Industrial Capacity as an Element of War Potential

The term "war potential" is not difficult to define. No insurmountable difficulties of definition are encountered in breaking this down into the classifications, "military potential" and "economic potential". The resolution of economic potential into its components, however, must be a rather arbitrary proceeding, since the components selected are themselves more or less synthetic in nature. If the whole subject of economic potential is to be considered under the headings, "geography", "population", "natural resources"; "industrial capacity", and "national policy"; then "industrial capacity", which is to be discussed in the present paper, must be defined rather broadly to include consideration of not only manufacturing facilities, but such services as power, transportation, and telecommunications.

For the purposes of this paper, industrial capacity for war may be defined as that part of the economic potential that relates to the ability of the industrial facilities of a country to produce and transport those manufactured and processed items that are necessary for the prosecution of a war, excluding the elements of manpower and raw materials.

"Items necessary for the prosecution of a war" embrace all those essential to the civilian economy, as well as those having a strictly military application: soap is as indispensable as small arms ammunition, whether it be destined for civilian consumption or for issue to troops.

A logical approach to the problem of estimating the industrial capacity for war of any nation would be through the determination of the size and type of armed forces which that nation could equip and supply, in addition to maintaining the civilian economy at an acceptable level, assuming that the industrial output would not be limited by lack of manpower or raw materials. Materiel and supply requirements of the various types of military and naval units are known, so that it is feasible to make the necessary computations, providing a sufficiently large, well-trained staff is available for this purpose.

Given precise data, it would be possible to express the industrial capacity of any nation in terms of the land, air, and sea forces that it could maintain, subject to the limitations imposed by other factors of war potential. The labor involved in such a determination would be considerable: total requirements would necessarily be detailed to be distributed to individual manufacturing facilities; these would be examined, together with the facilities servicing them, in order to arrive at the total capacity for each item. In other words, a complete war production program would necessarily be established for the country under consideration.

Apart from the sheer magnitude of such an undertaking, there are some difficulties of a different order to be overcome. The type of Army, Navy, and Air Force desired by any nation depends to a great extent upon the kind of war to be fought, where the fighting is to take place, the duration

of the war, and level of economy acceptable to the civilian population. An intimate knowledge of the strategic and tactical planning of the nation in question is required in order to make intelligent assumptions concerning these points.

Another approach to the problem of estimating industrial capacities lies in the use of selected indices. This method has the enormous advantages of speed, ease, and simplicity, but even the best index can give only a rough approximation of the relative capacity of a country. For some purposes, this type of estimate is adequate.

The selection of indices is based on the criteria of availability of data and on the significance of the element. Many statistics which would be of considerable value in estimating industrial capacities are not reported by many nations; in peacetime no nation, except possibly the most powerful, has any interest in disclosing figures that make possible the accurate estimation of its war potential. In time of war, capacity and production figures are a closely guarded secret. There is also reluctance on the part of individual firms in many countries to release any information that might be useful to a competitor.

Industrial capacity figures are usually difficult to obtain, and even if available should be used with caution, since, at best, they are only estimates. The basis on which they are calculated must be known in order that they may be correctly employed. Production figures, in general, are more readily available, and have the advantage of being factual, in that they represent actual accomplishment.

In order to employ production figures as a guide to relative capacity, it is necessary to insure that the period covered in the comparison is one in which the countries compared were operating at approximately the same relative capacity, or else make a compensating adjustment. In 1937, which was a prosperous year for most nations, the United States produced three-eighths of the steel made in the world, about two and one-half times as much as its nearest competitor, Germany. In 1938, the United States production fell off about 45 percent, while the German production increased by some 15 percent; in fact, during certain months of that year, German production actually exceeded the United States figure. This phenomenon, which was of short duration, may be explained by the fact that Germany was preparing for war in 1938, whereas the United States had not yet initiated its large-scale rearmament program. The United States later accentuated its lead over Germany in steel production, so that a comparison based on production figures for 1938 would be exceedingly misleading.

