Secondary processing of raw materials will continue to be located in regions with the most favourable natural conditions. In these regions, a high degree of urbanization will be combined with large, unoccupied areas, including parks. The majority of the world's population will be found in these regions, with relatively low production costs for industrial development.

[14] In some new regions of the USSR, four-storey, prefabricated houses were erected. They were specially designed for the Northern, Siberian and Far Eastern regions.

4. THE LOCATION OF FOOD PROCESSING INDUSTRIES

by F. S. Martinkevich,[15] *Y. M. Aleksandrovich*[16] *and A. D. Pavlova*[17]

As part of over-all regional planning, the location of food processing industries is effected by the following factors: settlements of population and manpower, the location of natural resources within the region, infrastructure (especially transport facilities) and the economic conditions and technical progress in the national economy.[18] Factors that have special significance in planning the location of the food processing industry are raw materials, consumer demand and markets, the location and size of previously established plants, and the possible combination of several plants in a processing complex.

Raw materials

Agricultural raw materials present unique problems, since they are perishable goods and require specialized transport to the factory. The time and distance of transport may contribute to their deterioration. The efficiency of transport may be further reduced for many types of agricultural products with a high water content; the per cent of water content in the total weight is about 80 per cent for potatoes, 65 to 95 per cent for vegetables and 87 to 90 per cent for milk.

Therefore, the costs of raw materials are a large part of the total costs in food processing industries. The following per cents of raw material costs are typical: meat-processing plants, 95 per cent; dairies, 88 per cent; and sugar refineries approximately 80 per cent.

The food processing industry may be divided into three groups according to the quantity of raw material required for one unit of the processed product;

(a) More than 1.5 tons of raw product are required to produce 1 ton of the processed product;

(b) The quantity of raw product required is approximately the same as the weight of the processed product;

(c) The quantity of the raw product required is less than the weight of the processed product.

In group *(a)* are the majority of branches including meat products, cheese, sugar and conserves. Whole-milk processing is an example of group *(b)* and beer brewing an example of group *(c)*. Consequently, quick processing of perishable raw products that are difficult to transport is desirable, with short transport from closely located fields.

Furthermore, the perishability of agricultural products is an obstacle to the concentration of several different plants in an industrial cluster. The desired proximity of each plant to its own raw-material source strongly favours a separate location. However, this dependence is relaxed somewhat by modern transport facilities that permit the location of processing plants in areas that do not produce the raw materials.

An inverse, indirect effect of the location of food processing industries is the result of natural and economic conditions. However, agricultural locations are not completely determined by natural conditions, since new methods and the technical revolution allow some manipulation of the geographical environment and the nature of the vegetation.

One characteristic feature of food processing industries is directly related to the natural conditions, i.e. the seasonal nature of processing. The main volume of products are delivered to processing plants at the end of the agricultural year. The production capacity must bear a maximum load, as otherwise the loss of valuable raw products may result.

This seasonal problem can be mitigated by economic measures, such as a sliding price scale for raw-product delivery during different seasons. However, an increase of the production season is not feasible in all branches. Sugar refineries are good examples, for lengthy storage of sugar beets reduces the sugar content and the corresponding sugar yield.

The basic indices of the raw-product base are the volume of production, the regional demand for agri-

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[18] See the detailed discussion of these factors by Nekrasov in Volume I of the present publication.

cultural products, the relation of supply and demand, and the quality of the raw products. Higher regional levels of agricultural production ensure the delivery of large quantities of raw products for industrial processing; thus the regional consumption is high. Since the natural and economic conditions of agricultural production vary, the consumption of raw products fluctuates considerably in different regions of the USSR.

The raw-product density affects the location of processing plants through the delivery costs of raw products and the capacity of the plant. For a high density with a corresponding small delivery radius, the plant capacity should be large. Since the agricultural production is spread throughout a region, each plant receives delivery from a specific area.

The relationship between the annual capacity of the plant, the delivery radius for raw materials, and the consumption, is expressed by the formula $N_a = \pi R^2 C$, where N_a is the annual capacity of a processing plant, R is the maximum delivery radius, and C is the consumption per km^2. Thus the delivery radius is $R = (N_a \pi C)^{1/2}$.

To include delivery costs in the general optimum criterion, the average weighted, delivery distance for 1 ton of raw product must be known. It is determined by multiplying the maximum delivery radius R by a conversion factor that takes into account the straightness of roads, the pattern of dispersion of raw products in the region, and the relation of the industrial location to the centre of the area that produces the raw products.

Low-cost, fast motor transport is recommended because of the small distances. For example, in the BSSR the average transport distances are 30 to 40 km for sugar-beets, potatoes and vegetables, 40 km for milk and 50 km for cattle.

These special features of the raw-product base and the specific nature of its transport can be accounted for by the index of production costs and the total transport costs for 1 ton of raw product in calculations for rational industrial location. The specific natural and economic conditions of regional agricultural production are reflected in this index. Furthermore, the total costs include all the direct and indirect costs of transport. Thus, comparative indices of all production and transport costs are obtained for a unit of production.

CONSUMERS AND MARKETS

Since the principal consumer of the output of most branches of the food industry is the population, the administrative district is the most convenient unit for calculating the total consumption of both the urban and rural populations in the region. The volume of consumption or capacity of the market for food products depends not only on the size of the population but on the *per capita* consumption and differences in the food consumption patterns of urban and rural populations as well. The effect of consumer markets on industrial location is manifested in the market capacity and the delivery costs for the finished product.

The effect of labour resources on the location of the food industry is less basic, because the industry is not labour-intensive. The number of workers at a plant varies from 50 to 600; about 60 per cent of them are women. Thus, even small towns can supply an adequate labour force without recruiting workers from other areas.

OLDER PROCESSING PLANTS

The indirect effect of previously established plants is felt in the raw-product zone and the marketing zone. Although these zones have definite forms and sizes, their geometrical forms depend, not only on the capacity of a given plant, but on the capacities of other plants in the same branch as well.

The transport costs of raw products and output for a given plant and for the total number of plants is determined by limiting the raw-material zones and consumer markets to a combination of plants with various capacities. However, for any combination of capacities, there is, theoretically, an infinite number of pairs of raw-product zones and markets. Thus, an infinitely large number of transport costs may correspond to one and the same capacity. The problem is to find a rational industrial location, with a choice of capacities, to ensure the minimum total production costs and transport costs of raw materials and finished products to the consumer. One raw-product zone and marketing region would correspond to the optimal location.

The complex interweaving of raw-product zones of plants with demands for specific raw products requires careful co-ordination. The mutual dependence of these industrial branches is not directly apparent, since it is indirectly manifested through agriculture, which produces the raw material.

Small plants processing local raw products usually contribute to a fuller use of local resources and accelerate the agricultural production. However, their location near large factories may create difficulties in the supply of raw products. To avoid such situations, the location of large and small plants must be carefully co-ordinated.

The rational geographical location of the food processing industry is directly correlated with the optimal size of plants. Special features are associated with the raw product processed in each industrial branch, the technical level of the branch, and the production technology. Therefore, the optimal size of plants varies in each branch and, furthermore, depends on the external conditions in which the plants operate, e.g. the location of the agricultural production, its specialization and concentration. When large-scale production is concentrated on a

high level of specialization, the development of larger plants is possible.

The optimal size of a plant is smaller when the agricultural production is scattered. Large-scale industrial production in these conditions involves an increase in transport costs and in the production costs of the finished product.

At the optimal plant size, the contemporary technical level produces the maximum economic effect. Because of the range in variables for industrial location, different capacities may be optimal.

Combination of several plants

The combination of plants facilitates an increase in labour productivity. In industries that process raw agricultural products, intra-branch combination is common; subsidiary plants process products or by-products obtained from the main plant. Thus, a modern, large meat-processing complex includes more than 20 plants, and a milk-processing complex about 15 plants. The level of combination of plants is dependent upon the technical level and the production technology. Furthermore, it is affected by the location and size of a plant, because a complex requires a sufficient raw-product or by-product base.

In addition to the intra-branch combination of plants, plants of different branches may be combined on the basis of the joint use of auxiliary facilities, transport facilities etc. An interbranch combination can be effective because the costs of these facilities and services for food industries constitute from 26 to 50.3 per cent of the total building costs. Therefore, the joint use of these units by several plants decreases the expenditures for capital construction. However, there are undesirable consequences from combining plants processing agricultural raw products, which are difficult to transport, and which are of vegetable origin, such as sugar-beet, flax and vegetables. The organization of the raw-product zone is complicated, and transport and purchasing costs are increased.

