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CLIMATE AS A FACTOR OF INDUSTRIAL LOCATION

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Locational factors work in the economic interactions of all the factors affecting each other. In some cases, one factor may play a predominant role in determining the industrial characteristics of an area, or in determining location of an industry. Climate is ordinarily regarded as a minor factor of location, but people often tend to give it more significance than it deserves, since it has strong influence on the human body and human living conditions.

The purpose of this paper is to discuss the general aspect of climate as a locational factor of industries. In sections 2, 3, and 4, physical and economic effects of climate on industrial activities will be described. In section 5, as an illustration, the climate of Hokkaido, the northern island of Japan, and its other locational factors will be briefly discussed in connection with the industrial development of Japan.

1. INTRODUCTION

Climate is usually defined as “the average state of weather conditions prevalent at any place or area,” with due recognition of the fact that deviations from the average are often of equal or even greater significance to man.⁽¹⁾ [3:58]

The climate of a place is determined by a number of elements, or

⁽¹⁾ Climate and weather, -- the phenomena to be considered are the same regardless whether one is concerned with the climate or with weather of a place; the difference lies in the length of time considered. Weather refers essentially to short periods -- a day, a week, a month or longer; Climate is concerned with average conditions determined by observations made over extended periods. [42:16]

Climatology is a science of climate, whereas meteorology is a science of weather. [30:5, 3:58]

component parts, such as temperature, precipitation, humidity, wind velocity, duration of sunshine, and other minor ones. These elements are the results of the interaction of a number of factors, or determining causes, such as latitude, altitude, wind directions, distance from the sea, relief, soil type, vegetation, pressure areas and air masses, mountain barriers, ocean currents, storm area, etc.⁽²⁾ [30:6. Also, 3:58] It is these factors that determine the climatic conditions for a particular locality and produce the individual types and varieties of weather. The climate of a particular place can be described by showing the nature and magnitude of the climatic elements--such as degree of temperature and its diurnal and annual range, the form of precipitation (rain, snow, sleet, etc.) and its amount, amount of moisture in the air, presence of salt in the moisture,

(2) One phenomenon can be either an element or a factor, depending on one's viewpoint toward the problem under study. [30:6]

(3) The climate all over the world is classified into several types. The classification is, however, somewhat different from one author to another. Following are examples.

Austin Miller [30:78ff]

A. Hot climates

1. Equatorial
2. Tropical, marine
3. Tropical, continental

B. Warm temperate or sub-tropical

1. Western margin (mediterranean)
2. Eastern margin

C. Cool temperature

1. Marine
2. Continental

D. Cold climates

1. Marine
2. Continental

E. Arctic climates

F. Desert climates

1. Hot deserts
2. Cold deserts

L. Dudley Stamp [42:37-80]

Climate of low latitude, or the tropical zone (hot lands)

1. Equatorial type
2. Tropical type

velocity of wind, presence of sand or dust in the wind, length of day-time, presence of fog, and other miscellaneous things. [11:113-120]

The most industrial development in the recent past occurred in the regions of relatively moderate and rather cool climate,⁽³⁾ such as the eastern United States and Canada, western Europe, parts of Japan and north China, and similar climatic spots in the southern hemisphere. Together with these facts, the rise and fall of the civilizations in the world history are often attributed to the climate and its changes over the area where these civilizations flourished, particularly to the effect of the climate on the physical and mental energy provided to human beings.⁽⁴⁾ The proposition that climate was the main cause of a civilization is a doubtful one.⁽⁵⁾ However, it is clear that extremes of temperature are unfavorable for the

3. Monsoon type

4. Hot desert type

Climate of middle latitude, or the temperate zone

5. Mid-latitude desert type

6. Mediterranean type

7. Warm temperate east coast type

8. Cool temperate oceanic type

9. Mid-latitude continental type

10. Cool temperate east coast type

11. Cold temperate type

Climate of high latitude

12. Arctic or cold desert type

Lawrence E. Doyle, and Ronald D. Lemon [11]

1. Tropical climates

Rain forest

Savanna

Monsoon

2. Arid climates

Deserts

Steppes

3. Temperate climates

Mediterranean

Humid sub-tropical (marine west-coast type)

4. Humid continental

Warm summer type

Cool summer type

Sub-arctic type

5. Polar climate

human mind and body, and it is more likely that the moderate climate provides the ideal surroundings for industrial activities of human beings than otherwise [29:21-31]

Studies of climate as a factor in industrial location do not deal with the problem in such broad terms as climatic regions of the world. They are much more concerned with micro-climatic observations within the areas of temperate climate, under whose conditions most industries are currently located. Recently, however, the need of industrialization in the so-called underdeveloped countries, many of which are located in tropical and sub-tropical regions, and the efforts being made to expand the "*Lebensraum*" to sub-arctic regions, as in Canada and Siberia have brought the problem of industrial location in the less temperate climate into the picture, which is being made possible by technological development in climate control. The theory of industrial location is hoped to contribute to this new field of its application, where more emphasis may have to be given to climate as an important locational factor than it is now in the advanced industrial areas.

