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THE FACTORS AFFECTING COLONIAL INDUSTRIALIZATION THROUGH THE METRO WORKER'S MIGRATION

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This paper attempts to find out the factors affecting the colonial industrialization based on the modified Krugman's model. We assume that technology transfer is possible only through the migration of farmers and workers from the metro to the colony. With this assumption, we find a surprising result that in the lower level of industrialization a metro is, the more likely its colony can be industrialized. We also obtain the following additional results: With the higher agricultural productivity (market size) of the colony, or with the lower transport cost, the more likely the colony can be industrialized. Thus, these results can explain the difference in colonial industrialization between India and Korea.

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I. INTRODUCTION

Most developing countries have undergone colonial experiences. However, their levels of industrialization achieved during their colonial periods are widely diverse. Their levels of physical and human capital stocks at the end of the colonial period were also very different among these countries. These different initial levels of human and physical capital stocks are very important for these countries' future economic growth, following the conditional convergence hypothesis and poverty trap theories.

However, few papers have attempted to find the mechanism of colonial industrialization process with a formal model. In this context, this paper attempts to find out the factors affecting colonial industrialization process and, thus, initial

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levels of physical and human capital stocks at the end of the colonial period.

The comparison between Indian and Korean colonial industrialization experiences provides a good motivation for this paper. In 1938, Korea's manufacturing sector's production index was 556, while India's 269, with the index of 1913 set to 100 for both countries. In addition, Japanese had invested 37.8 dollars in Korea, on the basis of per capita of the colony, while the British 8.4 dollars in India until 1938. Japanese invested mainly in heavy industry of Korea such as chemical industry, and the British mainly in light industry of India such as yarn and clothing industry. Finally, as for human capital accumulation, Korea's primary school enrollment rate was 43.4 per cent (4.3), whereas India's 19.8 (11.1) in 1941 (in 1911).[1] In a word, Korean colonial industrialization process is quite different from Indian in terms both of quantity and of quality. At this point, an interesting question is: What factors contribute to these differences between Indian and Korean colonial industrialization process.

One of the important channels through which colonies can experience technology transfers from metros is through the migration of farmers and workers, from metros to their colonies.[2] Thus, with the assumption that the colonial industrialization can be done mainly through the migration of farmers and workers, the above question boils down to what conditions determine their migration. In this context, this paper identifies the mechanism and the factors contributing to the migration of farmers and workers from metros to their colonies.

The model of this paper is a modified version of the Krugman's(1991) geography model with an additional assumption that the colonial industrialization is possible mainly through the migration of farmers and workers from the metro.

The migration decision of metro farmers or workers depends on their expected future utility. For example, as for workers, they will decide whether they will move their production sites to the colony, depending on how much expected future profits, discounted by living expenses, they can make in the colony. In this paper, workers and firms are used interchangeably. If they produce goods in the colony, they can provide their products at cheaper prices to inhabitants in the colony, by saving the transportation cost to transfer those products from the metro. However, their profits from their larger market share should be discounted by their higher living cost. This higher living cost is due to the additional transportation cost of the metro's products they consume in the colony. This setup is very similar to the Krugman's geography model. This paper, however, has an additional feature that farmers' migration before workers' migration can

[1] These numbers are quoted from Park [1996].

[2] Smith argued that "the colonists had brought to an underdeveloped territory the habit of subordination and a knowledge of agriculture and other useful arts", as quoted in p.158 in Skinner [1983].

increase the colony's agricultural productivity and, thus, its market size.

In this paper, we explore which factors determine the migration of metro farmers and workers, and the start of colonial industrialization. Thus, this paper will provide one of the mechanisms through which technologies are transferred from metros to their colonies. This will further shed another light on what determines the initial levels of physical and human capital stocks.

This paper derives the surprising result that the lower is the metro's level of industrialization, the colonial industrialization will be easier. We further derive the following results: it will be easier for the colony to be industrialized, if its agricultural productivity (market size) is higher, or if the transportation cost between metro and its colony is lower.