The interaction of factors

In the mutual interaction of the factors that have been analysed above, their effects are unequal and not always in the same direction. For example, the raw-products factor would favour the location of food processing plants in the agricultural regions producing the raw products, while the factor of consumers and markets favours their location in areas close to the markets. However, since the areas of agricultural production do not coincide with those of markets, the optimum location is one from which the consumer demand can be satisfied with minimum production and transport costs.

The interaction of factors is especially dynamic in the projection of future food-processing plants, as the factors change and develop during a given time period. Thus, as the agricultural base of the raw products develops, their production and purchase will increase considerably, even in a few years. Reclamation of land provides new agricultural regions, and technical progress makes possible the expansion of the raw-products and marketing zones. Thus, larger plants can be planned at optimal locations. The total effect of future changes is to decrease specific capital investments in plant construction and the costs of production and transport of a unit of output, and to increase the demand for the finished product.

5. PLANNING URBAN INDUSTRIAL AREAS

by C. P. Chernyshev[19] *and L. M. Eingorn*[20]

The planning of optimal industrial location is based on technical, economic and social considerations. There are three possibilities for the spatial location of industries with regard to the residential areas: i.e. within the residential area, on the outskirts of the residential area or location at a distance from it (see figure 1).

Industrial location within the residential areas should be limited to plants that do not create a health hazard, where the turnover of goods is small, and the labour supply is ample (see figure 2). It is advisable to locate on the outskirts of the residential area industries that create an insignificant health hazard and are associated with large turnover, spur railway tracks or docks for water transport (see figure 3). Location at a distance from residential areas is advisable for metallurgical complexes, and petrochemical and petroleum industries, which produce large quantities of toxic substances that are harmful to human health, as well as industries that are subject to explosion and fire hazards (see figure 4).

The development of new, urban industrial areas creates favourable conditions for common productive services, such as repair shops, laboratories and warehousing, as well as ancillary services, such as transport, communications and community centres. The advantages of these new industrial areas must exert a greater influence on industrial planning than the favourable conditions in large towns with previously developed industries, namely, the availability of highly skilled labour, the specialization of industry and the possibility for co-operation.

Industrial branches that are suitable for location in industrial areas include metallurgical, petrochemical, machine-building, electronics and wood-processing. In addition, plants of industrial branches, which are not technically related, but which are constructed and begin operation at approximately the same time, may be effectively grouped on adjacent lots. These plants enjoy the benefits of joint services and auxiliary shops. The size of industrial areas may be limited by water or power resources, the excessive concentration of toxic substances, the pollution of the environment by industrial wastes, and the excessively heavy passenger traffic, which causes construction and operational difficulties.

To reduce the total health hazard, plants should be located in decreasing order of harmfulness with respect to the residential area. In any given industrial area, harmful production should not take place in plants adjacent to "safe" plants, in order to avoid subjecting the workers of these plants to unfavourable conditions.

Industrial location can be assessed from the point of view of urban transport as follows:

(a) For small plants located within the boundaries of the residential area, the transport problem is most easily solved;

(b) When industry moves from the town, the traffic intensity and the travel time increase;

(c) When plants are concentrated in one or several large areas, the transport problem is complicated by traffic congestion in a limited number of directions. Excessive concentration of passengers is no more desirable than excessive dispersion;

(d) In an urban area with a long length in comparison with its width, industry should be located along the longitudinal axis to reduce the average time of transportation;

(e) The most densely settled area and the plants requiring large labour resources should be located in close proximity to reduce the traffic.

The planning of engineering systems for industrial plants requires careful consideration of the total urban water supply, canals and pipelines, as well as the power supply. Technical and economic factors determine the feasibility of separate engineering systems for individual plants.

Rational planning of an industrial area can have a considerable effect on the economy of the region, as well as on the creation of favourable technical conditions and cultural and welfare services for the workers. In planning industrial areas, the following zones are distinguished: production areas (for the location of industrial plants and associated units), buffer strips (for the

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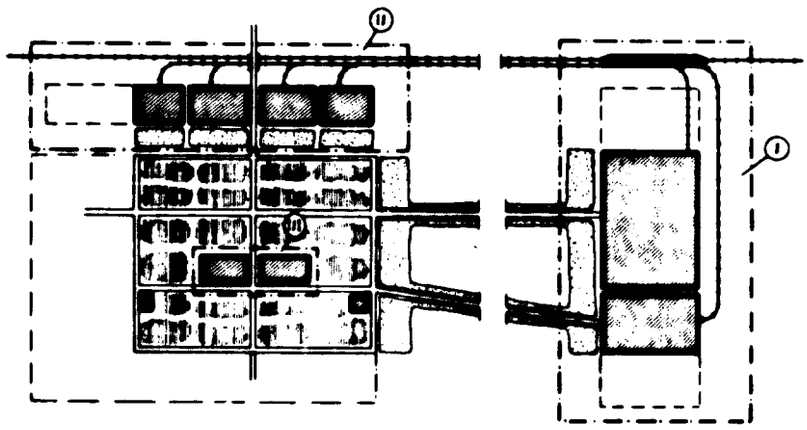
[20] Architect, Minsk.

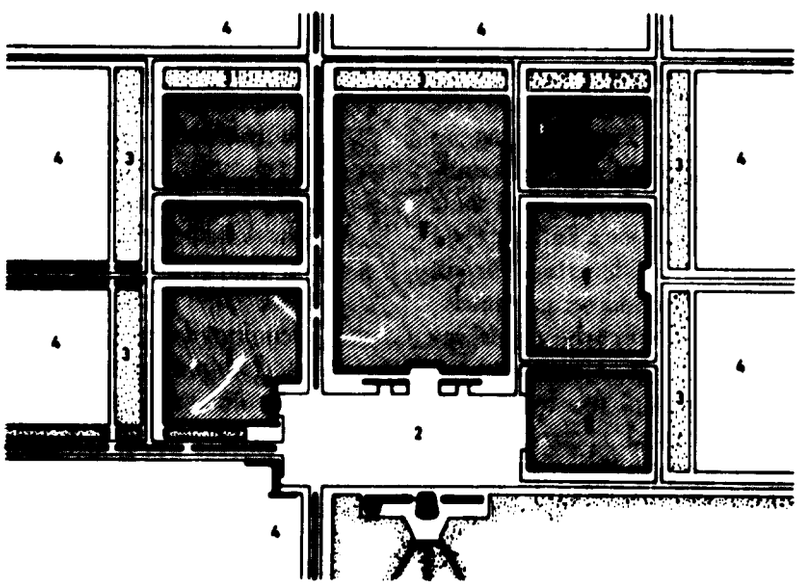
Figure 1. Types of urban industrial areas and their location, depending on health hazards and turnover



I — Industrial area located at a distance from the residential area; II — Industrial area located on the outskirts of the residential area; III — Industrial area located within the residential area.

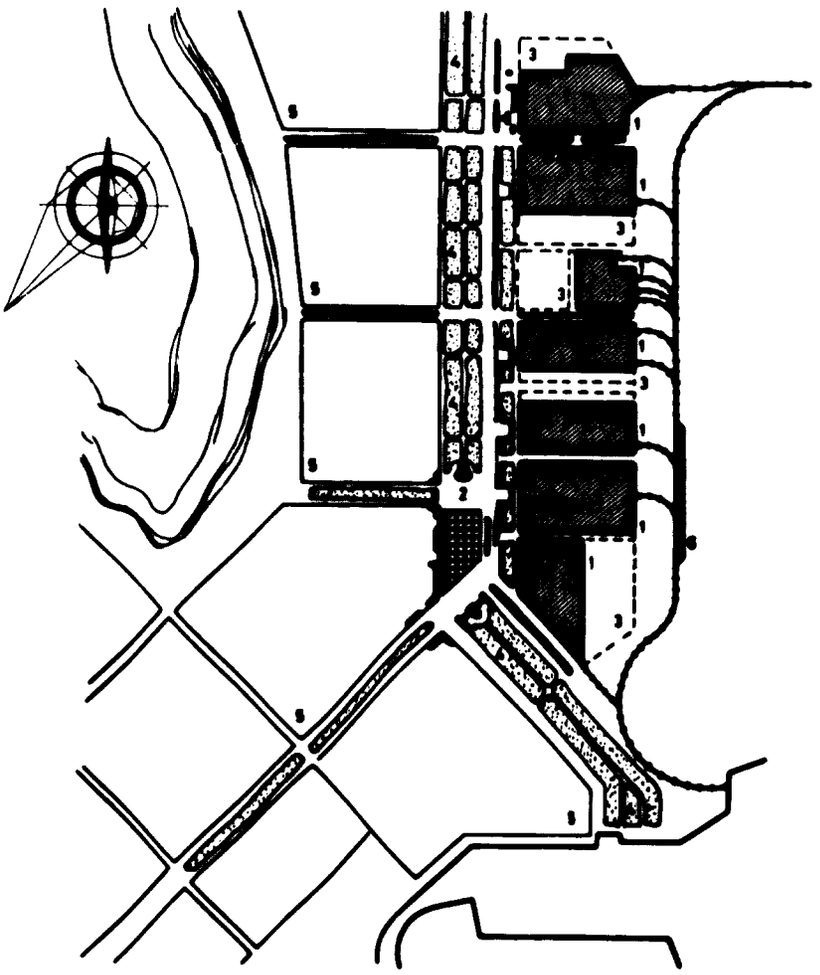
Industrial area
Residential area
Landscaped area and buffer zone
Boundaries of industrial area
Boundaries of residential area
Railway network
Motor roads