Climate *per se* is a natural phenomenon, and as such it has physical effects on the physical aspects of industrial activities. It enters the economic interactions of locational factors through affecting the processing cost. In the theoretical, and abstract treatments of industrial location from the standpoint of pure economics, such as Losch's [27], Isard's [20], and to a large degree Hoover's [18], too, authors do not give much attention to climate, but in those which take more practical approaches, such as

⁽⁴⁾ The most eminent opponent of climatic determinism of history is Ellsworth Huntington. [19. Also, *The Mainsprings of Civilizations*, 1955] His theme is that mental attitudes depend in the last resort upon geographical factors. [25:56]

⁽⁵⁾ Before the Industrial Revolution, agriculture was the basic economic activity of societies. Therefore, it is conceivable that a good climate brought about abundance of agricultural products on the base of which a civilization prospered. But, actually, civilizations in the past flourished in the countries varying widely in their climates, from the hot river valleys of the sub-tropics, to the high altitudes of Mexico and Peru, or the cold and dark winters of Northwestern Europe. [25:53] Since the Industrial Revolution, the most rapid economic growth has been found in the temperate zones, but here again there is no necessary reason that the economic development does require a temperate climate,

Greenthut's [13] and Yaseen's [40], greater emphasis is given to climate.

2. PHYSICAL EFFECTS OF CLIMATE ON INDUSTRIES

Climatic conditions do affect several aspects of industrial activities.

Labor. Firstly climate exerts great influence on human efficiency and behavior. More crimes are committed during the hot, humid period between July and August than in any other period of the year. The desire to work and capacity to produce are affected by daily weather. Snow, rain, glaze and sun-shine all have an effect on the efficiency of both employer and employee. [40:12] The best working condition is estimated as 60°-75°F of temperature with moderate humidity, i.e., relative humidity between 40% and 70%. In order to have this humidity, precipitation of 20 to 60 inches evenly distributed throughout the year is required. [11, 38, & 29:15ff] The ideal condition is different according to the work performed. For heavy workers, the best pace is attained at lower temperature, if they are well-clothed and accustomed to low temperature. On the other hand, for desk workers warmer temperature, at around 70°F, with light clothes is most comfortable. [11, & 38]

Extreme climatic conditions often lead to diseases. For example, exceptional dryness, anything below 25% of relative humidity, promotes susceptibility to the common cold and other respiratory diseases. [40:125] One type of tropical climate is characterized by constant, uniformly high temperature with high humidity. This type of weather contributes to inefficiency, not only because of the magnitude of the climatic elements, but also because of lack of fluctuations. Periodic return to climates with annual temperature fluctuation is necessary to maintain efficiency. [11] The same can be applied to other climatic regions, too. Period of continuous wet spells or constant sunshine may lead to "weather monotony" and reduce initiative and accomplishment. A climate with frequent but moderate weather changes and gradual seasonal changes, with temperature of approximately 40°F during the winter season and 64°F in the summer, is considered to be ideal. [40:125]

The climatic conditions and their effect on labor are reflected in the

labor cost, fuel cost and other cost factors. Efficiency can be maintained in perfectly air-conditioned buildings, but it should be noted that any industrial activity involves some outdoor work such as unloading raw materials and shipping finished products.

Equipment. Secondly, equipment may have to be maintained in moderate climatic conditions.

High humidity is hard on equipment because it is the major cause of steel corrosion. Steel rusts excessively with relative humidities of around 80% or more; this effect is accelerated by higher temperature. In high temperature and humidity, electric equipment and electronic devices are more prone to failure. Also, paper, cloth, and leather suffer from mildew. [38]

In cold temperature, ordinary rubber gets stiff; plastics become defective; and oil and lubricants stop being effective. Precision machinery suffers in quality. For ordinary carbon steel, embrittlement occurs at 0°--30°F. At below 32°F with high humidity, the operation of compressed air equipment becomes difficult; the air moisture condenses and freezes on the exhaust outlets, stopping the equipment. [38] Frost collects on conveyer belts at 15°-32°F. The belt itself tends to freeze under cold temperature with moisture in the air. [38, & 11]

Other climatic elements also should be taken into consideration, such as wind. Some parts of machines-motors, bearings, fans, gears, and pumps, are particularly susceptible to windblown dust and sand. [11]

Process. Thirdly, the production process and the materials to be processed are under the influence of climate.

