# KEIO ECONOMIC OBSERVATORY

# OCCASIONAL PAPER

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## Economies of Scale, Technology, and Intra-Industry Trade

by

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This paper is preliminary and comments and discussions are welcome.

Title:Economies of Scale, Technology, and Intra-Industry Trade.

## 0. Introduction

The purpose of this paper is to test empirically economies of scale, defined by technology in Intra-Industry Trade(IIT). B.Balassa found first the existence of IIT. Grubel and Lloyd, Linder, Dreze, and others treated IIT as consisting of final goods. But P.Rayment found that IIT consists mostly of intermediate goods and he tried to explain IIT by economies of scale and specialization. However, to test the relationship between economies of scale and IIT, I will use I.Ozaki's definition on economies of scale, defined by technology. I.Ozaki sees technology, measured in plant scale, as the basis of economies of scale. In order to connect the relation between the economies of scale and IIT, Ozaki's technology types, classified by statistically estimated parameters values must be first introduced. I converted this into Standard International Trade Classification (SITC) data, then calculated Balassa index for each of these sectors and see if economies of scale and IIT can be related. Through this empirical test, I confirmed the assumption that IIT is based on economies of scale, defined by technology. Also, I found that this relation did not exist in East-West trade.

According to traditional international trade theory, international unit cost differences arise from national differences in factor endowments. But in this theory, only the final goods trade is treated and not the intermediate goods trade. Because in this theory all the production process is assumed to be done within the country, so that the concept of the industrial structure is completely ignored.

This traditional approach has two weaknesses in explaining the situation of today's world trade. First, it cannot explain why trade developed so rapidly between countries whose factor endowments are so similar as in European Communities(EC). Second, it cannot explain why industries operate in terms of the intermediate goods so that a high proportion of trade can be characterized as the Intra-Industry Trade(IIT) where the same good is both imported and exported. If we consider today's world trade, it is necessary that we have a new approach which can answer these two points.

Traditional trade theory sees international trade as originating from comparative advantage differences of economic development. Countries with relatively more capital tend to be industrialized countries and countries with relatively more labour tend to be developing countries, so that the Heckscher-Ohlin theory means international trade will grow where the differences of development are large. Also, there was a traditional view that the relative importance of manufactured goods in world trade will decline, for the developing countries will soon acquire modern technology and economic growth. But according to Economic Survey of Europe's (1987-88), [1] empirical analysis, the features of the international trade after World War II can be seen in the increase of manufactures trade and the increase of that trade among the industrialized countries. Therefore, manufactures international trade after World War II did not move the way as the traditional theorists have imagined. Instead, the ratio of manufactures in the world trade has increased and world manufactures trade is dominated by the industrialized countries, which is made up mostly from IIT, the same good imported and exported simultaneously.

The outline of my paper is as follows:First,representative theories and measurements of IIT of industrial countries are shown. Second,considering that IIT is made up mostly of intermediate goods,Rayment,trying to explain IIT by specialization and economies of scale,will be introduced. In order to empirically test this relationship,I introduce Ozaki's definition on economies of scale,based on technology. Third,empirical results, using Ozaki's technology types,on IIT with eocnomies of scale and specialization is stated. France,Germany,EC,Austria,and Hungary are taken as example. Fourth,explanation of the whole process is summarized and last but very important,further research is mentioned.

As a further research,an empirical analysis of IIT,explained by the economies of scale and specialization,has to be pursued. I will provide an example by analyzing the automobile's components within EC countries and between eastern and western countries. I will follow my analysis by taking General Motors(GM) in Europe as an example and try to see GM's export and import of components of automobiles to and from Austria. Countries which I will be handling with are:Austrian trade with Germany,France,United Kingdom,Spain, Belgium and finally to see East-West trade,Hungary-Austria will be taken as an example.

## 1.1 Intra-Industry Trade of Industrial Countries

### Theory and Measurement of Intra-Industry Trade(IIT)

The existence of IIT was first found by Balassa. He explained this phenomenon,using Balassa index,as the result of IIT development.

$$1/n\sum_{i}^{n}|Xi-Mi|/Xi+Mi \qquad \ldots.(1)$$

n:number of commodities,
i:commodity
X:export
M:import

Important theoretical explanations on IIT are:Grubel(1967) explained IIT by monopolistic competition theory model. Grubel and Lloyd(1971) explained IIT by oligopolistic production differentiation. Linder(1961) explained IIT by demand side's product differentiation. He said that factor endowment theory can explain the primary product trade's division of labour but when manufactured good trade's division of labour exists,domestic demand condition must be considered. Manufactured good trade occurs more among nations where per income level is similar than countries with different factor endowment. His conclusion was that in order to export manufactured good,domestic demand must exist first.

Dreze(1961) also considered the relations between trade and domestic demand important, but he thinks that according to the size of domestic market,one can specialize in standardized production run good and the other in longer production run good. One nation will import standardized intermediate components and the other exports for example, more ferentiated finished good. This must definitely increase IIT and manufactured trade.

But Grubel, Grubel and Lloyd, Linder, and Dreze models, cannot explain manufactured good trade, consisting of intermediate and capital goods among the industrialized countries. So we need a new approach, focusing on intermediate goods trade, explaining IIT by specialization and economies of scale.

## 2.1 Specialization and Economies of Scale

International division of labour can be normally divided into two groups(4): vertical division of labour and horizontal division of labour. Vertical division of labour means primary products and manufactured good traded between industrialized countries and developing countries. This trade occurs between countries of different stages of development. Horizontal division of labour, on the other hand, means manufactured good traded within industrialized countries.