This paper proceeds as follows. Section 2 presents the basic structure of the model. In Section 3, we discuss implications about the colonial industrialization, based on the model. Section 4 concludes.

Ⅱ. THE MODEL

The model is based on Krugman's [1991]. Because the model is similar to the Krugman's, we will describe the model briefly in this section. We follow the Krugman's notations to describe the model.

This model economy consists of two regions, the metro and its colony. In each region, two kinds of production are possible: agriculture and manufactures with an increasing returns to scale technology.

All economic agents in the metro and those in the colony have the following preferences, respectively, as

$$U^M = C_M^{\pi} C_A^{1-\pi}, \quad U^c = C_M^{\pi'} C_A^{1-\pi'} \tag{1}$$

where C_A represents the consumption of the agricultural product, C_M that of the manufactures aggregate, and $\pi > \pi'$, $\pi > \pi'$ implies that agents in the metro consume a higher share of their income in the manufactures than those in the colony.

We define the manufactures aggregate as

$$C_M = [\sum_{i=1}^{n} C_i^{\sigma-1/\sigma}]^{\sigma/\sigma-1} \tag{2}$$

where n denotes the number of manufactures products available in this economy, and denotes the elasticity of substitution of consumption among the products. Each firm produces only one kind of product among n different kinds of products due to the increasing returns to scale technology, which we will explain later.

Each economic agent, a farmer or a worker, can migrate from one region to another freely with the initially given farmer supply of $(1-\pi)$ in the metro, and that of one in the colony. The worker population π in the metro and none in the colony, initially. In other words, initially there assumed to be no manufactures in the colony. represents the metro's level of industrialization.[3] We also assume no job mobility between two sectors in each region to simplify the problem.

Workers can produce the manufactured good i with the increasing returns to scale technology of

$$L_{M_i} = \alpha + \beta x_1 \tag{3}$$

where L_{M_i} represents the total labor used to produce good i, and x_i the amount of the output of an i good.

The structure of the transportation cost between the two regions is identical to that of Krugman's. We make two assumptions to make the problem simpler. First, transportation cost of agricultural output is assumed to be zero. This assumption makes agricultural output to be a numeraire. The agricultural wage equal to the marginal productivity of labor in the metro is assumed to be one, whereas that in the colony d. By assuming that economic agents supply one unit of time inelastically, the terms of total wage and productivity are used interchangeably. One thing we should also note is that d can represent the market size of the colony if the farmer's population in the colony is assumed to be one within accessible areas.

Second, we also assume that transportation costs for manufactured products will take Samuelson's "iceberg" form. This means that the fraction $1-\tau$ of one unit of any manufactured product will be consumed during transportation between two regions. Thus, $1-\tau$ is the cost per one unit of product of transportation from the metro to the colony. Usually, this transportation cost is lower in the coastal areas. However, in this paper, τ is assumed to be fixed because we assume that the distance between two regions, metro and colony, is fixed.

Now, turn to the behavior of firms in the metro. Suppose that there are a large number (n) of manufacturing firms, producing n different products. Then, given the definition of the manufacturing aggregate as in (2) and the assumption of the iceberg transportation cost, the elasticity of demand for any product of any individual, in metro or in colony, is σ. It is well known that in the Dixit and Stiglitz model the profit maximizing representative firm in the metro follows

[3] The concept of industrialization in this paper captures two features of industrialization: The more industrialized one country is, the higher proportion of population is devoted to manufacturing sector, not agriculture, and the higher share of income to manufactures not agricultural products.

the markup pricing strategy as

$$P_m = \left(\frac{\sigma}{\sigma-1}\right)\beta W_m, \tag{4}$$

where W_m is the wage rate of workers in the metro; an identical relationship applies to that in the colony. The intuition behind (4) is: The lower is the elasticity of substitution of consumption among products, the more above the marginal cost the price is set. It is because the lower elasticity provides the stronger monopoly power.