In high temperature and humidity, blast furnace efficiency decreases; inferior castings are formed at 80°F and relative humidity of 80%. [38]

In low temperature, water freezes and preventing measures such as heating for storage tank, insulation, and anti-freeze solutions are necessary. Also, care must be taken for water discharged into sewage and waste-disposal systems. [11] On the other hand, the cooling effect of water tanks is greatly reduced in high temperature. Some other liquids, such as viscous liquid, are also hard to handle when either frozen or eva-

porated. Bulk materials containing moisture, such as coal,⁽⁶⁾ are also hard to handle when frozen. [11]

Aircraft frames cannot be satisfactorily pressed below 40°F. Paintshop operations become slow at 60°F, and operations cease at 40°F. The pouring of concrete and frame stripping at below freezing temperature is usually avoided since preventing measures against freezing are expensive. [38]

The cases illustrating the influences of climate on products are reported from Colorado where humidity is relatively low. [6] ⁽⁷⁾ A manufacturer of aluminum pistons in Colorado reported that the dry air is favorable to sound castings. In the high humidity Great Lake region, where the company formerly operated, the molten metal often attracted moisture so that blowholes resulted. Rejections for this cause have declined substantially in Colorado. Other cases cited are: a concern making electrical instruments has benefited by the dry climate because the metals it uses do not rust or tarnish readily; a printing firm discovered that ink dries quicker and paper retains its dimensions better than in areas where the humidity is high.

Building. Fourthly, types and construction of buildings are under the influence of climate. In order to adjust to the climatic conditions of the locations, and to maintain the efficiency of labor, equipment, and

(6) "Stockpiled coal or coal being shipped in railroad cars begins to freeze at temperatures which depend on the wind and the amount of moisture in the coal: frozen coal, of course, must be knocked apart with sledges or thawed before it can be handled. On the other hand, stockpiled coal does not oxidize and depreciate in quality as fast under winter conditions as in the hot summer. For example, coal that can be stored for three months in winter and still remain its coking qualities may not retain equal qualities after more than one month of summer storage, when spontaneous combustion possibilities increase also. The optimum coal storage temperature ranges from 40°F down to just above the freezing point." [38]

(7) This article shows the results of interviews at 116 firms in Colorado. One-fourth of them answered that they were attracted to the area primarily because of the favorable climate. One company obtains 90% of raw materials and sells 95% of products east of the Mississippi, but other conditions being equal, climate was an attractive factor. The fact shown in this article indicates that the climate does affect the site selection of firms.

process, such measures as insulation, air-conditioning, humidity control, central heating, air-purification, artificial lighting, etc., may be required. Also, sewage and waste-disposal systems must be adjusted to the climatic conditions so that they work without interruptions throughout the year. These are factors directly bearing on the capital investment, maintenance and depreciation cost, which in turn affect the location of industries in economic terms.

In order to determine the types of necessary construction, and the types of installment for climatic control, and at the same time to estimate heating costs, data on "degree-days" are utilized. The "degree-day" is defined as "a departure of one degree per day in the mean daily temperature from an adopted standard reference temperature, usually 65°F." [40 : 127-8] The engineers depend on degree-day computation to determine heating capacity, size of boiler, radiators, and other heating devices, and the amount of fuel needed. According to the computation, for example, in areas with mild weather, space or wall heaters are used instead of a costlier central heating system. The heating cost is said to be quite accurately determined by the consideration of "degree-days." [40 : 127-8]⁽⁸⁾

Storms, etc. Finally, in most areas of any country, there is some kind of natural hazard such as storms. Snow storms, sleet, high winds, thunderstorms, lightnings, heavy rainfalls, tornadoes, hurricanes, or typhoons, all these may cause plant shutdown, breaking of electric power transmission lines or of telephone lines, and traffic hazards. Wherever there is a possibility of one of them to happen, precautionary measure must be taken, which incurs additional cost to the operation of the industry. [38, & 40 : 124]

⁽⁸⁾ Following figures are average seasonal degree-days in selected cities of the United States (Base 65°F). [40 : 128]

Season Total		Season Total		Season Total	
Minneapolis	7966	Pittsburgh	5430	San Francisco	3137
Detroit	6560	New York	5280	Atlanta	2985
Chicago	6282	Baltimore	4487	Dallas	2367
Boston	5936	Nashville	3613	Los Angeles	1319

The U.S. Weather Bureau is furnishing data on degree days with base 85°F.

3. INDUSTRIES RELATIVELY SENSITIVE TO CLIMATE

For a few industries of certain types, climate is an important factor in their location. The following are some examples.

Outdoor job. Climate is a crucial factor in those industries involving a large amount of outdoor work, such as agriculture, construction, shipbuilding, painting, and the motion picture industry.