This horizontal division of labour can be further divided into three groups: (A), (B), (C). (A): exchange of differentiated product (exchange of labour-intensive consumer goods with capital+physical capital-intensive goods). (B): exchange of different production stages of the same industry product (exchange of machine components with assemblying process). (C): exchange of differentiated goods of the same industry (exchange of differentiated consumer goods). (A) and (B) types, which can be explained by traditional trade theory, take place between industrialized countries and developing countries. (C) cannot be explained by the traditional trade theory, so we needed the theory by Linder, Dreze, and others mentioned earlier. But we know now that IIT consists mostly of intermediate goods. So the above mentioned theories, explaining IIT by final consumer goods, are not suitable. Rayment (1983), focusing on intermediate trade, tries to explain IIT by specialization and economies of scale. IIT is explained by the increased specialization of industrial activities, which increase intermediate goods trade. With the market spreading, division of labour will develop, dividing the production stage into smaller units. This "disintegration of industrial activities increases the intermediate goods trade. This type of trade develops among countries with a similar production structure. Therefore, one can say that the division of labour process increases as the differences of national economic development decreases. This phenomenon is shown in the trade statistics as the increase of IIT and in the production statistics as the increase of the intermediate consumption import. The European Economic Survey (1987-1988) has provided us with some data. They investigated if manufactures trade consists of narrowly differentiated consumer goods or if it consists of highly specialized intermediate goods. They statistically examined by using Western Europe's trade data. According to this empirical evidence, IIT consists mostly of parts and components. Therefore, we must separate final goods market and intermediate goods market when considering IIT. Rayment states that IIT can be explained by vertical specialization process. It is the same thing as saying that he explained IIT by fragmentation of industrial activities, pursuing longer production run.

Trying to explain IIT by differentiated final goods,has been done by several authors I mentioned before:Linder,Dreze,etc. It is true that differentiated final good is traded among industrialized countries,but we have found out that large percentage of IIT is made up of intermediate goods. As we all know that if there are many differentiated final goods traded,there will be even more intermediate goods needed to produce final goods. Final good shows only the demand side,so here I will take the demand side as given and handle the supply side only,concerning intermediate goods.

Next,the assumption that IIT can be explained by econmies of scale and specialization ,has to be empirically tested. I will pursue with the following method. First of all,economies of scale must be defined. Economies of scale is a compound of two conceptions. One is an economic meaning of the tendency of decreasing input factors as scale increases. Another is an engineering approach. In a traditional trade theory engineering meaning of an economies of scale has been ignored. Here,this engineering relations is taken as an estimation of the technology production function of capital plant.

In order to prepare for the empirical research,I have to explain how to connect the economies of scale and specialization with IIT. For this,Ozaki's technology type must first be explained.

From his earlier statistical test,Ozaki confirms the assumption of constant returns to scale for an intermediate input function,but rejects the assumption of constant returns to scale for the labour and capital input functions in the Leontief-type approach. Therefore,he develops a more generalized production function which excludes substitutability as in Leontief-type approach,but allows variable returns to scale for labour and capital. He calls this production function ,plant base factor-limitational production function.

Since capital embodied technical change plays the most important role in our modern technology system,he introduces the concept of a plant as a production unit in which fixed capital is embodied. He assumes that the different technical characteristics of plants can be described by different vectors composed of plant capacity and all input variables required to operate each plant. This means that a vector,consisting of plant capacity, labour input,material inputs,represents the technical character of the plant,and various vectors would represent the various types of technology. Then,technical indivisibility of each plant is assumed. This means that each of the plant with a different technology has a definite plant capacity. Next,a fixed technological coefficient is assumed for a given plant capacity that is,physical inputs are uniquely determined by the plant scale alone, meaning there is no substitutability.

The whole thing can be explained by an example. There are many plants,each with different technology,to produce one good,machinery. There is a plant to make engine,giers, and other parts,from which one machinery is produced. This plant has crossed over the border,thereby increasing IIT. He defines economies of scale,as the plant capacity increases,there is decreasing tendency in input variables required to operate the plant. So he estimated this plant base factor-limitational production function and Cobb-Douglas production function for each fifty-two sectors of the Japanese Input-Output table,using time-series data of labour and capital inputs and gross output. His classification result is shown on page 14,table 1.

Now I will quote the results of Ozaki's estimation of the parameters of the production function for all 52 sectors of Input-Output tables of Japan.

" Experimental equations are as follows:[6]

Factor-Limitational Type

$$L = \alpha_L X^{\beta_L} \quad K = \alpha_K X^{\beta_K} \qquad (1)$$

Linear Homogeneous Cobb-Douglas Type

$$X = \alpha_o L^{1-\beta_o} K^{\beta_o} \qquad (2)$$

Generalized Cobb-Douglas Type

$$X = \alpha L^{\gamma_L} K^{\gamma_K} \qquad (3)$$

where $X$ = gross output, $K$ = capital stock

$L$ = labor, $\alpha, \beta, \gamma$ = parameters

On the basis of the result obtained in the estimation,he divided 52 sectors into two large groups,i.e. groups which are characterized by capital-intensive type technology, where plant base factor-limitational production function is a measuring formula and labour-intensive type technology,where Cobb-Douglas production function is a measuring formula. Then he groups together the sectors which are of the similar parameters into six different groups of technologies:K(I-B),K(I-M),K(II),(L-K),L(I),and L(II).

1)Type K(I-B) technology

It is the case of $\beta_L$ <1 and $\beta_K$<1 in equation (1),meaning that economies of scale prevails tremendously in both labour and capital input. If the demand side is enough,this industry production will keep on growing indefinitely by expanding of the plant size with this type of technology. This characteristic is common to K(I-M) technology also. The differences between the two types of technologies are K(I-B) technology's value of elasticity of the labour input is extremely small and the value of capital intensity (K/L) is large. This is because massive investment is required and large size equipment allows drastic labour saving. (examples:petrochemical,iron,and steel industries).