From the above relationship, we derive

$$\frac{P_m}{P_c} = \frac{W_m}{W_c} \tag{5}$$

If we assume that firms can enter into the manufacturing sector freely, profits must be zero. Thus, from (3) and the zero profit condition we obtain

$$(P_m - \beta W_m)x_m = \alpha W_m. \tag{6}$$

(6) yields

$$x_m = \frac{\alpha(\sigma-1)}{\beta} \tag{7}$$

That is, output per firm is identical to all products in both of the regions, metro and colony. With the above basic structure of the model, we can characterize the equilibrium of the model.

Conditions for Metro Worker's Migration

This subsection explores under what conditions the concentration of all workers (firms) in the metro is not an equilibrium. In other words, we attempt to find out conditions which enable workers in the metro migrate to the colony to maximize their profits.

Consider initially that all workers are concentrated in the metro. Thus, workers' wage in the metro (W_m) will be determined in an equilibrium as follows. Using the fact that sales of manufactures equal its wage income,[4] we have

[4] This fact can be easily derived utilizing the following two facts: The only production input is labor, and the free entry condition yields the zero profit condition.

$$\pi((1-\pi)+\pi W_m)+\pi' d=\pi W_m \tag{8}$$

where d is the wage rate of farmers in the colony. We assume that farmers in metro as well as in colony hold the same area of land. Then d represents the agricultural productivity, for example, per acre in the colony. To derive (8), we also use the fact that a share $\pi(\pi')$ of total income of metro (colony) is spent on manufactures, which can be easily inferred from the logarithmic utility function of (2).

Solving (8) for W_m yields

$$W_m = 1+\frac{\pi' d}{\pi(1-\pi)}. \tag{9}$$

Then, the total income ratio between two regions is

$$\frac{Y_c}{Y_m}=\frac{d}{(1-\pi)+\pi W_m}=\frac{(1-\pi)d}{1-\pi+\pi' d}, \tag{10}$$

where Y_c represents the colony's total income, and Y_m the metro's.

Now, we will derive the condition for the metro worker's migration. If it is not possible for metro workers to increase their utility by working and consuming in the colony, then concentration of production in the metro is an equilibrium, because no worker in the metro will migrate to the colony; if it is, concentration of workers in the metro is not an equilibrium.

For the production of manufactures in the colony, the higher level of worker's wage is necessary to attract workers from the metro. It is because of the higher living costs of the colony due to the fact that all manufactures must be imported from the metro at the higher prices due to the transportation cost. Thus, to attract workers, the following relationship must hold.

$$\frac{W_c}{W_m}=\left(\frac{1}{\tau}\right)^{\pi}. \tag{11}$$

This relationship says that workers in the colony should be compensated to have the same real wage with the worker's real wage in the metro, considering the higher living costs of the colony due to the transportation cost. This higher living costs represent the migration cost in this model. Given this higher worker's wage in the colony, firms in the colony should charge a profit-maximizing price higher than that of firms in the metro by the same proportion as in (11). We can use this fact to derive the value of the firm's sales.

The value of sales in the metro of the representative firm in the colony should

be identical to that of the representative firm in the metro times $\left(\frac{W_c}{W_m}\tau\right)^{1-\sigma}$. This multiplying factor is due to the substitution and income effects between the product produced in the metro and that in the colony. Similarly, the value of sales in the colony of the representative firm in the colony will be that of the representative firm in the metro times $\left(\frac{W_c\tau}{W_m}\right)^{1-\sigma}$.[5]

Therefore, noting the fact that consumers spend a share π of their income on manufactures, the total value of sales of the representative firm in the colony will be

$$V_c=\left(\frac{\pi}{n}\right)\left[\left(\frac{W_c}{W_m\tau}\right)^{1-\sigma}Y_m+\left(\frac{W_c\tau}{W_m}\right)^{1-\sigma}Y_c\right] \tag{12}$$

where n denotes the total number of manufacturing firms.