Figure 2. An urban industrial area located within the boundaries of the residential area



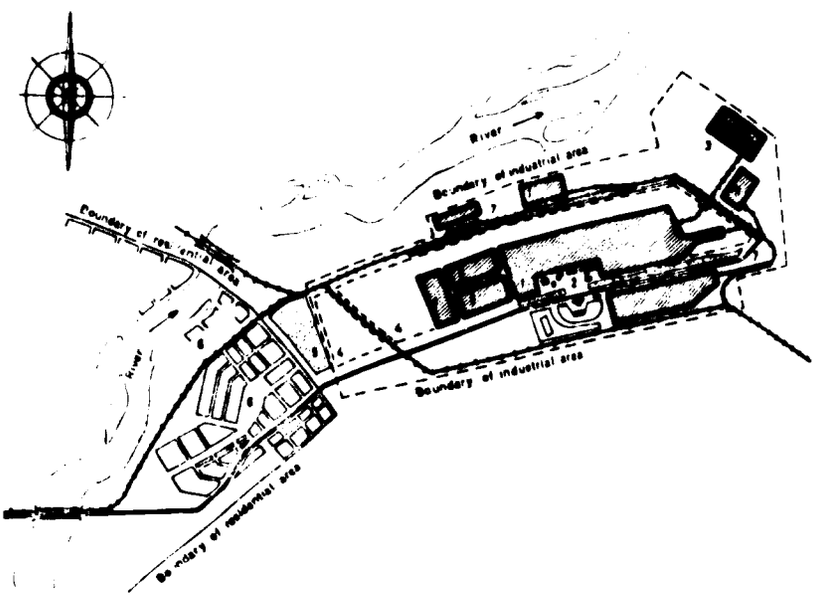
1 — Industrial area; 2 — Community centre; 3 — Buffer zone; 4 — Residential area.

Figure 3. Urban industrial area located on the outskirts of the residential area



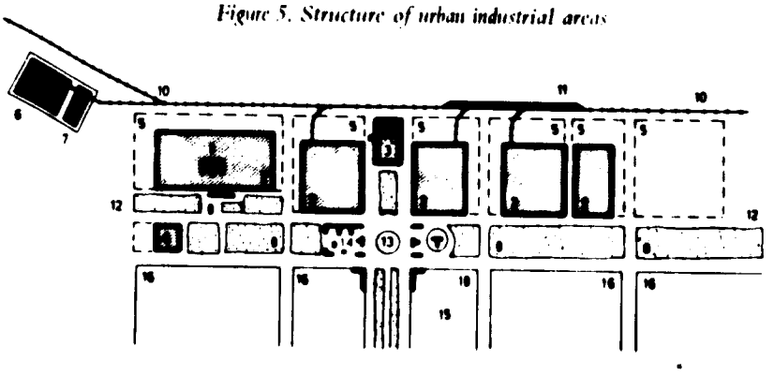
1 — Industrial area; 2 — Community centre of the industrial area; 3 — Reserved area for future use; 4 — Buffer zone; 5 — Residential area; 6 — Railway yards.

Figure 4. Urban industrial area located at a distance from the residential area



1 — Industrial area; 2 — Community centre of industrial area; 3 — Dump area and scrap-processing plants; 4 — Reserved area for future use; 5 — Landscaped area and buffer zones; 6 — Residential area; 7 — Railway yards.

Figure 5. Structure of urban industrial areas



1 — Site of discharge of harmful production wastes; 2 — Industrial plants; 3 — Co-operative heating and power station; 4 — Co-operative motor pool; 5 — Reserved area for future use; 6 — Dump area; 7 — Facilities for processing industrial wastes; 8 — External buffer zone; 9 — Internal buffer zone; 10 — Railway line; 11 — General freight yards; 12 — Motor road; 13 — Industrial community centre; 14 — Scientific and technical centre; 15 — Landing place for helicopters; 16 — Residential area.

protection of the residential zone from harmful industrial wastes), power and warehouse units, transport facilities, cultural and service institutions, educational and research institutions, and technical-servicing units (see figure 5).

The approximate distribution of land use in a region is as follows:

	Per cent
Industrial plants and associated units	50–60
Transport structures and facilities	7–10
Community, scientific and technical centres	3–5
Miscellaneous and landscaped areas	25–30

The network of cultural and welfare services within the industrial area is part of the larger unit serving the inhabitants. The large unit has the following purposes:

Management of production;
Research and design of production processes;
Worker training;
Cultural and welfare services.

The location of institutional units for the workers of an industrial area is dependent upon the nature of the unit and the radius of the area to be served. Alternatives are: location in a factory shop, in a plant building, or adjacent to the plant premises, and in the community centre of the industrial area.

The community centre of the industrial area should be situated beyond the limits of the buffer strips. Industrial plants without harmful wastes that are adjacent to residential areas should share a common community centre and thus enable maximum co-operation between cultural and welfare units.

The harmonious combination of industrial development and the creation of favourable living conditions for the inhabitants should be reflected in a general plan for town development. Industrial location should conform to this general plan and to the plans for regional development.

Part II

INDUSTRIAL LOCATION IN THE USSR

1. INDUSTRIAL LOCATION IN SOVIET ARMENIA

by M. A. Adontz[21]

Industrial development and location in the Armenian SSR are determined by the position of the region in the all-Union division of labour and by natural and economic factors. The combined effects of its geographical position, an average elevation of 1,800 m above sea level, and the several climatic zones in its boundaries, produce diverse natural conditions.

Armenia has rich deposits of copper, molybdenum, iron ore, aluminium, zinc and other ores. Among the many natural construction materials found in Armenia are basalt, granite, marble, pumice and perlite. Many of these deposits are mined; the development of other deposits is planned.

The water resources of Armenia are limited. Although the mean rainfall is seven times less than the mean rainfall for the USSR, the quantity of water necessary for irrigation of each hectare of cultivated land far exceeds the national requirements. Therefore, it is necessary to limit the development of production that requires considerable quantities of water, to accumulate and regulate the flow of rivers, to transfer water from districts where it is abundant to other districts that lack it, and to prevent pollution of rivers.

For each 100 km² of Armenian territory, there are 1.5 km of railroads and 27 km of motor roads. Due to insufficient development of railroads and the mountainous terrain of the region, 88 per cent of the freight is transported by motor vehicles. However, Armenia is favourably located for exports by railway to countries of the Middle East.

Among the advantageous conditions for the development of Armenia's national economy are the high growth rates of the population and the availability of labour resources. Since the Second World War, the average annual population growth rate exceeded 3 per cent, which is twice as large as the average growth rate for the USSR. The working-age group of citizens is 52–55 per cent of the total population. In 1968, the population density in areas between 390 and 800 m above sea level was 187/km². In order to reduce the further increase of population in the lower altitudes, it is expedient to confine new industries to locations between 1,000 and 2,000 m above sea level. Although these areas are not ideal for the development of agriculture, they are suitable for industrial development.

Pre-Soviet Armenia was an agrarian country. It produced agricultural products by simple methods. The industrial development was on a low level. The main industrial branches were copper mining, production of wine and brandy, and other food-processing branches. Light industry included cotton-ginning, hide-processing and carpet-making in small, semi-handicraft units. Industry contributed only 23.9 per cent of the national income and agriculture 76.1 per cent.