2)Type K(I-M) technology

It is the same as the first type technology,but compared to the first one,the value of the parameter for labour input is a little more than K(I-B) type technology while the value of capital intensity (K/L) is not as large as the first one.(examples: machinery sectors)

3)Type K(II) technology

This is the case if $\beta_L$<1 and $\beta_K$>1 in equation (1). This means that while economies of scale have a strong effect in the labour input process,in the capital inputs the diseconomies of scale prevails and the value of capital intensity is comparatively large. (examples:intermediate goods sectors,pulp,cement,inorganic chemical,chemical fertilizer, and coal product industries)

We can include all above 3 types of technology as capital-intensive type.

4)Type (L-K) technology

This is the case $\beta_o<1$ in equation (2). (examples:small-scale industries that have divisible technology and factor substitution implied by $\beta_o<1$ and a low capital-labour ratio)

5)Type L(I) technology

This is the case $0<\gamma_L<1, 0<\gamma_K<1$, and $\gamma_L+\gamma_K>1$ in equation (3). This is the ordinary type of generalized Cobb-Douglas production function with increasing returns to scale and factor substitutability.

6)Type L(II) technology

This is the special case of type L(I) with $\gamma_L>1$. In both type L(I) and L(II), the degree of capital intensity is low, while labour absorption ability is high. Type(L-K), L(I), L(II) can be named as labour-intensive technology.

In table 1(7), Ozaki states that which sectors are associated to which technology. One can see from this table that the economies of scale is working in type K. So he grouped all sectors into 6 technology types, according to the evaluation of the estimated parameter's values. They are:1)Type K(I-B) technology(large-quantity processing technology), 2)Type K(I-M) technology(large-scale assembly production technology), 3)Type K(II) technology(capital-intensive technology), 4)Type (L-K) technology(Cobb-Douglas constant earnings type), 5)Type L(I) technology(Labour-intensive technology), 6)Type L(II) technology(Labour-intensive technology)."

According to this classification by Ozaki, I now explain what I did to test the relation between economies of scale and IIT. I shall explain on my data first. Following examples were taken. France and Germany to see the bilateral relations. France and European Community and also Germany and European Community were taken to see multilateral relations. Finally Austria and Hungary were taken to see East-West trade relations. The year 1980 is taken for my data. I assume here that the phase of industrialization between Japan, Germany, and France is at the same level, so that I can use Ozaki's classification, using Japanese Input-Output table, into these countries. I assume that production function's parameters $\beta_L$ and $\beta_K$ are almost the same in these countries. This is because engineering design law for producing a commodity should be in common among these countries, which is approximated by labour and capital input functions in Ozaki's approach. Ozaki has earlier estimated the parameters of capital-intensive technology type, and made the comparison of the parameter among Japan, Germany, and USA. The result was that parameters are very similar. So I can assume that in countries, as in Japan, Germany, and France above mentioned is valid.

As for the case between Austria and Hungary, if IIT is low, reason for this can be explained by the different phases of industrialization among these countries or by different economic systems among these countries. So I converted Standard International Trade Classification(SITC) of 2-digits into Ozaki's 52 sectors of the Japanese Input-Output table. This result is shown on page 17.

Then on the basis of this data, for each 90 sectors of the SITC, aggregated into 52 sectors, a Balassa index is calculated. If the result is such that in capital-intensive technology type where economies of scale plays a great role, IIT was high, we can conclude that division of labour is caused by the economies of scale, resulting in IIT's increase.

## 2.2 Empirical Results on IIT with Economies of Scale and Specialization

The empirical results is shown in table 2 on page 16.

Standard Internationa Trade Classification's exports are valued by free on board(f.o.b.) and imports are valued by cost,insurance,and freight(c.i.f.). That is why there are two columns for each case. For example IIT between Germany and France,first column is seen from German side and second column is seen from French side.

Empirical Results:(9)

(1) IIT between Germany and France

Corresponding to Type K(I-B) technology,except electric current and gas,natural and manufactured,there are the connection between the scale merit and IIT. Especially in organic chemicals,non-ferrous metals,iron and steel,and petroleum refining products,are IIT increasing. In Type K(I-M) technology,except beverages,IIT is large. Motor vehicles, machinery,electrical machinery,precision instruments,and fiber spinning have large IIT. In Type K(II) technology,except chemical manure and miscellaneous coal products,IIT is large. Basic inorganic chemicals and paper have large IIT. In Type (L-K) technology,IIT is not large,meaning that with the linear-homogeneous classical Cobb-Douglas production function,which is observed in small-scale industries,IIT is not large. So I confirmed that IIT can be explained by the economies of scale and specialization. In Type L(I) and L(II) technology,even though they are labour-intensive,IIT is not small. But this does not contradict the above just mentioned result. The reason for this result can be explained,I think,by the special close trade relations in these particular sectors between France and Germany.

(2) IIT between Germany and EC

In type K(I-B) technology,IIT is large, meaning the existence of economies of scale in explaining IIT. In type K(I-M) technology,IIT is also large. In type K(II),IIT is rather large. In type (L-K), IIT is small. In type L(I) and L(II),IIT is rather large. We can conclude that IIT can be explained by economies of scale. Next,if we compare the bilateral trade between West Germany and France and multilateral trade between Germany and EC countries,we can conclude the following interesting points. In K(I-B) technology, gas and water supply(2),artificial fiber materials(5),in K(I-M) technology,machinery(10), fiber spinning(13),beverages and alkoholic drinks(14),in K(II) technology,pulp(16),cement (17),chemical manure(19),and miscellaneous coal products(20),Germany's IIT with EC is larger than bilateral trade with France. This can be interpreted that in these sectors, multilateral relations exists between Germany and EC. For example, machinery is not only traded bilaterally,but also multilaterally within EC countries.