We can easily infer that the total value of sales of each firm in the metro will be

$$V_m=\left(\frac{\pi}{n}\right)(Y_m+Y_c). \tag{13}$$

From (11), (12), and (13), we can derive the ratio of the value of sales of the firm in the colony to that of each firm in the metro as

$$\frac{V_c}{V_m}=\tau^{\pi(\sigma-1)}\left[\left(1-\frac{(1-\pi)d}{1-\pi+\frac{\pi' d}{\pi}}\right)\tau^{\sigma-1}+\frac{(1-\pi)d}{1-\pi+\frac{\pi' d}{\pi}}\tau^{1-\sigma}\right]. \tag{14}$$

Now, we can derive the migration condition for workers in the metro by deflating the above ratio by the relative living cost, as

$$V\equiv\frac{V_c}{V_m}\tau^{\pi}=\left[\left(1-\frac{(1-\pi)d}{1-\pi+\frac{\pi' d}{\pi}}\right)\tau^{\sigma-1+\sigma\pi}+\frac{(1-\pi)d}{1-\pi+\frac{\pi' d}{\pi}}\tau^{1-\sigma+\sigma\pi}\right]. \tag{15}$$

With $v>1$, the colony will be industrialized with the migration of better knowledged workers from the metro, and, thus, their physical and human capital stocks will increase. It is because: When $v<1$, it will not be profitable for a firm to migrate to the colony, if all other manufacturing productions are concentrated in the metro. Thus, in this case, the concentration of manufactures

[5] Utilizing (11), we can easily infer that the higher the elasticity of substitution, the higher sales in the colony a firm in the colony can make compared to a firm in the metro. It is because the firm in the colony, producing one kind of product, can enjoy the larger market with the higher elasticity of substitution among different types of product. However, the lower elasticity is assumed in this paper.

production in the metro is an equilibrium, while with $v>1$, it is not.

Now, let us find the specific conditions which will enforce v in (15) to be greater than one. In other words, by analyzing (15), we can understand what kinds of restrictions on the parameters of π, τ, and d will lead to the colonial industrialization. We will apply the Marshallian analysis at the initial state of concentration in the metro. We obtain the following results by applying the partial differentiation of (15) with respect to π, τ, and d.

$$\frac{\partial v}{\partial \pi}<0, \text{ if } \sigma \text{ is close to one, or } \pi>0.5^{6}, \tag{16}$$

$$\frac{\partial v}{\partial d}>0, \tag{17}$$

$$\frac{\partial v}{\partial \tau}>0, \text{ if } \sigma \text{ is close to one, and} \tag{18}$$

$$\frac{\partial v}{\partial \tau}<0, \text{ if } \sigma \text{ is big enough.}$$

The surprising result of (16) implies that the lower the metro's level of industrialization (π) is, if σ is small valued or if π is greater than 0.5, the more probably firms in the metro will migrate to the colony. And this will, in turn, industrialize the colony. The intuition behind this is very simple. If the metro worker's share of manufactures consumption in income (π) is lower, the living cost ratio of the colony to the metro represented by (11) will be lower. It is because the highly priced manufactures due to the transportation cost imported from the metro constitute a smaller portion of consumption of the agents in the colony, if the elasticity of substitution is small.

By (17) and (18), we can infer that the possibility of the metro worker's migration to the colony will be higher with the higher agricultural productivity of the colony, or with the lower transportation cost, if we assume that the elasticity of substitution is small. In other words, with the higher agricultural productivity of the colony, there will be more incentives for workers in the metro to migrate to the colony due to the larger market size of the colony. The lower transportation cost has the same implication with the lower level of the metro's industrialization. Further and detailed implications will be pursued in the next section.

Ⅲ. IMPLICATIONS

In this section, from the model of the previous section, we will attempt to find the conditions under which the metro firms move their production sites to

[6] If $\pi<0.5$, then the sign of the partial differentiation is uncertain.

the colony. These conditions are critical for the industrialization of the colony, because the migration of farmers and workers from the metro to the colony is one of the main channels of technology transfers from the metro to the colony. In this context, we assume that this is the only one channel through which the colony can get technology spillovers and, thus, be industrialized.