Agriculture is the product of climate in the sense that crops to be grown in an area are predominantly determined by the climatic conditions, together with the types of soil and topographic features of the land.⁽⁹⁾

Shipbuilding is essentially an outdoor job. Consequently, areas with mild climate, where winter is not vigorous, have an advantage by providing favorable working conditions. The advantage of the United States west coast in this respect made it possible to establish record production during World War II. [15 : 388]

Most activities in the construction industry are, naturally, carried on as outdoor work, and their efficiency is greatly conditioned by weather. Especially in low temperature, economic operations are often impossible.⁽¹⁰⁾

As for the motion picture industry, it is a well-known fact that the even climate throughout the year of the Los Angeles area makes it attractive for its location. [36 : 35]

The effect of wind must also be taken into consideration in the cases of outdoor work. When there is no wind at all, or conversely there is

⁽⁹⁾ This paper is primarily concerned with manufacturing industries other than agriculture. Therefore, a more detailed description of agriculture is omitted.

⁽¹⁰⁾ According to Doyle and Lemon, the low temperature limits for economic operations in the construction industry are as follows: [11]

<i>Operation</i>	<i>Temperature</i>	<i>Operation</i>	<i>Temperature</i>
Surveying	-10°F	Roofing	40°F
Excavating	20	Plumbing & heating	-20
Pile driving	20	Electrical	
Concrete forms	0	installation	-30
Concrete pouring	10	Painting	32
Masonry	10	Structural steel	
Carpentry	-12	erection	10

an excessive wind, the efficiency of labor declines. Wind is detrimental when combined with rain, or snow.

Painting is halted when dust or sand is blown by wind of over 15 mph. [11]

Aircraft industry. Climate is significant in the location of aircraft industry, much more than it is in most of other industries. Areas having a high percentage of days with good flying weather, i. e., clear skies and minimum of freezing temperature, throughout the year favor test flying and delivery of finished products to customers, or reception of planes flown to the plant for modification. Outdoor storage, repair, and maintenance are also possible with little interruption from inclement weather. Low cost of space heating in a mild climate is also a recognized factor of location for the aircraft industry, since the very large and open nature of the plants mean that heating becomes a major item in cold areas.⁽¹¹⁾ [15 : 383, 36 : 98, & 28] The fact that aircraft frames cannot satisfactorily be pressed at temperatures below 40°F has been already mentioned.⁽¹²⁾

The large movement of the aircraft industry, which began in the northeastern part of the United States, to southern California is largely attributed to the more favorable climate in the latter. Also, climate was a contributing factor to the expansion of the aircraft industry in Texas, which is not oriented toward either markets nor materials, combined with such factors as large space available, horizontally and vertically, and the decentralization policy of the industry into the interior of the country encouraged from the standpoint of national defense.⁽¹³⁾ [28]

Steel mills, etc. As already mentioned,⁽¹⁴⁾ steel mills and machine shops

⁽¹¹⁾ In general, "any manufactures utilizing a large amount of floor space in proportion to total number of employees, where maintenance is a factor, will prefer areas where there is no frost line problem and no freeze and thaw cycle—thus eliminating continuous pointing up of brick work, removal of ice and snow, elimination of enclosed loading platforms, and the winterizing of trucks and other plant equipment." [40 : 125]

⁽¹²⁾ Above, p. 189.

⁽¹³⁾ As of 1956, 47,500 people were employed in the aircraft industry in Texas, which accounted for 10% of all factory workers in the State. Texas was the fifth state of aircraft industry of the United States. [28]

⁽¹⁴⁾ Above, p. 188.

must avoid extreme temperature and humidity.

Raw material oriented industry. Climate can be an important factor in raw material oriented industries.

A good example is the processing of perishable agricultural products. Creameries, cheese factories, and condensed and evaporated milk plants are located close to the source of supply, which are mostly located in such cool climates as are found in the northern states of the United States. Canning industries of agricultural food, or of sea products, are also located in climates which are favorable for those materials to be obtained.

The pulp and paper industry is another example of a material oriented industry. It requires a great deal of water of which the supply and potentiality usually depends on the precipitation of the area. Easy access to wood is of course required for the pulp industry. Places that meet these requirements may have a disagreeable climate. Calkin points out that it is usually necessary to pay higher salaries and wages in the pulp and paper industry in order to induce personnel to live in a disagreeable climate. Therefore, favorable climate is an asset for the firm. [4 : 327]

As mentioned earlier, ⁽¹⁵⁾ bulk materials containing moisture such as coal is hard to handle when frozen. It is quite probable that this will call for a consideration of climate in selecting location for the industries in which large amount of such materials is used.

Climate-sensitive-commodity producing industry. In a few industries, climate is an important factor because the nature of the commodities they produce requires special care. The problem of climate control in the processing of the materials is involved here. An example is seen in the textile industry. The existence of cool, moist climate makes the yarn more pliable and less likely to break. This is one reason often cited for the location of the textile industry in New England. [36:16] In dry climates, more artificial humidification has to be used than in damp climate. [18:7-9]

A cool climate is favorable for a dairy because its processing needs more cooling equipment in a warm climate than in a cool climate. [18:7-9]

⁽¹⁵⁾ Above, p. 188-89.