(3) IIT between France and EC

In type K(I-B), K(I-M), and K(II), except in electric power supply(1), gas and water supply(2), Precision instruments(12), chemical manure(19), miscellaneous coal products(20), and Tobacco(21), IIT was high. Therefore, we can also conclude that IIT can be explained by economies of scale. Next, we compare the bilateral trade between France and Germany and multilateral trade between France and EC countries. In K(I-B) technology petroleum refining products(3), iron and steel(6), in K(I-M) technology, motor vehicles(9), machinery(10), electrical machinery(11), in K(II), paper(15), pulp(16), cement(17), chemical manure(19), miscellaneous coal products(20), France's IIT with EC is larger than bilateral trade with Germany. Especially in motor vehicles(9), machinery(10), and electrical machinery(11), existence of multilateral relations between France with other EC countries, is interesting to observe. We can interpret this result that many of the components of these sectors are traded among EC countries multilaterally rather than only bilaterally.

(4) IIT between Austria and Hungary

There is almost no IIT found in the East-West trade between Austria and Hungary. Exceptions are other wood product(40), wood milling(27) and beverages and alkoholic drinks. In type K(I-M) technology, motor vehicles(9), machinery(10), electrical machinery(11), precision instruments(12), one can say that IIT is quite low in these sectors. So one can conclude that there is almost no relation between economies of scale and IIT in capital-intensive technology type in East-West trade yet.

Therefore, one must increase IIT in these sectors, where economies of scale prevails, in East-West trade. The reason is because for the economic reform which Hungary is now pursuing, the main target of economic policy should be the promotion of structural change. In order to promote structural change, first, Hungary should be directed more to international market competition. Second, a more integral participation in the world-wide division of labour, meaning increase in IIT, especially in capital-intensive technology type is needed. As I have pointed out in my empirical results, for example in motor vehicles, machinery, electrical machinery, precision instruments where IIT is yet low, should increase.

In order to do so, Hungary must not promote large scale production of these sectors from above or from the Central Planning Bureau. Because then, economies of scale can work only in final assembling stage, for example, but not at the level of producing these sectors. I have shown in this paper that there is a relation between economies of scale, defined by technology and IIT, consisting mostly from intermediate goods. In order to be integrated in the world-wide division of labour with EFTA(European Free Trade Association) and EC(European Community) countries, Hungary must give the sectors where intermediate goods are produced to compete in market mechanism, not to be given orders from the Central Planning Bureau, so that economies of scale merit will work within these sectors, thereby increasing IIT in East-West trade.

## 3.0 Summary

Here in this article, I wanted to convey the following procedure of the line in explaing IIT.

| | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| disintegration of the process | ---> | economies of scale | ---> | international division of labour | ---> | increase in IIT | ---> | integration of EC (large market) |

(1) When disintegration of the process has been done, the technological scale merit will work on the particular sector.
(2) We have seen that which sectors are easily connected to the international division of labour, instead of just saying, IIT consists mostly from intermediate goods. This is to say that which sectors were affected and increased IIT by the expansion of the market.
(3) The fact that IIT increased if the division of labour exists, can be taken as the problem of the aggregation to a certain extent. But there is an empirical study from Grubel and Lloyd(1971), stating that IIT persisted even with 7-digit level. Another example is given by Rayment, stating that for most countries, the growth of IIT at 4-digits level has been growing faster than at 3-digits level, meaning that impact of disaggregation on IIT has been declining over the year 1962 to 1973.[10] So when sectors are aggregated there will surely be an increase in IIT, but it certainly does not mean that disaggregation will wipe out IIT.
(4) When parts and semi-finished products trade increase among countries within EC, complementary relationship occurs within them, increasing IIT, thereby increasing the intermediate goods within EC as a whole. This will lead to the integration of EC, supplying larger market and increasing the demand.

Here, I have confirmed that becuase of the enlargement of the market, IIT increases in Type K technology, where economies of scale works. This result supports the assumption that EC integration is based on economies of scale, defined by technology. One can say that compound goods like motor vehicle and machinery, where economies of scale exists, are traded not only bilaterally but also multilaterally within EC countries.
In East-West trade also, this type of technological relation must increase especially in capital-intensive type technology.

## 4.0 Further Research

On the empirical analysis of IIT, very little has been done of a case study type. Industry specific studies can provide with rich information, but very few studies exists. Therefore, I like to take up automobile's trade of components as an example of IIT and to see the relationship between economies of scale and IIT. I will provide an example by analyzing the automobile's trade of components within EC countries and between East and West countries. I will follow my analysis by taking General Motors (GM) in Europe as an example and try to see GM's export and import of components of automobile's to and from Austria. Countries which I will be handling with are:Austrian trade of components of cars with Germany,France,United Kingdom,Spain,Belgium and finally to see East-West trade Austria-Hungary will be taken as an example.

We have found that within EC countries,IIT,made up mostly of intermediate goods,occurs by pursuing economies of scale,decreasing unit cost. Therefore,we can conclude that economies of scale,defined by technology is the main cause of IIT in EC. On the other hand, within CMEA countries,specialization is very low in general. Therefore,I conclude that Eastern countries can increase IIT only through promoting East-West trade in intermediate goods.

I think study on EC and CMEA give a good example for our future world in three points.

- If integration like EC shall be realized in Asia(Japan,China and other Asean countries) or in USA(USA,Canada,and South America)? If so,what will the effects of these block sectors to the world trade be?
- If IIT will increase by introducing market mechanism in countries like USSR and China?
- East-West trade between EC country and CMEA coountry can give an example model to the future relationship between Japan and China.

From this point of view,I like to make my further research.

Footnotes

(1) Economic Survey of Europe in 1987-88. Comtrade data bank(United Nations) was used to calculate trade share, trade intensity coefficients, and IIT ratio.

(2) Ozaki's technology types are K(I-B), K(I-M), K(II), (L-K), L(I), and L(II). This will be explained in section 2.1 Specialization and Economies of Scale in this paper.