Initially, assume that all workers are concentrated in the metro. Additionally, v in (15) is assumed to be less than one. In other words, the agricultural productivity of the colony is not large enough to induce the metro workers' migration.

However, with better skills, farmers in the metro can increase the productivity of the colony's agriculture, if they migrate to the colony. Then, with the migration of a sufficient number of metro farmers to the colony, the market size that is represented by the wage times the population size within the accessible areas (assumed to be equal to one, here) and that is equal to d, will increase.[7] If this increase pushes the value of d in (15) to be greater than one after farmers' migration, workers will also move to the colony.

Through this process, the metro's technology can be transferred to the colony, just like the technology transfer in the case of foreign direct investment. With this process, the colony can be industrialized and, thus, can achieve higher physical and human capital stocks at the point of decolonialization, than in the case of no migration of farmers and workers.

This paper analyzes this process by studying sufficient conditions of the migration of metro farmers and workers to the colony. Now, this industrialization process will be analyzed in three stages below.

Stage 1

Migration of metro farmers will increase the average agricultural productivity (the market size), thus the market size, of the colony d. We assume that the technology transfer or spillover is possible only through the migration of better skilled and knowledged farmers and workers from the metro to the colony. Thus, the condition for the metro farmer's migration to the colony is very important. This condition can be described as

$$\tau^{\pi} d \frac{q_m}{q_c} > 1 \tag{19}$$

where d is the increased agricultural productivity of the colony after the better knowledged farmers' migration into the colony, q_m and q_c represent the land price in the metro and in the colony, respectively.[8]

[7] Some economists including Park argue that agricultural productivity in Korea increased significantly during the Japanese colonial period.

This condition implies that the real wage of a farmer in the colony, adjusted by the high price level due to the import transportation cost of manufacturing products from the metro, and also adjusted by the land price ratio, should be higher than that in the metro which is assumed to be one.

With an increased value of d[9], the higher τ or the lower π is, the more likely (19) holds. In other words, if the distance between a metro and its colony is smaller, or if the metro's level of industrialization is lower, the colony's market size can increase more likely, through the migration of metro farmers.

We should also note that, even with the migrating farmers having superior skills and knowledges, technology transfers may happen slowly if the cultural difference between a metro and its colony is large. It is because of the high communication cost that hinders the technology transfer.

Stage 2

With the increased market size of the colony due to the better knowledged metro farmers' migration or control, workers can migrate to the colony. However, if the colony's original market size without experiencing Stage 1 is big enough, then the colony can go to Stage 2 directly without first experiencing Stage 1.

With a sufficiently increased market size satisfying (19), workers will migrate from the metro to the colony, if the worker's migration condition (15) holds.[10] Workers' migration will start the colony's industrialization. This stage will be analyzed further below.

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[8] For this condition to be satisfied, the increased agricultural productivity in the colony times the land price ratio should be greater than one. This can be possible, considering that the land price of the colony is much cheaper than that of the metro. Here, we assume that farmers who migrate to the colony buy land in the colony with the money obtained from selling their land in the metro.

[9] At this point, note that d represents the market size of the colony as well as the increased agricultural productivity (the wage) of farmers in the colony. It is because the market size is the wage (d) times population size within the accessible areas that assumed to be one. This idea is important when we consider resource rich colonies as those in South America. If we consider the primary resource sector as agriculture, the market size (d) of the colony may still be small, even though farmers who migrated from a resource poor European country to a resource rich colony can make huge income. It is because the average agricultural productivity of all farmers or population size within the accessible areas may still remain small even with the migration of farmers from the metro as in the case of the hacienda system.