Transportation. Transportation is always under the influence of climate and weather conditions. Excessive rain often causes damage to transportation facilities. Railway tonnage is reduced by as much as 10% when the train is moving against headwinds. In extremely cold weather, engines stop working: locomotives become idle at -50°F , diesels do not work at -40°F . In other extreme, in the humid tropical areas, abundance and rapid growth of vegetation can cause difficulty in the establishment and maintenance of rail and highway transportation. [11]

In the regions where temperature falls below the freezing point, expansion of soil, concrete, and other materials supporting the rail and highway, caused by the fluctuation of temperature, is a constant menace and a source of problems. Snow storms cause loss of visibility. In the deep-snow areas, keeping roads and paths clear constitutes a major item of the operation cost. Frozen waterways are detrimental to the economic activities of a region like the Great Lake region.

Others. In some cases, velocity and direction of prevailing wind may constitute a problem, affecting the ventilation of a factory, especially when the factory produces noxious odors, fumes, or heat. [40 : 125]

4. CLIMATE AS AN ECONOMIC FACTOR OF LOCATION

In the preceding sections, the effect of climate on the physical aspect of industrial activities has been discussed. Investigation of the economic effect, or economic significance, is now due in this place, since the location of industries is always determined by the interaction of various economic factors and our real concern is in the relationship of one factor to all others in this interaction, as the authors emphasize. [18, 13, 27, 20, at various places]

Climate *par se* is a natural phenomenon, as noted earlier, and as such is "neutral stuff" exactly as the case of any other kind of raw materials. [41 : 8] Just as we transform neutral stuff into useful resources by applying technological arts and by introducing the materials into our economic life, we take climate into our economic activities through our reactions and responses. Only then, the advantages and disadvantages of climatic

conditions of one particular location come into the picture of our economic life. In this sense, climate may be classified into the category of raw materials as one of the factors of location. In fact, in an industry where climate is a predominantly important factor of location, like the aircraft industry, the economic role it plays is quite similar to that of raw materials in a raw material oriented industry. [36 : 98]

One of the characteristics of climate as a locational factor is its permanency. [18 : 5] Certainly, a climatic condition of a place does not change in a short time if everything is left as it is.⁽¹⁶⁾ However, our reactions, adjustments to the climate, or the climatic control, are constantly changing as our technological ability of dealing with it develops. [25:51] Moreover, climatic condition can be changed by public works. Good examples have been shown in the United States by the works of federal government agencies such as the Bureau of Reclamation. This and other related agencies have shown that by reclamation of arid land in the western half of the United States, or by reforestation, we can change the climatic conditions of the region. A great change in the economic life occurred as the result of such public works and ensuing climatic changes. Their works have not only helped agriculture prosper but also brought about processing industries, increased population, and in turn induced a variety of industries to come into the region. [24:24ff] In this way, a seemingly disadvantageous climate may be changed into an advantageous one. We do not change the climate directly but we can turn it into our advantage by changing other related factors existing in the region. [18:262]

Changes also occur in measures of climatic control in individual factories. The introduction of air-conditioning for controlling temperature has greatly reduced the locational significance of temperature. Moreover, year-around temperature control has come to be combined with air-purification, humidity control, and artificial lighting arrangements, so that the cost of installation and operation can be distributed among multiple

(16) Climate does change over a long span of time. [30 : 281-304] But we are not concerned with that kind of changes over the long history of the earth.

benefits, which have made the cost-benefit analysis directly bearing on climate difficult. Windowless buildings incorporating these features are a result of the development of climate control in this direction and permit greater freedom in location.⁽¹⁷⁾ [36:14-16] It is important to note that due to the development of climate controlling devices, climate is losing a measure of its importance as a location factor. [15:359]

The problem of climate as an economic factor of location mostly expresses itself as a problem of the cost of climatic control which affects the return on capital. Usually, however, the cost of climatic control does not appear as an independent cost item. It tends to be absorbed into other cost items and is shifted as an addition to the capital cost, maintenance cost, and depreciation cost incurred by measures needed in dealing with the climatic conditions. In any case, the cost attributable to climate is classified as a processing cost as distinguished from transportation, procurement, and distribution costs. [18:7-9, 20:138, & 13:124-5]

Extra cost incurred in construction of buildings, and installing air-conditioning, may be regarded as an increase in land value. It may be shifted to such items as interest, or cost of extra electricity for operating air-conditioners. [18:76] Since climate is inseparable from the particular locality where the plant is operated, it may be regarded as having the similar nature as tax. [13:20]

By these reasons, climate is generally regarded as a minor factor in determining locations of industrial activities. This may be more so in advanced economies than in less advanced. In advanced economies, the relative weight of capital investment in the total outlay is likely to increase, but the relative weight of that portion needed for climatic control is likely to decrease.