(3) SITC 2-digits converted to Ozaki's 56 sectors are given in table 1.

(4) Yamasawa, "International Economics", Standard Economic Series, Toyo keizaishinposha.

(5) Rayment, P. (1983), page 21.

(6) Ozaki, I. (1976), pp. 97-100.

(7) Ozaki's table 1 is given in the appendix.

(8) Ozaki's classification converted into SITC 2-digits is shown in table 3.

(9) Empirical results are shown in table 2.

(10) Rayment, P. (1983), pp. 10-11.

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TABLE I

PRODUCTION TECHNOLOGY TYPES

(1) K type (capital-intensive technology) — K(I) type

(A) Large-Quantity Processing Technology: K(I-B) Type

| Technology Type | | Sector | (1) Production Function Parameters $\beta_L$ $L=\alpha_L X^{\beta_L}$ | $\beta_K$ $K=\alpha_K X^{\beta_K}$ | (2) $\left(\frac{\bar{K}}{\bar{L}}\right)_i$ 1951-68 Average | Technological Characteristics |
|---|---|---|---|---|---|---|
| K(I-B) | 1 | Electric power supply | 0.12 | 0.80 | 17.43 | (i) Measuring formula: |
| K(I-B) | 2 | Gas & water supply | 0.68 | 0.73 | 2.59 | (1) $L=\alpha_L X^{\beta_L}$, $K=\alpha_K X^{\beta_K}$ |
| K(I-B) | 3 | Petroleum refining products | 0.27 | 0.65 | 14.76 | (ii) Parameter characteristics: |
| K(I-B) | 4 | Basic organic chemicals | 0.33 | 0.72 | 5.70 | $\beta_L<1$, $\beta_K<1$ |
| K(I-B) | 5 | Artificial fiber materials | 0.10 | 0.84 | 3.89 | (iii) Parameter value: $\beta_L \fallingdotseq 0.2$-$0.3$ |
| K(I-B) | 6 | Iron and steel | 0.30 | 0.80 | 3.86 | (iv) Capital intensity: $(\bar{K}/\bar{L})$ value is |
| K(I-B) | 7 | Nonferrous primary products | 0.38 | 0.73 | 3.84 | large (>3) |

(B) Large-Scale Assembly Production Technology: K(I-M) Type

| Technology Type | | Sector | (1) Production Function Parameters $\beta_L$ $L=\alpha_L X^{\beta_L}$ | $\beta_K$ $K=\alpha_K X^{\beta_K}$ | (2) $\left(\frac{\bar{K}}{\bar{L}}\right)_i$ 1951-68 Average | Technological Characteristics |
|---|---|---|---|---|---|---|
| K(I-M) | 8 | Ships & ship repairing | 0.07 | 0.80 | 1.19 | (i) Measuring formula: |
| K(I-M) | 9 | Motor vehicles | 0.46 | 0.70 | 2.12 | (1) $L=\alpha_L X^{\beta_L}$, $K=\alpha_K X^{\beta_K}$ |
| K(I-M) | 10 | Machinery | 0.52 | 0.88 | 0.62 | (ii) Parameter characteristics: |
| K(I-M) | 11 | Electrical machinery | 0.55 | 0.91 | 1.00 | $\beta_L<1$, $\beta_K<1$ |
| K(I-M) | 12 | Precision instruments | 0.53 | 0.97 | 0.59 | (iii) Parameter value: $\beta_L \fallingdotseq 0.3$-$0.5$ |
| K(I-M) | 13 | Fiber spinning | 0.26 | 0.59 | 2.07 | (iv) Capital intensity: $(\bar{K}/\bar{L})$ value is |
| K(I-M) | 14 | Beverages & alcoholic drinks | 0.33 | 0.79 | 2.26 | median (<3) |

(1) K type — K(II) type

(C) Capital-Intensive Technology: K(II) Type

| Technology Type | | Sector | (1) Production Function Parameters $\beta_L$ $L=\alpha_L X^{\beta_L}$ | $\beta_K$ $K=\alpha_K X^{\beta_K}$ | (2) $\left(\frac{\bar{K}}{\bar{L}}\right)_i$ 1951-68 Average | Technological Characteristics |
|---|---|---|---|---|---|---|
| K(II) | 15 | Paper | 0.13 | 1.03 | 3.07 | (i) Measuring formula: |
| K(II) | 16 | Pulp | −0.29 | 1.23 | 3.94 | (1) $L=\alpha_L X^{\beta_L}$, $K=\alpha_K X^{\beta_K}$ |
| K(II) | 17 | Cement | 0.08 | 1.03 | 9.07 | (ii) Parameter characteristics: |
| K(II) | 18 | Basic inorganic chemicals | 0.04 | 1.01 | 2.71 | $\beta_L<1$, $\beta_K>1$ |
| K(II) | 19 | Chemical manure | −0.71 | 1.71 | 4.97 | (iii) Parameter value: $\beta_L<1$ |
| K(II) | 20 | Miscellaneous coal products | −0.09 | 1.67 | 1.50 | (iv) Capital intensity: $(\bar{K}/\bar{L})$ value is |
| K(II) | 21 | Tobacco | 0.18 | 2.30 | 1.83 | large |