Differences in methods of reporting may cause difficulties in the use of figures. The Sixteenth Census of the United States (1940) shows that 23.4 percent of all persons over fourteen years of age, gainfully employed, were engaged in manufacturing, and 2 percent in mining. The figures for persons in manufacturing do not include those who are essentially employed

in distribution or construction activities, even though they may be associated with manufacturing establishments; other countries do not exclude such persons from the mining and manufacturing category. Recent statistics on selected countries show the following percentages of the total working population as being engaged in mining and manufacturing:

England and Wales	48.2
Germany	40.6
Australia	36.3
France	35.1
Italy	28.7
United States	25.4

It is conceivable that England and Wales, and Germany may be more industrialized than the United States, but this can hardly be true of Australia.

Industries that may be well-developed in peace are not all of equal importance to a war effort. Many industries are susceptible of diversion or conversion to war production, with modifications of varying degree: in 1943, the steel industry was still making steel, and the radio industry was turning out radio equipment, while the automobile and washing machine industries were manufacturing a number of items that were quite dissimilar to their normal, peacetime products. Other industries, such as those making articles of wearing apparel for the so-called luxury trade, are not of great value for war purposes. France found its numerous small factories producing ladies' gloves and "articles de Paris" of little use in a war economy. Difficulty was experienced in this country in integrating the furniture industry into war production.

Some industries develop to an unusual degree in certain countries because of peculiar economic conditions, such as broad markets or the combination of raw materials and cheap labor. Comparisons based on such industries are likely to be distorted. The automotive industry, for example, is one which is readily convertible to war uses, as was demonstrated recently in the United States, yet an estimate of relative industrial capacities based exclusively on automotive production would be too favorable to this country. In 1938, the world production of motor vehicles was divided among the various countries as follows:

United States	62.5 percent
United Kingdom	11.2 "
Germany	8.8 "
France	5.4 "
U.S.S.R.	5.3 "
Canada	4.2 "
Italy	1.7 "
All other countries	0.9 "

Few persons would maintain that the United States in 1938 possessed seven times the industrial capacity of Germany, or twelve times that of Soviet Russia.

An example of the distortion in industrial development brought about by the proximity of raw materials to a large market and cheap labor is the position of British India in cotton spinning. In 1939 British India ranked third, after Great Britain and the United States, in the number of spindles installed, preceding Germany, Japan, and Russia.

Any index derived from an element judged to be truly representative of the entire industry of a country can be tested by applying it to all of the great powers in the period immediately preceding World War II. All such indices should indicate the same general pattern--that is, the values of the various indices should not show a wide divergence, unless economic conditions peculiar to the country under consideration provide an explanation for the variations. Total energy produced and electrical energy could normally be expected to bear a more or less constant ratio to each other, except in the case of a country like Italy, where the scarcity of fuels combine with the availability of waterpower to weight the ratio in favor of electrical energy. Indices, to be of merit, should also indicate comparative industrial capacities in line with what experience in World War II now shows them to have been at the outbreak of hostilities; this is a matter of appreciation, as no generally accepted standards have been fixed.

Certain statistics expressed in terms of money are useful for the purpose of establishing economic indices. These usually reflect industrial activity, in addition to other factors, such as agricultural and raw material production. The total income figures are indicative of the total economic activity of a country, whereas the per capita income can be used for the purpose of estimating the level of civilian economy. Imports and exports, especially when divided into various classes of raw materials and finished products, yield a good deal of information on both the industry and general economy of a country. Capitalization figures constitute a measure of the size of the industries to which they refer. Expenditures for research are, to some extent, commensurate with the importance of the industries involved, but measure directly their progressiveness and throw some light on their technological development.

The first, and possibly the most significant element of industrial capacity, is total energy. The production of energy is an industrial function and energy consumption by industry is an excellent measure of industrial activity. Unfortunately, total energy statistics, based on consumption of fuels and waterpower without regard for type of consumer or the purpose of the consumption, include a considerable amount of energy employed for non-industrial uses. This is not too serious, since it is safe to assume that it is the nations with the highest degree of industrial development that consume the most energy for non-industrial uses.

From figures compiled by Professor Read of Columbia University for energy produced from common fuels and waterpower in the leading industrial countries in 1939, it appears that the United States leads the world by a wide margin, with a daily average of 1,568.1 million horsepower--hours

of total energy, of which one-half was furnished by coal and natural gas, 39 percent by petroleum, and 11 percent by water power. The per capita production of energy from these sources was 11.9 horsepower-hours a day.