The differences in living expenses attributable to differences in climatic conditions may be reflected in wage differentials. However, wage differentials existing in a national economy seem to be caused by social

⁽¹⁷⁾ Windowless building has other purposes, too. That is, more efficient use of space inside the building, noise control, and supply of constant amount and direction of light,

factors rather than mere climatic conditions. Hoover notes that the difference in consumption requirements is ambiguous between the cities in the United States. Moreover, he goes on to say that in advanced economies, geographic differences in living cost cannot account for any major part of the existing differentials in wages. [18: 105-6] It is reasonable to believe that in advanced economies where wages and salaries are paid far in excess of the bare subsistence level, differences in climatic conditions account for only a fraction of differential wages.

Summarizing, climate is not a factor which affects the location of every kind of economic activity and industry, but it plays a significant role in many of them. In advanced economies, however, as the technological and societal arts [41: 31ff] overcoming disadvantageous climatic conditions develop, the measure of economic significance of climate is apt to be lost from sight. Since economic interactions among different industries and firms play the most important part in shaping the pattern of locations as a whole, and one locational factor works in the interactions with all other factors, a change in climatic conditions is bound to break the existing economic equilibrium. In connection with the adjustments to such interruptions of equilibrium, many serious problems involving industrial location may arise. Therefore, consideration will always have to be given to climate although it will remain a minor factor of location.

5. A NOTE ON HOKKAIDO

In the preceding sections, a general description of climate as a factor of industrial location has been given. In this concluding section, a few remarks will be made on the climate and industries of Hokkaido ⁽¹⁸⁾

Hokkaido is the northernmost of the four major islands of Japan. Its area is the second largest of these four. This island has been, and is, the most underdeveloped, sparsely populated, and least industrialized

⁽¹⁸⁾ This paper is originally written in the State of Texas, U.S.A., for the interest and information of the local people. Because of lack of appropriate data on Hokkaido, the contents of this section is largely based on chapters of Kenzo Henmi, *Hokkaido No Keizai To Nogyo* [14], the book which happened to be at hand. I hereby acknowledge my indebtedness to the author of the book.

of all regions of Japan. The Japanese government, since the day of collapse of the feudal system in 1860's, has been making efforts in transplanting population and developing the economy in this hitherto uncultivated island, though the extent of efforts has varied with the course of time in Japan's modern history. What has been achieved, however, is far from what was expected. A cold and snowy climate has frequently been blamed as the cause of this failure. The original purpose of this section was to investigate the validity of such assertions and to determine what significance the climate actually has on the industrial development of Hokkaido. However, as mentioned several times in the earlier sections, the whole pattern of location is determined by numerous factors, not only geographic but political, economic, social, and historical factors. And it has turned out to be an impossible task to investigate them fully in this short section. Therefore, I would like to limit myself by making just a few remarks about the island now, and leave the rest of the study to my future inquiry.

Hokkaido is the northernmost island of Japan. This fact is a decisive factor for its economic position in the national economy. Because, since development of Hokkaido began relatively lately, it must from the start solely rely on the great deal of inflowing influx of population, capital, and industrial skill from the central part of Japan. Since the neighboring region, Tohoku, has been an agricultural area and lacked modern industries, everything must come from the central part of Japan leaping over the Tohoku region. This situation is not changed much even today.

The size of Hokkaido is big by Japanese standards. It has 31,000 square miles, approximately one-fifth of the total area of Japan, which is 140,000 square miles. Population is relatively sparse, 110 per square miles, which is again one-fifth of the national figure. [14:11] The island is, roughly speaking, divided into three parts by chains of mountains. This is detrimental to the development of transportation which is also menaced by snow, wind, and frozen soil during the long winter season.

The average monthly temperature ranges from 10°F to 70°F, though

it varies from one place to another. ⁽¹⁹⁾ The temperature of Hokkaido is not so cold as to deter industrial development entirely. It can be well compared with temperatures in the highly industrialized areas of Europe or the northeastern part of the United States. However, it is sometimes unbearable because the mode of adaptation to cold climate in Japan is poor. Snow, which usually reaches several feet deep, also greatly affects the economic activity of the island. The mean annual rainfall for the western half of Hokkaido is from 40 to 60 inches; that for most of eastern Hokkaido is under 40 inches. This is small as compared with 60-80 inches for most of the western and central parts of Honshu (mainland) and 40-60 inches for much of eastern Honshu. Hokkaido's relatively dry climate is a factor of some adversity in relation to both agricultural and hydro-electric power developments. [22:29]

Judging from the distribution of workers by industry, percentage of primary industry including agriculture, fishery, and mining has always been higher than others; manufacturing industry low. This high percentage of primary industry has been maintained over the whole history of Hokkaido, whereas for Japan as a whole, the percentage of manufacturing industry has been constantly increasing. [14:22-3]