Industrial development of Armenia

In order to provide an energy basis for the industrial development, the water reserves of Lake Sevan were augmented by the construction of eight hydroelectric stations on the Hrazdan river, in addition to stations at Dzoraget, Leninakan, Shakin, Idjevan and elsewhere. All the power stations in Armenia are united in one system with centralized remote control. Armenia's energy system is included in the energy system of the Transcaucasus region. Its power resources are supplemented with energy obtained from Azerbaidzhan and Georgia.

Machine building is the industry with the highest rate of growth. Its output includes lathes, instruments, radio and electronic products and chemical equipment. Metalworking and repair plants are part of this industry as well. Favourable conditions for the development of the machine building industry include the availability of natural resources and skilled labour, and assistance from research institutes.

Non-ferrous metallurgy is a full-cycle industry. Its output includes refined copper, molybdenum concentrates, aluminium and aluminium rollings, lead and zinc concentrates and chemical by-products, such as sulphuric acid and copper sulphate.

[21] Director, Institute of Economics and Planning, Gosplan of the Armenian SSR.

The petrochemical industry has developed rapidly during the past ten years. Its production includes fertilizers and herbicides, synthetic rubber, fibres and polymer materials, resins and plastics.

The production of building materials has had a parallel development with expanded construction activities. Among the building materials produced in Armenia are marble, granite, pumice, cement, asbestos cement, lime, plaster and ceramic pipes. All techniques for the extraction and processing of stone and other building materials are mechanized.

The production of glass, porcelain and faience is based on large reserves of raw materials. Enlarging the capacities of the existing plants and production of crystal and high-quality glassware are planned.

The diverse output of light industry includes cotton, woollen and silk fabrics, knitted wear, stockings and hosiery, leather articles, shoes and other consumer goods. The raw-material basis for the further development of light industries has been increased by the output of the Armenian petrochemical industry.

The total volume of production of the Armenian food industry is surpassed only by the production of its machine building industry. The main branches of the food industry are wine and cognac production, canneries (fruits and legumes), dairy production, confectionery, baked goods, meat, tobacco and sugar production.

The important position of industry in Armenia's economy is indicated by its contribution of 64.1 per cent of the national income in 1967. The share of other sectors of the economy are: agriculture, 14.4 per cent; construction, 11.3 per cent; commerce, 8.1 per cent; and transport and communications, 2.1 per cent. The labour force was employed as follows: 35 per cent in industry, 30 per cent in agriculture, 12.2 per cent in service industries and the remaining 22.8 per cent in other occupations.

All industrial branches in Armenia have had a high rate of development. The mean annual growth rates of the gross output of the industry has been 11—12 per cent since the Second World War. Therefore the Armenian SSR closely approaches the Union's mean level of industrial production.

The planned direction of the national economy secured the rational territorial division of labour between the republics and the economic regions of the country. In this division of labour, the specialization of the industry of the Armenian SSR is characterized chiefly by the development of machine building, non-ferrous metallurgy and petrochemical industries, the building materials industry and several branches of the light and food industries.

According to the scope and intensity of economic relations, the Republic is divided into districts and integrated economic regions. Each district and region represent a definite co-ordination of economic relations. The districts coincide with the administrative districts. In each district are located the necessary industrial, commercial and cultural units.

The integrated economic regions include five to eight administrative districts with mutual economic and cultural relations. Industrial complexes with production plants and auxiliary branches are located in the integrated economic regions. The town that is the centre of the region influences the entire area. The integrated economic regions of the Armenian SSR are Ararat, Shirak, Lory, Sevan and Zanguezour.

Ararat Region

Ararat region is the largest integrated economic region in Armenia. It includes the Ararat, Artashat, Massis, Echmiadzin, Octemberian, Ashtarak, Abaran and Abovian administrative districts. The Ararat economic region is the main area for the cultivation of grapes, vegetables and fruits. Most of the Republic's production of wine, cognac and tinned foods is from this region.

Although large radio and electronic plants are located in the Bovian and Echmiadzin districts and several petrochemical plants are being constructed in the Massis district, the industrial development is greatest in the capital Yerevan. It is a large centre of machine building, petrochemical, and light and food industries. Branches of these industries are located in most of the other districts. Furthermore, Yerevan is the largest cultural and scientific centre of the Republic. Although the majority of technical personnel and skilled workers are concentrated in Yerevan, specialists and technical help are available to all districts.

Shirak Region

The centre of the region is the town of Leninakan, which is the second largest town in Armenia. Shirak region includes the administrative districts of Akhourian, Ani, Artik, Amassia, Ghougassian and Talin. Several branches of the machine building, building materials, and food and light industries have developed in the region.

Lory Region

The town of Kirovakan is the centre of the region. Lory region includes the administrative districts of Alaverdi, Noyemberian, Spitak, Stepanavan, Gougark and Kalinino. Kirovakan is one of the largest petrochemical centres. It is the location of a synthetic fibre factory and a petrochemical complex that produces ammonia fertilizers and synthetic materials. Branches of non-ferrous metallurgy, machine building, and food and light industries are located in Kirovakan.

In the Alaverdi district are located a copper refinery, a mining and metallurgy complex and a factory producing fire-proof material. Factories producing high-quality Swiss cheese are located in the districts of Stepanavan and Kalinino, wine factories and canneries are in the district of Noyemberian, whereas the sole sugar refinery in the Republic is in the Spitak district.

Zanguezour Region

The Zanguezour region is the centre of Armenia's mining industry. Rich deposits of molybdenum, copper, zinc and rare metals are found in the Kafan, Meghri and Sissian districts, and deposits of iron ore in the Goris district. Plants for processing molybdenum and copper ore employ male workers, while women are employed in light and food industries.

Sevan Region

Sevan region includes the Hrazdan, Sevan, Martuni, Vartenis, Krasnoselsk, Idjevan, Shamshadin and Kamo administrative districts. Favourable factors for the industrial development of the region are its location as the terminus of the recently constructed Yerevan-Sevan railway, adequate power sources and rich mineral deposits. The output of plants in the Sevan Region includes lathes, machines, wooden furniture and glass fibres. Furthermore, electrical engineering, and food and light industries are located here.

On the basis of natural resources in Hrazdan district, a large chemical complex is being built for the production of aluminium, cement and other products. On the basis of the Soudaguian deposits of high-quality iron ore, metallurgy is being developed. An experimental plant for the production of precision and electrotechnical steel has been constructed. Large-scale extraction of gold is taking place near Zod.

CONCLUSION

The economic regions of Armenia have the following specialized industrial development:

Ararat region—machine building, petrochemical, wine and cognac;

Zanguezour region—non-ferrous metallurgy;

Lory region—petrochemical and non-ferrous metallurgy;

Shirak region—textiles and machine building;

Sevan region—mining and petrochemical.

Although industry is not equally distributed in Armenia, no region is wholly agrarian. The industrial development of Armenia will continue at a high rate of growth with an accelerated rate of development for small towns and poorly developed districts.

2. INDUSTRIAL LOCATION IN THE GEORGIAN SSR

by G. G. Grelesiani[22]

The location of industry in the Georgian SSR was determined by the all-Union division of labour and by local factors. The economic geography of the Republic was created by the mutual interaction of these factors.

The main area of industrial location is the narrow lowlands between mountain ranges that occupy about one-third of the total area of the Republic. Tbilisi and Kutaisi are the most significant industrial centres. Almost all of the large industrial plants are concentrated in these centres.

In Tbilisi, the dominant industries are engineering, metallurgy, light and food. The following large engineering plants are located in Tbilisi: electric locomotives, aircraft, machine tools, agricultural and food engineering, electrotechnical and instrument making. Silk, wool, knitted fabrics and tanning branches of light industry are located in Tbilisi, as well as wine (including brandy and champagne), dairy, meat, baking and confectionery branches of the food industry.

After the Second World War, a large metallurgical plant was built in the ancient Georgian town Rustavi, near Tbilisi. It includes the complete metallurgical cycle and produces coke, cast iron, steel, steel pipes and rolled metal. The Rustavi metallurgical works have been the foundation for the development of the petrochemical industry in Georgia. The Rustavi fertilizer plant supplies the entire Transcaucasus region with ammonia saltpetre.

In Kutaisi, engineering is the leading industrial branch. Automotive, electrotechnical and chemical plants are located in Kutaisi.