The following table indicates the total and per capita production of energy in 1939 by the leading countries of the world expressed in percentages of the United States figures, together with the relative contribution of each source:

TABLE I

Country	Percentage by Source			Percentage of U. S. Total Production	Percentage of U. S. Per Capita Production
	Coal	Petroleum	Water		
Germany	90	4.5	5.5	39	45
Great Britain	86	13	1	22.5	64
U.S.S.R.	68.5	26.5	5	19	16
Canada	23	15	62	11	129
France	60	15	25	11	34
Japan	?	?	?	7-10 ?	?
Italy	25	13.5	61.5	5	15
China	94	6	—	3.5	1

All the nations compared above derived half or more of their total energy from coal, with the exception of Canada, Italy, and possibly Japan. The United States and the U.S.S.R. were the first two countries in the utilization of petroleum, obtaining 39 and 26.5 percent, respectively, of their total power from this source. Canada and Italy both produced over 60 percent of their total energy from water power. The Japanese coal figures for 1939 were not available, making it impossible to complete Table I for this country; from figures of an earlier date, it appears probable that Japan occupied seventh position in the production of total energy, with somewhere between 7 and 10 percent of the United States production.

Table I shows that Canada produced more energy per capita than any other nation. Although per capita energy production is normally an indication of the degree of industrialization of a country, it is not necessarily true that Canada is more industrial than the United States; the unusual development of cheap hydro-electrical power in Canada, which permitted that country to set up an alumina-reduction industry in its territory and even to sell some electrical energy to the United States, is probably responsible for the high power-population ratio.

The production of electricity is perhaps even a better guide to industrial capacity than is total energy produced, since electrical statistics relate only to stationary plants. Not all electricity is consumed by industry, but a great deal of it is used in manufacturing establishments, telecommunications, and some in transportation and other utilities.

According to the Statistical Yearbook of the League of Nations, the world production of electricty in 1937, the last year for which reasonably complete statistics were available, was 424,000 million kilowatt-hours. Production of the leading countries of the world in 1937, expressed in percentages of the United States figure, is shown in the table below:

TABLE II

Country	Percentage by Type of Production Thermal	Hydro	Total Production in Percentage of U. S. Prod.
United States	64	36	100
Germany	86	14	40
U.S.S.R.	81	19	29
United Kingdom	97	3	23
Canada	2	98	22.5
Japan	18	82	21.5
France	46	54	15
Italy	4	96	12

Steel production would also appear to be an excellent guide to the relative industrial capacities of the nations of the world. Steel is a raw material essential to many manufacturing industries and is used extensively in equipping practically all industries, as well as for war materiel and munitions. The creation of a war machine without large quantities of steel would be impossible, since even the light metal industries require steel for their construction and equipment.

The importance of the steel industry in the United States may be gauged from the fact that 12.2 percent of all persons employed in manufacturing in 1939 were employed in iron and steel industry; 17.6 percent were employed in industries utilizing steel as a raw material--"Electrical machinery", "Machinery other than electrical", "Automobiles and automotive equipment", and "Transportation equipment except automobiles". This means that 29.8 percent of the persons deriving their livelihood from manufacturing are intimately concerned with steel; few persons, in or out of industry, are unaffected by steel. It is not likely that steel is any less important to other industrial nations than it is to the United States.

Steel production is sensitive to business conditions and consequently reflects booms and depressions as well as industrial capacity, as is demonstrated by the fact that it shows wider variations than total industrial production. A comparison of the steel and general production indices for the great powers in the pre-World War II years, published in the League of Nations Statistical Yearbook, will bear out this statement. Because of the variations due to business cycles, care must be used in the selection of years for comparison of steel production, in order to insure that the countries compared were operating their facilities at approximately the same percentage of capacity.

1937 was a good steel production year for practically all industrial countries. The world production was in excess of 135 million tons, which figure was not exceeded until 1940. The United States produced about 38.5 percent of the world total in 1937. The table below shows the position of other important producing countries.