Though agriculture is still the most important occupation in Hokkaido, it has several natural disadvantages: short length of frost-free season (130 to 160 days as compared with 180 to 250 days in the southern parts of Japan), low average temperature in the growing season, small precipitation and its unfavorable seasonal distribution (small in the spring and early summer planting season; larger in the fall harvest season), unstable

⁽¹⁹⁾ The average monthly temperature, January and August, for selected cities in Hokkaido and Honshu are shown as follows: [22:27]

<i>Hokkaido</i>	<i>Jan.</i>	<i>Aug.</i>	<i>Mainland</i>	<i>Jan.</i>	<i>Aug.</i>
Hakodate	25°F	70°F	Akita	29.5°F	75°F
Sapporo	20	68	Sendai	31	75
Asahikawa	15	68	Tokyo	37	80
Obihiro	10	65	Osaka	40	81
Abashiri	18	65	Kagoshima	45	80
Nemuro	21	62			
Kushiro	20	64			

yearly fluctuation of weather, and the wide distribution of unproductive types of soils such as volcanic ash and peat bog. [17:5] Due to these facts and to the mountainous topography, the ratio of land utilization is low-11% as compared with the national average of 16%. Possible cultivable land is estimated at best at 17%. [34:101ff] Unless there is a vast amount of capital investment or technological innovation, land and people employed in agriculture in Hokkaido do not seem likely to increase in future.

Most of the land not under cultivation is covered with forest that provides the basis for the wood processing, pulp and paper industry in Hokkaido, but it is not enough to meet the demand.

The potential amount of resources for the fishing industry in Hokkaido is hard to estimate. Fishing used to be one of the most important industries in Hokkaido, but the overfishing in coastal waters during and after the war, and international complications in the postwar period aggravated its declining tendency in Hokkaido, from which it has not fully recovered yet. [10:124ff]

The mining industry, of course, solely depends on the existence of mineral resources. The only mineral resource that deserves attention in Hokkaido is coal. The coal reserves in Hokkaido (including proved, probable, and possible reserves) is estimated at about 8 billion metric tons. This is about half of the total estimated coal reserves in Japan. [1:212]

One characteristic of the population in Hokkaido is that the growth of urban populaton has been relatively small as compared with other parts of Japan. This implies that Hokkaido has fewer opportunities to benefit from the agglomeration of industrial activities, that is, smaller benefit of the external economy in Alfred Marshall's term. In this sense, dense population is advantageous for industrial development. Wakefield once pointed out, speaking of the early colonies in the United States, that industrial production was hindered by too small a number of population. [39:255ff] Exactly the same situation, in fact, can be seen in many localities in Hokkaido. Also, sparsity of population in Hokkaido as a whole directly results in the insufficient means of transportation,

which further prevents the benefit of external economy, and in larger burden of local taxes.

The conditions surrounding the economy of Hokkaido, in short, are not very advantageous for industrial development. Although there are some exceptions, most industries located there are what may be called "local" industries, that is, either those for which raw materials are locally readily available, or those of which the products are consumed in the local market. Major ones are processing of agricultural and sea products such as breweries of sake, beer, dairy plants, canneries, beet sugar plants, and peppermint extraction plants, and wood processing such as furniture, pulp, paper and paper products.

Understanding of the problems of industrial location in Hokkaido may be facilitated by the following two observations. One is the historical function Hokkaido had in the past economic development of Japan. Another is the causes of industrial development in the central part of Japan.

Measured in terms of per capita national income, Japan's economy has showed a phenomenal growth since 1868. This has been mostly done by outward expansion, that is, Japan went the "Prussian way." [37:5] Hokkaido was the first territory for old Japan to expand into, but it was later replaced by other oversea territories. The following quotation quite succinctly describes the situation Japan faced.

The overpopulation of Japan has reached disturbing proportions. The paucity of domestic resources seemed to present rigid limit to the growth of output and income. Cultivation of industrial skills and fostering of industries which would import raw materials and export processed goods appeared to be the only outlet for economic energies and the only way to prevent a continuous deterioration of the already low standard of living. To the industrial interests of Japan, the control of raw materials sources and the acquisition of export markets appeared thus to be an essential condition for the country's economic prosperity. [37:5]