(2) L type — (L-K) type

(D) Cobb-Douglas Constant Earnings Type: (L-K) Type

| Technology Type | | Sector | (1) $\beta_0$ $\frac{X}{L}=\alpha_0\left(\frac{K}{L}\right)^{\beta_0}$ | (2) $\left(\frac{\bar{K}}{\bar{L}}\right)_i$ 1951-68 Average | Technological Characteristics |
|---|---|---|---|---|---|
| (L-K) | 22 | Agriculture, forestry, and fisheries | 0.67 | 0.46 | (i) Measuring formula: |
| (L-K) | 23 | Coal & lignite | 0.56 | 0.90 | (1) $X/L=\alpha_0(K/L)^{\beta_0}$ |
| (L-K) | 24 | Mining | 0.64 | 0.56 | (ii) Parameter characteristics: simple and symmetrical |
| (L-K) | 25 | Silk reeling & spinning | 0.70 | 0.59 | (iii) Parameter value: $\beta_0>0.5$ |
| (L-K) | 26 | Vegetable & animal oil & fat | 0.69 | 1.91 | (iv) Capital intensity: $(\bar{K}/\bar{L})$ value is |
| (L-K) | 27 | Wood milling | 0.78 | 0.68 | small (<1) |

| | | Technology Type | | Sector | (1) $X=\alpha L^{\gamma_L}K^{\gamma_K}$ $\gamma_L$ | $\gamma_K$ | (2) $\left(\frac{\bar{K}}{\bar{L}}\right)_i$ 1951-68 Average | Technological Characteristics |
|---|---|---|---|---|---|---|---|---|
| (2) L type (labor-intensive technology) | | (E) Labor-Intensive Technology (Increasing Returns to Scale): Types L(I) and L(II) | | | | | | |
| | L(I) type | L(I) | 28 | Building & construction | 0.75 | 0.45 | 0.25 | (i) Measuring formula: $X=\alpha L^{\gamma_L}K^{\gamma_K}$ |
| | | L(I) | 29 | Meat | 0.44 | 0.61 | 1.52 | |
| | | L(I) | 30 | Seafood, preserved | 0.90 | 0.48 | 0.59 | (ii) Parameter characteristics: $\gamma_L+\gamma_K>1$ |
| | | L(I) | 31 | Transport services | 0.70 | 0.67 | 1.04 | |
| | | L(I) | 32 | Paints | 0.58 | 0.73 | 1.51 | (iii) Parameter value: $\gamma_L<1$, $\gamma_K<1$ |
| | | L(I) | 33 | Rubber products | 0.99 | 0.63 | 0.99 | (iv) Capital intensity: $(\bar{K}/\bar{L})$ value is about 1 |
| | | L(I) | 34 | Glass products | 0.44 | 0.88 | 1.46 | |
| | | L(I) | 35 | Miscellaneous industrial products | 0.83 | 0.93 | 0.78 | |
| | L(II) type | L(II) | 36 | Other transport equipment | 1.31 | 0.54 | 1.01 | (i) Measuring formula: $X=\alpha L^{\gamma_L}K^{\gamma_K}$ |
| | | L(II) | 37 | Metal products | 1.35 | 0.30 | 0.49 | |
| | | L(II) | 38 | Leather products | 2.21 | −0.07 | 0.40 | (ii) Parameter characteristics: $\gamma_L+\gamma_K>1$ |
| | | L(II) | 39 | Furniture & fixtures | 1.82 | 0.44 | 0.40 | |
| | | L(II) | 40 | Other wood products | 2.33 | 0.68 | 0.26 | (iii) Parameter value: $\gamma_L>1$, $\gamma_K<1$ |
| | | L(II) | 41 | Paper articles | 1.29 | 0.56 | 0.72 | |
| | | L(II) | 42 | Pottery, china & earthenware | 1.39 | 0.55 | 0.51 | (iv) Capital intensity: $(\bar{K}/\bar{L})$ value is small (<1) |
| | | L(II) | 43 | Structural clay products | 1.59 | 0.96 | 0.57 | |
| | | L(II) | 44 | Other nonmetallic mineral products | 1.87 | 0.19 | 1.15 | |
| | | L(II) | 45 | Medicine | 1.20 | 0.80 | 1.25 | |
| | | L(II) | 46 | Weaving & other fiber products | 1.75 | 0.63 | 0.79 | |
| | | L(II) | 47 | Footwear & wearing apparel | 1.93 | 0.28 | 0.31 | |
| | | L(II) | 48 | Printing and publishing | 1.43 | 0.27 | 0.57 | |
| | | L(II) | 49 | Other food, prepared | 1.26 | 0.35 | 0.65 | |
| | | L(II) | 50 | Trading | 1.95 | 0.84 | 0.65 | |
| | | L(II) | 51 | Finance & insurance | 1.60 | 0.22 | 0.70 | |
| | | L(II) | 52 | Communication services | 3.38 | 0.08 | 0.17 | |

Table2

IIT between:

| | Germany & France | | Germany & EC | | France & EC | | Austria & Hungary |
|---|---|---|---|---|---|---|---|
| 1. Electric power supply | | | 0.4448 | 0.3212 | 0.5234 | 0.6415 | 1 |
| 2. Gas and water supply | 0.6869 | 0.6765 | 0.0319 | 0.6106 | 0.8766 | 0.8695 | 0.9994 |
| 3. Petroleum refining products | 0.3242 | 0.2612 | 0.8165 | 0.8101 | 0.0864 | 0.0694 | 0.9233 |
| 4. Basic organic chemicals | 0.0516 | 0.0666 | 0.041 | 0.41 | 0.066 | 0.0278 | 0.255 |
| 5. Artificial fiber materials | 0.3415 | 0.0221 | 0.0177 | 0.0641 | 0.1829 | 0.0665 | 1 |
| 6. Iron and steel | 0.1419 | 0.1354 | 0.1079 | 0.116 | 0.088 | 0.0756 | 0.1771 |
| 7. Nonferrous primary products | 0.0423 | 0.0243 | 0.1024 | 0.0821 | 0.0769 | 0.1013 | 0.2038 |
| 8. Ships and ship reparing | | | | | | | |
| 9. Motor vehicles | 0.1889 | 0.209 | 0.368 | 0.3422 | 0.1671 | 0.1305 | 0.4943 |
| 10. Machinery | 0.3713 | 0.3397 | 0.334 | 0.318 | 0.235 | 0.31 | 0.744 |
| 11. Electrical machinery | 0.2023 | 0.2047 | 0.28 | 0.265 | 0.1097 | 0.122 | 0.499 |
| 12. Precision instruments | 0.268 | 0.2002 | 0.221 | 0.201 | 0.769 | 0.1633 | 0.779 |
| 13. Fiber spinning | 0.1543 | 0.1642 | 0.006 | 0.052 | 0.218 | 0.245 | 0.451 |
| 14. Beverages and alkoholic drinks | 0.8839 | 0.8832 | 0.499 | 0.4968 | 0.5272 | 0.5412 | 0.0248 |
| 15. Paper | 0.132 | 0.1347 | 0.1368 | 0.1722 | 0.0963 | 0.0975 | 0.8061 |
| 16. Pulp | 0.5576 | 0.4706 | 0.1069 | 0.047 | 0.065 | 0.0829 | 0.293 |
| 17. Cement | 0.4827 | 0.427 | 0.0023 | 0.0188 | 0.0652 | 0.0427 | 0.355 |
| 18. Basic inorganic chemicals | 0.1418 | 0.0954 | 0.1835 | 0.2486 | 0.1658 | 0.0947 | 0.5636 |
| 19. Chemical manure | 0.7773 | 0.7402 | 0.0269 | 0.0187 | 0.6198 | 0.605 | 0.649 |
| 20. Miscellaneous coal products | 0.8618 | 0.8284 | 0.1008 | 0.0242 | 0.7037 | 0.7094 | 0 |
| 21. Tobacco | 0.4398 | 0.3699 | 0.3773 | 0.2762 | 0.7391 | 0.7025 | 0.8305 |
| 22. Agriculture, forestry, and fisheries | 0.7043 | 0.7517 | 0.642 | 0.685 | 0.561 | 0.499 | 0.955 |
| 23. Coal and lignits | 0.8984 | 0.8361 | 0.044 | 0.0949 | 0.828 | 0.8843 | 1 |
| 24. Mining | 0.3249 | 0.28 | 0.638 | 0.667 | 0.016 | 0.135 | 0.732 |
| 25. Silk selling and spinning | 0.7991 | 0.8747 | 0.0753 | 0.4295 | 0.7321 | 0.0431 | 0 |
| 26. Vegetable and animal oil and fat | 0.0208 | 0.1023 | 0.387 | 0.369 | 0.019 | 0.021 | 0.698 |
| 27. Wood milling | 0.5576 | 0.469 | 0.0283 | 0.0116 | 0.9559 | 0.6136 | 0.0136 |
| 28. Building and construction | | | | | | | |
| 29. Meat | 0.1694 | 0.1466 | 0.4092 | 0.4082 | 0.3796 | 0.3845 | 1 |
| 30. Seafood preserved | 0.1042 | 0.0678 | 0.3711 | 0.6457 | 0.3727 | 0.3885 | 0.7751 |
| 31. Transport services | | | | | | | |
| 32. Paints | 0.388 | 0.459 | 0.4058 | 0.3796 | 0.3313 | 0.2678 | 0.9938 |
| 33. Rubber products | 0.1783 | 0.1913 | 0.0548 | 0.0671 | 0.1703 | 0.1553 | 0.9539 |
| 34. Glass products | 0.0028 | 0.0415 | 0.019 | 0.022 | 0.033 | 0.028 | 0.251 |
| 35. Miscellaneous industrial products | 0.2012 | 0.1903 | 0.021 | 0.014 | 0.181 | 0.058 | 0.506 |
| 36. Other transport equipment | 0.0918 | 0.1591 | 0.0446 | 0.0325 | 0.3094 | 0.0467 | 0.4336 |
| 37. Metal products | 0.2755 | 0.2146 | 0.2646 | 0.2498 | 0.1478 | 0.2014 | 0.8027 |
| 38. Leather products | 0.1124 | 0.2208 | 0.305 | 0.437 | 0.161 | 0.07 | 0.288 |
| 39. Furniture and fixtures | 0.8212 | 0.1809 | 0.1006 | 0.0824 | 0.4885 | 0.5287 | 0.5667 |
| 40. Other wood products | 0.2622 | 0.293 | 0.1408 | 0.1573 | 0.0808 | 0.0336 | 0.056 |
| 41. Paper articles | 0.132 | 0.1347 | 0.1368 | 0.1722 | 0.0963 | 0.0975 | 0.8061 |
| 42. Pottery, china and earthenware | 0.3499 | 0.3544 | 0.0066 | 0.0308 | 0.1959 | 0.2149 | 1 |
| 43. Structural clay products | 0.5743 | 0.4634 | 0.0029 | 0.0129 | 0.5336 | 0.601 | 0.8714 |
| 44. Other nonmetallic mineral products | 0.2116 | 0.2477 | 0.039 | 0.025 | 0.434 | 0.319 | 0.971 |
| 45. Medicine | 0.8253 | 0.9507 | 0.0111 | 0.0043 | 0.1382 | 0.1522 | 0.4767 |
| 46. Weaving and other fibre products | 0.0157 | 0.0101 | 0.0876 | 0.1 | 0.0956 | 0.1264 | 0.3205 |
| 47. Footwear and wearing apparel | 0.4511 | 0.5382 | 0.385 | 0.406 | 0.015 | 0.016 | 0.552 |
| 48. Printing and publishing | 0.5862 | 0.6152 | 0.0164 | 0.0095 | 0.4163 | 0.371 | 0.7515 |
| 49. Other food, prepared | 0.1917 | 0.1914 | 0.063 | 0.028 | 0.225 | 0.075 | 0.863 |