Growing industrial towns west of Tbilisi include: Kaspi, with cement, slate and electrotechnical plants; Gori, with a cotton mill, cannery and instrument plant; Agara, with a sugar refinery, Khashuri, with a glass plant, as well as a haberdashery and plastics factory under construction. Near Kutaisi are large mines of high-quality manganese in Chiatura, coal mines in Tkibuli and a large ferroalloy plant in Zestafoni.

A number of industrial towns are located on the Black Sea coast, e.g. Batumi (petroleum refining and engineering) and Poti (flour mill and electrotechnical plants). A unique industrial zone is located on the Black Sea coast between the Adjarian and Abkhazian autonomous Republics, where there are many food-processing plants for subtropical agricultural products (tea, tobacco and citrus fruit). Another unique location is found in the eastern part of the Republic, where small industrial centres in Kakhetia have a developed wine-making industry.

Thus Georgia can be divided into the following three areas of industrial development:

Central industrial zone. Rustavi, Tbilisi, Kaspi, Gori and Khashuri are the industrial centres. It is the zone with the largest concentration of industry and the most favourable conditions for location of large-scale industry. The annual output of the central zone accounts for 67 per cent of the total ferrous metallurgy production, 62 per cent of the engineering production, 71 per cent of the petrochemical production and 70 per cent of the building materials.

Kolkhidian zone. The towns of Batumi, Poti, Sukhumi, Zestafoni and Chiatura are in this zone. In the western part of the zone, the dominant food industry is based on local agricultural products, while the development in the eastern part includes hydropower stations, engineering, electrometallurgy, mining, silk- and wine-making industries.

Eastern industrial zone. This is primarily the location of the wine-making industry, which accounts for 87 per cent of the total industrial production of the zone. There are small petroleum fields in the Tsitelitskaro district.

Thus the geography of Georgian industry illustrates both concentrated and dispersed forms of location. The former is shown by the three principal industrial centres, and their concentration of industries that produce more than 55 per cent of the gross output of all Georgian industry:

Tbilisi–Rustavi (ferrous metallurgy, petrochemical, engineering, building materials, light and food industries);

[22] Head of the Department, Institute of Geography, Academy of Sciences of the Georgian SSR.

Zestafoni—Chiatura (mining, electrometallurgical, electrotechnical and wine-making industries);
Kutaisi—Tkibuli (coal-mining, engineering, light and food industries).

The development of many branches of the mining, food and building materials industries shows a dispersed form. Proximity to the raw-material sources is necessary and indicates the optimal location.

The uneven distribution of industry in Georgia is a result of the mountainous relief of two-thirds of the total area, which is unfavourable for the development of large-scale industry. In the lowlands, the availability of transport, communications, labour and power resources provided favourable conditions for development.

The proximity of areas of population and production with resources precludes the necessity of transporting the labour to the location of resources, or vice versa. Industry developed in the old towns of Tbilisi, Kutaisi, Batumi, Tshinvali, Poti, Samtredia, Tkibuli, Zugdidi, Zestafoni and Sukhumi, as well as in the new industrial centres of Rustavi, Tkvarcheli and Vale.

Of the 102 urban settlements in Georgia, the five cities of Tbilisi, Rustavi, Kutaisi, Batumi and Sukhumi produce 60 per cent of the total gross industrial output of the Republic; 19 towns produce 19 per cent of the total output, while the remaining 77 towns produce only 21 per cent of the total output. These data show that industry is concentrated in a few large centres.

The rational use of labour resources requires the further location of industry in the smaller towns of the Republic. The industrial development of smaller towns has many long-range aspects for the economic development of the Georgian SSR. Although many small towns have favourable conditions for industrial location, town planning and urban development are prerequisites for industrial development. New industrial plants are being constructed in Kaspi, Khashuri, Samtredia, Zugdidi, Tskhakaya, Tsulukidze, Sagaredjo, Tsnori, Gurdjaani, Telavi and other towns.

Industrial development in the Georgian SSR is characterized by a high level of specialization. About 70 per cent of the industrial output is exported from the Republic to other regions of the USSR.

The main specialized branches of Georgian industry are manganese mining (33 per cent of the total national production) and production of ferroalloys, engineering (95 per cent of the total national production of electric locomotives in addition to machine tools and electrotechnical products), and the food-processing industry (95 per cent of the total national production of tea as well as tobacco, wine, edible oils and mineral water). The production of pipes and some branches of light industry are approaching the necessary level of specialization.

In contrast to the high level of specialization is the relatively small degree of complex development. The internal economic integrity and interconnection of industrial branches have not been attained. Difficulties are presented by the inadequate local fuel base which must be supplemented by fuel transported from other republics. Furthermore, branches of the petrochemical, engineering, wood and building materials industries are not sufficiently developed to supply the Republic's demand.

The achievement of comparative economic advantage in industrial location is illustrated by the Rustavi metallurgical plant. Although its production costs are higher than those of some metallurgical plants in other regions, the Rustavi plant is significant in the economy of the Georgian SSR, because it is the basis of an industrial complex with the following output: nitrogen fertilizers, caprolactum, synthetic fibres, machines, cement, reinforced concrete constructions and other building materials. Additional plants to produce carbamide, potassium permanganate and manganese dioxide are planned.

Georgia has industrial and economic ties with most of the republics of the USSR. The strongest economic connections are with the RSFSR (45 per cent of the total exports and more than 65 per cent of the total imports) and with the Ukrainian SSR (about 20 per cent of the total exports and 12 to 13 per cent of the total imports).

However, the balance of exports and imports is not favourable for Georgia; it imports 11 to 12 million tons more than it exports. Since the value of exports exceeds the value of imports, the balance is positive.

As a result of economic development, the Georgian SSR exports goods to more than 65 foreign countries. Its industrial development will continue to progress in the future.

3. INDUSTRIAL LOCATION IN UZBEKISTAN

by S. M. Khodzaev[23]

In pre-Soviet Uzbekistan, the economy was centred on the production and local ginning of cotton. The gins and plants to extract oil from the cotton seed were concentrated in the Ferghana Valley, Tashkent and Samarkand districts.

The economic development of Uzbekistan was initially centred on improving the traditional cotton-growing industry, which is the leading industrial branch. It formed the nucleus for an economic complex with cotton-ginning, oil extraction from cotton seed, machine building, chemical, power, textile and food industries.

The location of industries proceeded as follows:

(a) Processing plants were built in agricultural areas in order to reduce transport costs by the proximity to the source of raw materials;

(b) Industrial plants were built in consumer areas;

(c) The necessary power base to expand industry was developed by building hydroelectric stations, which used the abundant water resources;

(d) Mineral deposits were surveyed;

(e) The local building materials industry was organized;

(f) Plants for processing waste material and other auxiliary plants were built;

(g) The cotton gins and silk factories were modernized.

The development of the cotton-growing complex required industrial equipment to be delivered from the developed economic regions and the training of local technicians. The latter problem of increasing and training specialists was a part of the general problem of the Republic's industrial development, in which the entire industry had to be modernized at the same time as specialists were being trained. A first step in this direction was a literacy campaign, through a wide network of schools and study groups. Individuals and teams from the industrial centres of the country shared their experience and helped train local workers.

Substantial changes in the locations of industries in the Republic took place during the Second World War; 90 factories were moved to Uzbekistan from the western and central areas of the country. They formed the basis for large machine building plants. New branches of industries that developed at this time included coal mining, ferrous and non-ferrous metallurgy, petroleum extraction and refining, and petrochemicals. The two factors that were always considered in the location of industrial centres were the Republic's requirements for an industrial product, and the presence of raw materials in the Republic, or in a region adjoining it.

The petrochemical industry developed on the basis of large reserves of natural gas and the growing demand for its products. In addition to natural gas, other raw materials used in the petrochemical industry are: sodium chloride, potash, limestone, gypsum, sulphur, and the waste material from ferrous metallurgy, petroleum and cotton-ginning industries, and from cotton growing. These raw materials and cheap electricity made possible the production of synthetic fibres, artificial silk, synthetic resins, plastics, chemicals and defoliants.

The development of the non-ferrous metallurgical industry was promoted by the following favourable conditions: thorough surveys of copper, lead, zinc, aluminium, manganese, tungsten, molybdenum and rare-earth deposits, the availability of highly skilled technicians and engineers, and inexpensive power. Uzbekistan has the largest number of registered ore deposits and reserves of non-ferrous and rare metals of all the republics. It is quite probable that additional reserves of copper, tungsten and gold-bearing ores will be surveyed. In the development of the mining industry, tungsten and molybdenum ores have been extracted since 1935, fluorite since 1941, lead and zinc since 1952 and copper since 1959.