At first, Hokkaido was Japan's only "colonial possession" -raw material sources and export market and as such it played an important role. However, by wars, political annexation, and military occupation, vast areas of neighboring countries were later added to Japan's sphere of influence. The position of Hokkaido as a "colony" began to decline in the process of industrial-

zation of Japan that, practically speaking, started with the Chino-Japanese war in 1895-6. Comparing the capital-and-commodity-flow relationship between each of Japan's oversea territories (including Hokkaido) and Japan proper (excluding Hokkaido), we see that Hokkaido's position among these "colonial possessions" was at the bottom in 1930's, i.e., at the time when heavy manufacturing industries came to stay in the war-preparing Japanese economy, and remained there until the end of W.W. II when Japan lost all these territories except Hokkaido. The reason for this will become apparent by asking what Japan acquired from other "colonies." According to Jerome Cohen, to Japan proper, "Formosa provided sugar and rice; Korea rice, electric power, light metals and ferro-alloys; Manchuria offered iron ore, coal, soy beans; North China coking coal, aluminous shale, cotton, salt; the Mandated Islands phosphorite and phosphate. Later there were the oil and bauxite of the Netherlands East Indies, tin and rubber of Malaya." [7:33] Against the competition from these areas, what Hokkaido was able to provide was some coal, fish, and wood products, which amounted to hardly an important quantity in the whole economic operation of Japan. Hokkaido lacked a large population with cheap labor power. All the areas named in the quotation above are the areas where cheap labor power was most abundantly available in the world. Lack of abundant cheap labor power, that would have also provided a market for the industries—this seems to be the reason why Hokkaido could not contribute much to the industrial development of Japan and its position among the "colonies" declined.

In the course of the economic development of Japan, numerous industrial sectors were established and a number of manufacturing industrial centers were created. It must be noted, however, that the major industrial area occupies only a limited part of the country. John Orchard described this area that "it is the peripheral strip stretching along the southern shore of Honshu from Tokyo westward some 680 miles to the Straits of Shimonoseki and including the northern edges of the islands of Shikoku and Kyushu." [32 : 120] Although his description is based on the statistics in the 1920's and there has been some expansion of the area, the funda-

mental fact still holds today that this area includes practically all of the major manufacturing centers of Japan and most of the modern industrial development.

The principal advantage of this area for the development of manufacturing, and the one advantage common to all parts of it, is accessibility. It is the most accessible section of all Japan, and accessibility plays a decisive part in stimulating economic growth. [25 : 53] The advantages of the area were important even during the period of Japan's isolation and feudalism. Within it were concentrated most of the people of the country and of the commercial activities. Later, on this basis, the new government initiated the establishment of railroads, highways, and harbors. The natural and man-made accessibility of the area permitted the import of raw materials and ready disposal of the finished products. The growth of transportation facilities played the most conspicuous role in the economic development in Japan, and the most important ones were laid down first in this area as a government enterprise. Moreover, this area has numerous island seas, bays, plants, raw materials, and potential market. Thus, the modern industrial activities were initiated in this area.

Once an industrial center is established, it creates within itself other advantageous locational factors, and more and more advantages are accumulated. That is, the principle of agglomeration starts working. Even when some of the original advantages cease to exist for some reason, other induced factors will remain strong enough to maintain the locational advantage of the area. Modern manufacturing industries need raw materials, energy sources, labor power and wide markets. They tend to concentrate in the area where these factors are readily available. But agglomeration of these industries creates these factors among themselves. This is what actually happened in the industrial area of Japan.⁽²⁰⁾

The overwhelmingly advantageous location of Japan's major industrial

(20) Both of the two types of agglomeration, as distinguished by Losch, are seen in this area. (27:68 ff)

One is the agglomeration of similar enterprises. An example is the center of wool weaving industry in the Nagoya area, where the weaving industry and its subsidiary industries—spinning factories, dye-houses, wool processing plants, trading

area has been thus produced in the process of reciprocation, in which agglomeration of industrial activities induced by favorable locational factors further creates new advantageous conditions.

Seeing it in this light, in Hokkaido that had been almost void of human population and located further north of Tohoku region which itself was industrially undeveloped, it is natural that there has been no functioning of economy of agglomeration, no benefit of external economy.

Although, as mentioned at the beginning of this section, it is difficult to single out climate as a locational factor contributing to the lack of industrial activities in Hokkaido, it seems reasonable to conclude that the climatic conditions are not the fundamental factor. The real cause seems to lie in the fact that there have not been enough economic inducements that are strong enough to initiate industrial activities, strong enough to overcome the disadvantages attributable among other things to an unfavorable climate.

companies, and public facilities such as experimental laboratories—stand together, each providing locational advantages to another. [23:218]

Another is the agglomeration of dissimilar enterprises. An example is seen in the concentration of economic activities in the Tokyo area. Tokyo is the center of the national economy. It has big wholesalers, is well equipped with transportation and warehouse facilities. Financial and market institutions are well organized. It is also the political, cultural, and educational center of the nation. Its activities as the center of the national economy attract, and enable it to maintain, a large population. It has a large demand for skilled labor, offers higher wages and more opportunities for acquiring higher skills, and provides a variety of entertainments. Conversely, various kinds of labor, especially highly skilled labor, are readily available. It is a great market for consumer goods. Thus, every kind of industry can be found in this area. Printing and publishing industries, manufacturers of high quality apparel, precious metal products, toilet articles, enjoy almost exclusive advantages in Tokyo. [14:67]

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