TABLE III

Country	Percentage of U. S. Production
Germany	38.5
U.S.S.R.	34.5
Great Britain	25
France	15
Japan	11

Transportation, which usually becomes a bottleneck in time of war, is much more difficult to compare as an element of industrial capacity. Inland transportation is so affected by geographic factors, such as the shape of the area served, distribution of population, location of raw materials with respect to manufacturing centers, and the location of these latter with respect to markets and ports, that a detailed study of the transportation system of each country is necessary to reach any conclusion in regard to its contribution to the industrial capacity.

In the United States, railways carry most of the freight. According to the National Resources Board, in the year 1938, railways accounted for 63 percent of the ton-miles; inland waterways 14 percent; pipelines 14 percent; and highways 9 percent; while the contribution of the airways was negligible.

Comparing railway statistics of 1937-1938 of the leading countries, it is found that the United States led in operated mileage and ton-miles of freight moved, but held fifth place in ratio of length of track to area served. Several countries of secondary importance, such as Canada, India, Australia, Argentina, preceded some of the great powers in these elements. The table below, from which all except the great powers have been excluded, indicates the difficulty of deriving any sort of significant index of industrial capacity from the railway statistics mentioned above:

TABLE IV

Country	Percentage of U. S. Figures		Ratio: Square Miles of Area to Mile of Track
	Operating Mileage	Ton-Miles Freight	
United States	100	100	13
U.S.S.R.	22.5	68	152
Germany	16	14	4.75
France	11	6.5	8
Great Britain	8.5	5.5	4.7
Japan	4.5	3	14
Italy	4.5	2	12

A large merchant marine is important to any industrial country for its foreign trade. Geography plays a role in determining the size of the fleet required: island-empires, such as the British, Dutch and Japanese, are relatively in much greater need of shipping than nations such as the United States and the U.S.S.R., which are more nearly self-sufficient in food and raw materials. It can hardly be expected, therefore, that the size of the merchant marine of any country should reflect accurately its industrial capacity. According to League of Nations statistics, Great Britain had the largest merchant marine in 1939, with about 26 percent of the world total, followed by the United States with some 17 percent. The following table shows the relative standing of the leading nations of the world in that year with their respective tonnages expressed in percentages of the U. S. tonnage:

TABLE V

Country	Percentage of U. S. tonnage
Great Britain	152
United States	100
Japan	47.5
Norway	40.5
Germany	38
Italy	29
Netherlands	25
France	25

In conclusion, it appears that the production of power, both total and electrical, and steel are elements that are better suited to provide indices of industrial capacity than the other elements considered. This does not mean, of course, that many others, not mentioned, should not be taken into account, but it is certain that all of them, in some measure, will be reflected in these three, of which the respective indices and their arithmetical means for the great powers are compared in the following table:

TABLE VI

Country	Percentages of U. S. Production			
	1939 Total Energy	1937 Electricity	1937 Steel	Mean
Germany	39	40	38.5	39
U.S.S.R.	19	29	34.5	27.5
Great Britain	22.5	23	25	23.5
Japan	7-10 ?	21.5	11	13-14
France	11	15	15	14
Italy	5	12	4	7

From an inspection of Table VI above, it is noted that the three indices for Germany and Great Britain show little deviation from the mean; the relatively low index for total energy in the case of France is probably due to a weakness in the coal position and an almost total lack of petroleum. The wider deviations in the case of the U.S.S.R. may possibly be explained on the basis that the industrial development of that country is of recent date, with much emphasis on the production of electricity and steel. The relatively high electricity indices for Japan and Italy are probably due in both countries to shortages of fuel and iron ore, combined with a rather intensive hydro-electrical development.

Transportation does not seem to lend itself to treatment by indices. It can be assumed, however, that the transportation, as well as the telecommunication systems of any country are adequate for the amount of industrial activity shown by the indices of energy and steel production. Both transportation and telecommunications may be limiting factors in industrial capacity, but they, together with all other limiting factors, such as manpower and raw materials, will be reflected in production figures.

The development of atomic power may modify profoundly the industrial situation as it stands today. It is unlikely that either Germany, Italy, or Japan will be allowed to participate to any great extent in this development, at least in the near future. On the other hand, there is no particular reason to suppose that, subject to the availability and disposition of the necessary raw materials, other nations will not develop this source of energy to the extent that their industrial capacity and resources may permit. These, and all similar considerations are more or less idle speculation; only the future can answer the questions that are uppermost in everyone's mind.

25 95850