The mining of non-ferrous ores has been augmented by the development of the metallurgical industry. Continued development of the metallurgical industry will produce end-products of rolled copper and heat-resistant metals, lead and zinc, as well as alumina for aluminium production.

The development of new branches of heavy industry changed the structure of industry in the Republic. Al-

[23] Head of the Department, Institute of Economics of the Uzbek SSR.

though the number of light and food industries increased, their percentage in the total industrial production declined in favour of heavy industry.

Regional industrial complexes are a result of these structural changes. Plants in a given branch are grouped in industrial centres on the basis of planned locations. Auxiliary services are shared by plants in the industrial centre, thus reducing basic construction costs, as well as production costs. The following industrial districts are being formed as production complexes: Tashkent, Bukhara-Navoii, Angren-Almalik, Ferghana, Andijan, Samarkand and Nukus-Hodjaili.

The level of development in all the industrial complexes of the Republic is not the same. Tashkent is the most developed industrial complex, primarily because it is situated at the terminus of the sole railway in Uzbekistan and Central Asia that links the Republic with the European part of the country. In addition, hydroelectric power was developed in the Chirchik river basin and traditional craftsmen and artisans contributed their skills to the development. The high rate of development was furthered considerably by the evacuation of many plants to Tashkent during the Second World War.

In the Angren-Almalik industrial district the following branches form the basis of industrial development: non-ferrous metallurgy, coal mining, building materials, power industries and the petrochemical industry. In this district are surveyed reserves of copper, lead, zinc, molybdenum, fluorite, rare metals, coal, kaolin clay and raw materials for the building materials industry.

The following characteristic features of the mineral deposits favour the industrial location of production complexes:

(a) The concentration of deposits of different minerals in small areas and close to the surface (coal, kaolin clay and non-ferrous ores) permits open-pit mining;

(b) The availability of inexpensive fuel and power resources;

(c) Deposits of kaolin clay above and below seams of coal are convenient for extraction of both resources;

(d) Deposits of mixed ores contain a considerable quantity of rare elements.

In the incipient industrial centres of Angren, Almalik and Ahangaran, plants and branches form a complex to process raw materials and manufacture end-products. An example of this interrelation is the production of mineral fertilizer on the basis of sulphuric acid that is a by-product of non-ferrous metallurgy.

The Angren industrial centre includes a coal mine, a thermal power station, a reinforced-concrete parts plant, an asphalt plant and repair shops. The large Altin-Topkan industrial complex in the Almalik centre includes 15 plants that use common raw materials and waste products. Among them are copper and lead-zinc mills and smelters, plants for concentrating copper, lead and zinc, a thermal power station, a lime plant and a plant that produces sulphuric acid. The Ahangaran industrial centre of six plants includes cement and tile mills and a reinforced-concrete parts plant. The extractive industry is developed in the Ahangaran river basin.

Small towns with 13,000 to 15,000 inhabitants are centres of local economic districts. Old towns, such as Khiva, Turtkul, Karshi, Chimbai and Biruni, as well as new towns such as Chirchik and Navoii, have small production plants that employ some of the rural population.

Thus, industrial location in Uzbekistan is part of the all-Union co-operation. The development of transport and economic ties with other republics has furthered the continued industrialization of Uzbekistan.

4. INDUSTRIAL LOCATION IN THE BYELORUSSIAN SSR

Regional planning

by V. F. Medreder[24]

Planning in the Byelorussian SSR has evolved in several historic stages from simple assumptions and annual plans for a given sector to long-term perspective plans for the national economy. The following types of economic plans are used: long-range, perspective projections, medium-term, five-year plans and annual, operational plans.

General, perspective projections for the development of the economy during a period of 10 to 15 years or more give a long-range orientation of the economic development and provide the basis for the more efficient use of resources. These projections consider complex problems, such as the efficiency of the regional specialization, the conditions for the development of urban settlements, the probable efficiency of new production complexes, the main trends of agricultural development, estimates of production and consumption balances for the most important industries by districts, and an estimate of the capital investments.

Five-year plans reflect the direction, production volume and growth rates for individual sectors of the economy, and the national economy as a whole, as well as changes in industrial locations. Although each five-year plan has its particular tasks and features, experience has indicated that a five-year period is the optimal time span during which major innovations can be successfully introduced into production processes.

The detailed, itemized five-year plan is determined by scientifically based norms and indicators. The system of plan indicators must satisfy the following conditions:

Reflect the direction and trend of sectoral, regional and over-all economic development;

Mobilize the resources of all units from the apex to the base of the economic pyramid;

Indicate the specific characteristics and features of each economic unit, sector, district and the Republic as a whole;

Ensure co-ordination between units and sectors;

Exhibit a unified method;

Provide flexibility for systematic improvement.

Annual, operating plans take into account the previous fulfilment of aims to prevent disproportionate success in the attainment of long-range goals. The sections of the annual plans are composed of the following groups:

Sectoral plans;

Regional plans;

Consolidated plans that cover manpower, wages, investments etc.

Regional plans ensure rational industrial location in the Republic and the balanced development of districts. During recent years, the interbranch balance has been used to analyse the pattern of the national economy. Although considerable experience has been gained in interbranch planning, the method is still at the experimental stage.

Optimization of economic specialization and the national economic pattern are achieved by using criteria for the economy as a whole as well as interregional calculations. However, calculations for specific conditions, which ensure a choice of preferable solutions, are based on a separate interbranch balance.

The indicators of the national economic plan are compiled by the method of "counter-planning" on the basis of economic data from regional economic units and departments as well as data from scientific and executive planning bodies. On the basis of data from economic units, proposals are drafted for the maximum use of resources and the development of the existing production capacities with local, natural and labour reserves. Research data are used to take into account the demand for specific output in a given region or in the country as a whole, the availability of resources, the relative efficiency of various technological methods, alternative production and industrial locations. Furthermore, the following significant, consolidated economic indicators are determined: the relationship between gross social product and national income, the breakdown of the latter into accumulation and consumption components, the growth rates of production and the planned level of consumption.

[24] BSSR State Planning Committee, Minsk, USSR.

Theoretical and practical criteria for the development of particular plants, sectors, districts and the national economy as a whole are elaborated in Byelorussia on the basis of the laws of economic development. The policy and practice of economic development may in particular cases depart from the principles on which planning is based, but the methodological foundations of planning must correspond to the requirements of the objective laws underlying the general line of economic development.

The choice of a new industrial location requires consideration of variable factors (including the improvement of existing plants) and determination indices of comparative economic efficiency and national advisability. After completion of this task, industrial branches are grouped by the concentration of labour resources and consumption of goods and by sources of raw materials, fuel and electric energy. This classification is the basis of the economic analysis of separate factors, since attention is focused on the one or two most significant economic components of each branch.

Accordingly, when choosing variable factors, it is necessary to use comparative indices of energy capacity, consumption of raw materials and labour, as well as more complex derivatives, such as the combined consumption of energy and labour, or of raw materials and labour. The resulting advisability of developing industrial branches is expressed through the maximum national economic efficiency.

When choosing the variable factors for location of a branch and a plant the above criterion may be modified, in particular, the maximum profit or minimum total costs. The total expenses are calculated by the formula:

$$H \quad C + \Sigma K + T,$$

where C is the current costs per unit of production,
K the specific capital investments,
Σ the branch normative coefficient of comparative efficiency of capital investments, and
T the transport costs.

In calculating the comparative economic efficiency, the general coefficient of efficiency 0.15 (corresponds to a normative period of compensation during seven years) has been used. In calculating the total expenses, both for prime costs and capital investments, all expenditures are taken into account, including costs of production, transport, storage, losses etc.

As a result of the comparative estimation of variables in industrial locations, areas with the most favourable conditions are determined, as well as the industries to be modernized or constructed. Detailed study of the economic development of the area is a prerequisite to industrial location. In addition, the problem of industrial location requires that production efficiency must be ensured by rational industrial specialization.

Thus, effective industrial location depends upon branch and regional planning. The economic efficiency of industrial location is increased, due to a more rational use of raw-material and energy resources, planned redistribution of population, and labour resources for their most effective use in production, regard for advances in science and technology, introduction of technological improvements, and means of technological and economic substantiation of industrial location.

Since industrial location is dependent on many factors, effective solutions of the economic problems can be obtained by application of econometric methods and computers. The econometric methods (especially nonlinear programming) present a choice of the most effective location from planned alternative locations. The optimum plan of development and location that ensures minimum costs, while obtaining maximum results, cannot at present be practically presented as a unique model, or a system of models, since some problems of econometric models remain unsolved.