| Ozaki's classification | SITC 2-digits classification |
|---|---|
| 1.Electric power supply | 35.Electric current |
| 2.Gas and water supply | 34.Gas,natural and manufactured |
| 3.Petroleum refining products | 33.Petroleum,petroleum products and related materials |
| 4.Basic organic chemicals | 51.Organic chemicals |
| | 582.Condensation,poly condensation and poly addition products, whether or not modified |
| | 583.Poly merization and copoly merization products |
| | 584.Regenerated cellulose;cellulose intrate,cellulose acetate and other cellulose esters,cellose ethers |
| 5.Artificial fiber materials | |
| | 585.Other artificial resins and plastic materials |
| 6.Iron and steel | 67.Iron and steel |
| 7.Nonferrous primary products | 68.Nonferrous metals |
| 8.Ships and ship repairing | |
| 9.Motor vehicles | 78.Road vehicles(including air cushon vehicles) |
| 10.Machinery | 71.Power generating machinery and equipment |
| | 72.Machinery specialized for particular industries |
| | 73.Metalworking machinery |
| | 74.General industrial machinery and equipment,N.E.S. and machine parts,N.E.S. |
| | 75.Office machines and automatic data processing equipment |
| 11.Electrical machinery | 76.Telecommunications and sound recording apparatus and equiupment |
| | 77.Electrical machinery,apparatus and appliances,N.E.S.,and electrical parts thereof |
| 12.Precision instruments | 87.Professional,scientific and controlling |
| | 88.Photographic apparatus,equip- |

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|---|---|
| | ment and supplies and optical goods,N.E.S.;watches and clocks. |
| 13.Fiber spinning | 263.Cotton |
| | 264.Jute and other textile bast fibers,n.e.s.,raw or processed but not spun; two and waste therof |
| | 265.Vegetable textile fibres(other than cotton and jute) and waste of such fibres |
| | 266.Synthetic fibres suitable for spinning |
| | 267.Other man-made fibres suitable for spinning and waste of man-made fibres |
| | 268.Wool and other animal hair(excluding wool tops) |
| | 269.Old clothing and other old textile articles;rags |
| 14.Beverages and alkoholic drinks | 11.Beverages |
| 15.Paper | 64.Paper,paperboard,and articles of paper pulp,of paper or paperboard |
| 16.Pulp | 25.pulp and waste paper |
| 17.Cement | 661.Lime,cement,and fabricated construction materials (except glass and clay materials) |
| 18.Basic inorganic chemicals | 52.Inorganic chemicals |
| 19.Chemical manure | 56.Fertilizers,manufactured |
| 20.Miscellaneous coal products | 323.Briquettes;coke and semi-coke of coal,lignite or peat;retort carbon |
| 21.Tobacco | 12.Tobacco and tobacco manufactures |
| 22.Agriculture,forestry,and fisheries | 04.Cereals and ecreal preparation |
| | 05.Vegetables and fruit |
| | 23.Crude rubber(including sythetic and reclaimed) |
| 23.Coal and lignits | 322.Coal,lignite and peat |
| 24.Mining | 27.Crude fertilizers and crude minerals(excluding coal petroleum and precious stones) |
| | 28.Metallferrous ores and metal scrap |

| | |
|---|---|
| | 33.Petroleum,petroleum products and related materials |
| 25.Silk selling and spinning | 261.Silk |
| 26.Vegetable and animal oil and fat | 22.Oil seeds and oleaginous fruit<br>29.Crude animal and vegetable materials,N.E.S.<br>41.Animal oils and fats<br>42.Fixed vegetable oils and fats,<br>43.Animal and vegetable oils and fats,processed,and waxes of an imal or vegetable origin |
| 27.Wood milling | 24.Cork and wood |
| 28.Building and construction | |
| 29.Meat | 01.Meat and meat preparations |
| 30.Seafood preserved | 03.Fish,crustaceans and molluscs, and preparations thereof |
| 31.Transport services | |
| 32.Paints | 53.Dyeing,tanning and colouring materials |
| 33.Rubber products | 62.Rubber manufactires,N.E.S. |
| 34.Glass products | 664.Glass<br>665.Glassware |
| 35.Miscellaneous industrial products | 81.Sanitary,plumbing,heating and lighting fixtures and fittings<br>893.<br>899. |
| 36.Other transport equipment | 79.Other transport equipment |
| 37.Metal products | 69.Manufactures of metal.N.E.S. |
| 38.Leather products | 21.Hides,skins and furskins,raw<br>61.Leather,leather manufactures, and dressed furskins |
| 39.Furniture and fixtures | 82.Furniture and parts thereof |
| 40.Other wood products | 63.Cork and wood manufactures (excluding furniture) |
| 41.Paper articles | 64.Paper,paperboard,and articles of paper pulp,of paper or of paperbord |
| 42.Pottery,china ana earthenware | 666.Pottery |
| 43.Structural clay products | 662.Clay construction materials and refractory construction materials |
| 44.Other nonmetallic mineral products | 663.Mineral manufactures<br>667.Pearls,precious and semi-precious stones,unworked or worked |

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|---|---|
| 45.Medicine | 54.Medicinal pharmaceutical products |
| 46.Weaving and other fibre products | 65.Textile yarn,fabrics,made up articles,and related products |
| 47.Footwear and wearing apparel | 83.Travel goods,handbags and similar containers<br>84.Articles of apparel and clothing accessories<br>85.Footwear |
| 48.Printing and publishing | 892.Printed matter |
| 49.Other food,prepared | 02.Dairy products and bird's eggs<br>06.Sugar,sugar preparations and honey<br>07.Coffee,tea,cocoa,spices,and manufactures thereof<br>08.Feeding stuff for animals(not including unmilled cereals)<br>09.Miscellaneous edible products and preparations |
| 50.Trading | |
| 51.Finance and insurance | |
| 52.Communication services | |