Plans for the development of the Byelorussian economy are closely co-ordinated with the requirements of the Soviet Union's national economy as a whole and with those of particular sectors and districts of the Republic. The general State plan for the development of the USSR economy is prepared, both by sectors and by regions. This principle is likewise used in drafting plans and projections for sectoral and regional development in the Republic. Thus it is possible to:

Take full account of the regional resources and the economic and historical conditions;

Ensure rapid growth rates for the leading sectors of industry and agriculture;

Modernize all sectors of the economy;

Increase the efficiency of capital investments and improve the use of material, natural and financial resources;

Reduce production costs by a substantial increase in production, with minimum outlay;

Ensure industrial specialization and co-operation with the development of the USSR economy.

The co-ordination of plans promotes harmony between the country's general interests and the national interests of the Republic. It does not restrict economic initiative in Byelorussia but provides active economic opportunities and improves the territorial division of labour.

In the national economic plan of the USSR, targets for the republics comprise the following indicators: gross industrial production, the volume of agricultural production, capital investments, and a few others. However, the Republic is responsible for the allocation of investments, the volume of agricultural production and the sectoral and regional budgets. The Republic's economic independence is manifest in the emphasis of priority development for those sectors which represent Byelorussian specialization within the system of the All-Union division of labour.

Policy and goals

by A. P. Koloshin[25]

The most important condition for the intensive development of the national economy is a correctly chosen and precisely formulated policy of regional planning and industrial location. The complex task of formulating a correct policy of regional development requires comprehensive research.

Precise data must be available on the raw-materials base, water and energy supply, and the availability of skilled and unskilled labour. The requirements of a given stage of development and concrete tasks determine the economic, social and political trends of regional development.

The final stage in formulating a policy of regional planning and industrial location is the preparation of preliminary forecasts, models and schemes for the development and location of the national economy. After a detailed examination and discussion of the proposals, the policy and objects of regional development and location of production are determined as the basis for comprehensive, short-, middle- and long-range plans. Detailed objects and methods are given, with separate indices of resources, and the main lines of their distribution, volumes of production, consumption, standards of living, internal and external economic ties and other factors.

The main form of regional planning is the long-term plan, which is prepared for five years or longer periods. The State Plan of Byelorussia envisages the development of all branches of the national economy. It includes the main trends in the following areas: technological development, industrial development and location, agriculture and forestry, transport and communications, capital investments for construction, labour and wages, and the increase in the standard of living and training of skilled workers.

The balance method of planning is a valuable tool, since it permits the determination of the balances of material, costs and labour in the national economy. By ascertaining material balances, the actual volume of material exchange between production branches can be determined. By means of cost balances the ratios in distribution and national consumption, as well as the national and individual incomes and expenditures, can be determined. Manpower balances provide a basis for planning the distribution of labour resources.

The most important development objectives in the general scheme for the Byelorussian economy during 1971–1980 are as follows:

Complete and rational use of natural resources of the region, in particular, acceleration of the study and industrial use of petroleum, rock and potash salts, and other mineral resources, the development of plants for wood processing and the use of industrial wastes;

High rates of growth in all branches of the economy, with a higher standard of living for the citizens;

Improvement of the structure of industrial and agricultural production by expanding existing branches and creating new branches, industrial specialization, raising the complexity of the economic development, expanding intra-regional and interregional ties, increasing the volume of production for export in addition to the further development of the most effective forms of transport, i.e. automotive, pipeline and electric;

Improvement of industrial location by constructing new plants, mainly in medium-sized and small towns.

During this period, the following industries form the basis of the Byelorussian economic complex: machine building, petroleum extraction and refining, petrochemicals, light and food.

A system of micro- and macro-economic models and mathematical methods are a component of planning the economic development of the Republic. The system embraces the entire economy and its separate functional elements of branches, regions, towns and individual plants. The solution of these problems, requires the prior solutions of other problems such as the future growth of towns and the evaluation of economic factors and natural conditions affecting the development of towns, the determination of the optimum growth of the urban population, labour reserves and possibilities for increasing the number of employees in the national economy, co-ordination of the development of towns and industrial location and the assigning of priorities for the industrial development of separate groups of towns and the nature of the industrial development.

One of the features of industrial location after the Second World War was the relatively high concentration in large towns. A considerable part of industry was concentrated in the capital Minsk, and the district centres of Gomel, Vitebsk and Mogilev, and in the new towns of Bobruisk, Borisov and Orsha, which had been developed earlier in the pre-war years.

However, the Republic contains 23 large and medium-sized towns and more than 50 small towns with less than 20,000 inhabitants. The development of small and medium-sized towns is necessary to improve industrial location, to increase the organizational level of the urban economy and to use labour resources more effectively. The location of plants employing less than 1,000 workers in small towns meets all these requirements. Likely candidates include specialized plants for instrument construction, plastic processing, machine building, knitting mills, and food and light industries. The industrial development of small towns in Byelorussia is facilitated by a unified power system, in which all towns are included, and by improvements in the transport

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system. During the 1961–1965 five-year plan, about 60 per cent of the new, large and medium-sized plants were located in small and medium-sized towns.

At the present time new industrial plants are largely located in industrial areas. These areas are designed in a single architectural plan that organically ensures good communications and transport to all districts of the town. In addition, the creation of industrial areas in a number of towns enables regulation of the engineering economy of these towns and the availability of improved cultural and welfare services for the citizens. New industrial areas are being constructed in the towns of Vitebsk and Brest, Mogilev and Bobruisk, Pinsk and Molodechno, Borisov, Mozyr and Novopolotsk.

The planned basic trends in the development of towns and industrial locations have facilitated a steady, high rate of industrial growth. The planned management of the economy and the training of specialists have been significant factors in the industrialization of the Byelorussian SSR.

Econometric models and methods

by V. F. Medvedev[26] *and V. A. Kagan*[27]

Econometric models and methods are used in the long-range planning of industrial location and development in the Byelorussian SSR. Optimal planning requires the observance at all levels of the plan optimum principle, i.e. conformity of an accepted economic criterion to the final objects of planning. The most effective method of obtaining optimal plans is to compare a number of alternatives. The technical and economic parameters can be varied by a computer, which formulates a number of plans and selects the best plan by special mathematical apparatus. This apparatus is an interrelated system of econometric models, numerical methods, algorithms and programmes.

The most important element in the theory of optimal planning is the construction of a system of econometric models and practical mathematical methods for computer solution. The model is a mathematical expression containing variables whose behaviour is analogous to a real system. A mathematical model gives a set of mathematical relationships which describes all available plans.

Structural econometric models for industrial development and location in Byelorussia are used, both for branches of the national economy and for separate industrial plants. Successive implementation of the hierarchical system of vertically linked structural models is the way to optimize the entire planning system. The optimization of long-term plans for the development of the national economy requires successive implementation of the following stages:

(a) Formulation of the problem and choice of the optimum criterion;
(b) Introduction of the actual economic conditions into the mathematical model;
(c) Application of numerical methods, algorithms and problem solution programmes;
(d) Preparation of initial information for the solution of the problem in accordance with accepted computer methods and programmes;
(e) Solution of the problem on the computer and subsequent econometric analysis of the results;
(f) Decisions by economic bodies.

Differences in the formalization of long-term planning problems of industrial location in mathematical models originate from the following factors:

(a) The number of commodities considered in the problem (single-commodity and multiple-commodity);
(b) The formulation method of alternative production capacities (discrete and continuous);
(c) The model of component criteria (transport-production, production and transport);
(d) Static and dynamic time factors (fixed periods and varying periods);
(e) The subsystem of the problem (single- and multiple-step).

The aim of long-term planning is to obtain a maximal effect. The results are indicated by quantitative parameters that are inherent in each alternative. The concept of the optimal criterion is derived from an objective evaluation of an alternative's effectiveness. The choice of the optimal criterion has a considerable effect on the formulation of a concrete problem. Thus each planning level has its characteristic local criteria. However, local criteria of optimality are not permitted to introduce contradictory factors into the econometric models. Optimal criteria in long-term industrial location are the total costs of production and transport, profit and amortization of capital investments.

The economic problem of industrial location may be formulated as follows. Demands for the product in the territory are calculated. Capacities of existing plants and possible alternative developments are determined. As a result of calculating factors ensuring labour resources, energy supply, the availability of building sites etc., possible locations are plotted. For each location, possible capacities are determined with corresponding indices of production costs per unit of output and specific capital investments. Transport costs are calculated for delivery of a unit of output from each production point to each consumer. An alternative must be found for improvement and development of existing plants, the location and volume of production of new plants, as well as a scheme of output deliveries, in order that consumers may be supplied with products at a minimum total cost.

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Mathematical models and methods have been used in the Byelorussian SSR in planning the location of the following industries:

Light industry (flax-processing and clothing plants);

Machine building and metalworking automotive assembly and repair, and machine (repair shops and centralized foundries);

Electrotechnical industry (electrical-appliance repair shops);

Agriculture (specialized shops for repairing agricultural machines and tractors);

Construction industry (plants for the production of wooden panels and reinforced concrete products);

Food industry (bakeries, breweries, dairies and meat-processing plants).

The solution of these problems of industrial location on the computer "Minsk 22" has shown adequate convergence of the algorithms (see table 1).

Table 1

PARAMETERS (DIMENSIONS) OF CERTAIN PROBLEMS OF INDUSTRIAL LOCATION AND COMPUTER TIME FOR SOLUTION

Number of locations	*Number of consumers*	*Number of possible plant capacities*	*Computer time (minute)*
11	28	8	21
20	28	14	12
11	28	7	51
12	28	8	21
16	28	7	31
16	28	9	21
24	62	8	160
9	22	6	51
10	20	5	51
22	22	8—10	26.2
40	30	4—8	50
44	99		300
35	117		350

By constructing optimal plans of industrial development and location, it is possible to find alternatives in which total cost is reduced by 10 to 12 per cent. Programmes for solving algorithms allow exact and approximate solutions. As can be seen from table 1, the parameters of problems (dimensionality) solved in the Byelorussian SSR are comparatively small. When solving large-dimension problems on the computer, the existing algorithms are not sufficiently effective because they converge slowly.

An important feature of the algorithms used by planners in the Byelorussian SSR is the possibility of obtaining groups of optimal alternatives for a selected criterion. The groups of alternatives are given in order of acceptability.

As an exemplary problem, consider the optimal location of specialized repair shops for grain harvesters. In static formulation, let m represent the number of possible locations of repair shops ($i = 1, 2 \ldots 11$) and n the number of exchange points ($j = 1, 2, \ldots 99$). The set of possible capacities for a shop located at the ith point is $\{a_{ih}\}$, $h = 0$, 100, 300, 500, 1,000, 2,000, 3,000. The converted costs for the ith shop are $\{f_i(a_{ih})\}$, $h = 1, \ldots, r_i$ (see table 2).

The requirement for repair at the jth exchange point is b_j. The transport costs for a unit of spare parts from the jth exchange point to the ith repair shop are C_{ij}. The volume of goods transported from the ith exchange point to the jth repair shop is x_{ij}.

In conventional symbols the problem is to find a non-negative value x_{ij} minimizing the function

$$F(X) = \sum_{i=1}^{44} f_i\left(\sum_{j=1}^{99} x_{ij}\right) + \sum_{i=1}^{44}\sum_{j=1}^{99} C_{ij}\, x_{ij},$$

while observing the following conditions:

(a) Capacity of a repair shop at the ith point is taken from the given set

$$\sum_{j=1}^{98} x_{ij} \in \{a_{ih}\},\ h = 0, 1, 2 \ldots 3{,}900,\ i = 1, 2 \ldots 44;$$

(b) Requirements of the ith exchange point for repair are fully met

$$\sum_{i=1}^{44} x_{ij} = b_j,\ j = 1, 2 \ldots 98.$$

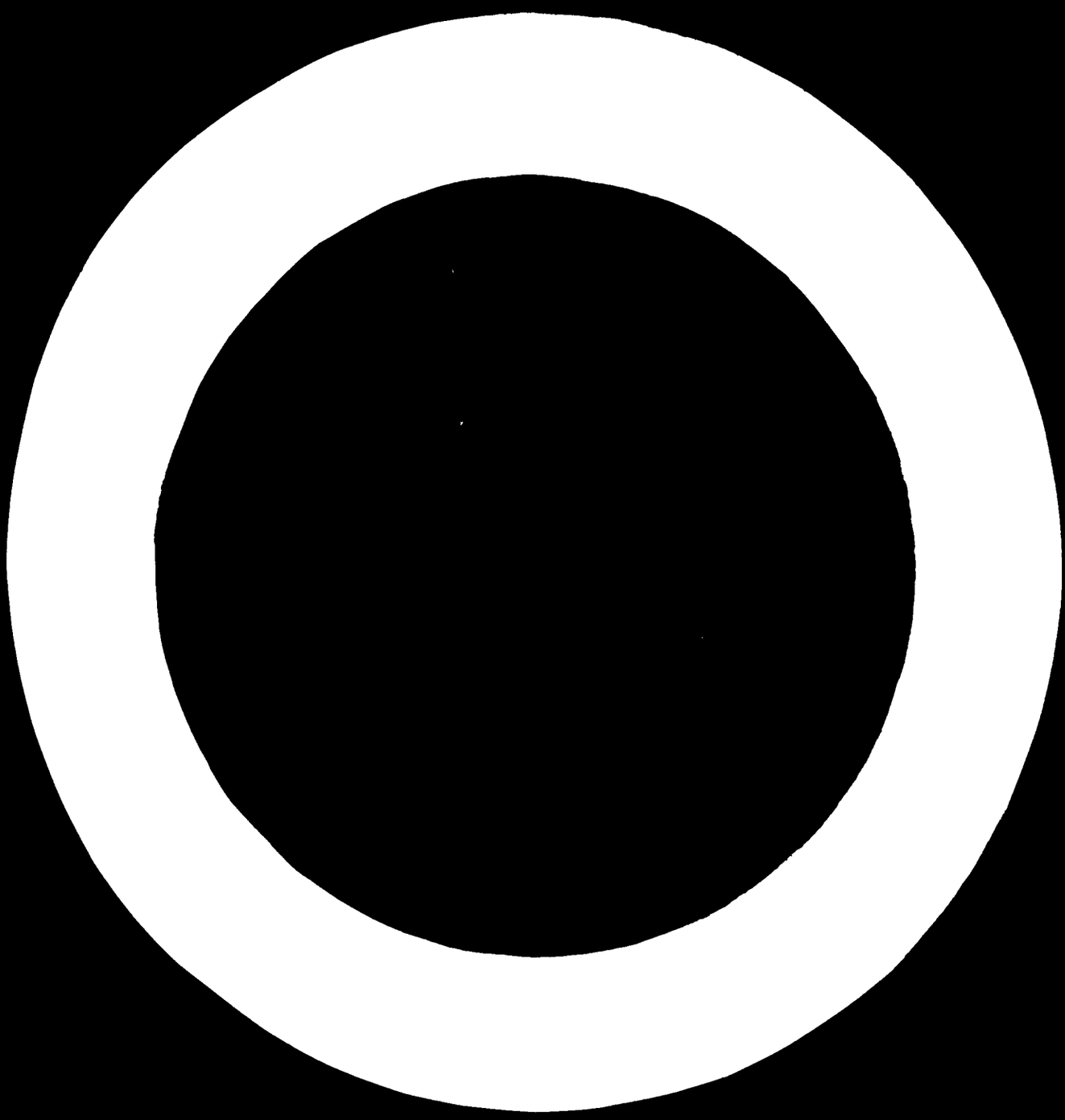
The conversion problem is solved by using an algorithm. The optimal alternative location is obtained; for the satisfaction of a total requirement for repairs equal to 8,700 units, four shops should be built with capacities of 700, 3,000, 3,000 and 2,000 units, respectively, at locations 4, 11, 26 and 29.

Table 2

CONVERTED COSTS (IN ROUBLES)[a]

Capacity	*Primary costs*	*Specific capital expenditures*	*Converted costs/unit*[b]	*Total converted costs*[c]
100	817	1,495	1,041.25	104,125
300	657	945	798.75	239,625
500	592	763	696.45	348,225
1,000	515	580	602.0	602,000
2,000	449	438	514.7	1,029,400
3,000	415	373	470.95	1,412,850
3,500	401	248	438.2	1,533,700

[a] The coefficient of efficiency is 0.15.
[b] The converted costs/unit are the sum of the primary costs and the coefficient of efficiency multiplied by the specific capital expenditures.
[c] The total converted costs are the capacity multiplied by the converted costs/unit.



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