[10] With the metro farmer's migration, the number of metro farmers will change, whereas this number is assumed to be fixed in the model. However, the decrease in the number of farmers in the metro gives more incentives for metro workers to migrate to the colony through the decrease in the market size of the metro.

Stage 3

With the metro's rapid industrialization (the rapid increase in π) without affecting other parameters, d and τ, the worker's migration condition may not hold any more.[11] At this point, some of workers will move back to the metro and decolonialization may happen.

Now, the above process can be summarized as:

The lower π, the higher d, or the higher τ is, the more likely the metro farmer's migration to the colony will happen. Thus, this will increase the market size of the colony (d), which, in turn, will make workers' migration possible. Additionally, the lower π or the higher τ also directly affects the worker's migration condition positively. If the migration of farmers and workers is the only one channel of technology transfer, these conditions will be necessary ones for the colony's industrialization. We should also note that all these exercises are performed under the assumption of a low elasticity of substitution.

Even if farmers do not migrate from the metro to the colony, workers can migrate if (15) holds even with the original productivity of agriculture. However, considering that the primary sector constituted more than half of the GNP in both a metro and its colony during the colonial periods, agricultural technology transfers must have been very important for the colony's industrialization through metro farmers' migration.

Through the above mechanism of the colonial industrialization, we can possibly answer the question why African and South American countries have not developed as much as the East Asian countries. Probably, the former countries had not experienced technology transfers, as much as the East Asian countries during the colonial periods, due to the higher π, the lower d, or the lower τ. Thus, with the lower level of human capital stock at the point of the decolonialization, they might have been caught in the poverty trap.

More specifically, South American large farms like the hacienda system might not contribute much to the increase in overall market size (d), because these did not increase the population density nor the average agricultural productivity. It may be also because τ is very low (transportation cost is very high). (19) implies that it is easier for Japanese farmers to migrate to Korea than the British farmers to India, mainly because both of the geographical proximity and of the Japan's lower level of industrialization. This may contribute to the higher physical and human capital stocks of Korea through the Stage 2 process at the point of decolonialization, than that of India.

Last, these conditions for the colonial industrialization are consistent with the

[11] With an increase in π, d may increase, too. Thus, the process of Stage 3 should be analyzed more carefully and analytically.

three factors that Adam Smith drew attention which contributed to explain America's rapid rate of expansion.

"First, Smith isolated what may be defined as 'institutional' forces in pointing out that the colonies possessed political institutions, derived from the British model, which encouraged economic activity by guaranteeing the security of the individual. In the same way, he pointed out that the colonists had brought to an underdeveloped territory the habit of subordination and a 'knowledge of agriculture and other useful arts', the legacy of the more developed economies from which they had often come....

Second, 'A new colony must always for some time be more understocked in proportion to the extent of its territory, and more underpeopled in proportion to the extent of its stock, than the greater part of other countries.'.....

Third, '..... the most perfect freedom of trade is permitted between the British colonies of America and the West Indies,' thus proving a 'great internal market' for their produce.....' Agriculture....the proper business which the cheapness of land renders more advantageous than any other."[12]

The first factor is related to the mechanism of technology transfer through migration. The second factor implies the possibility that the market size of the colony (North America) can increase with the metro farmers' migration by increasing the agricultural productivity. The third factor indicates that the British freedom of trade increased the market size of the colony, or lowered the transportation cost through competition among traders. It is because competition will lower the prices of goods imported and exported, and those of transportation services.

Ⅳ. CONCLUSION

In the literature on the growth theory, especially the growth regressions based on the conditional convergence hypothesis, the initial conditions of physical and human capital stocks are very important. Also, for the poverty trap or the chaos theory, these initial conditions are critical. In this context, this paper studies the effects of colonial experiences of most of developing countries on their initial economic state variables right after the decolonialization.

With a modified Krugman's model, we obtain the surprising result that the lower the level of the metro's industrialization is, the more likely the colony can be industrialized. In addition to this, we obtain the following results: The higher the agricultural productivity (the market size) of the colony, or the smaller the distance between the metro and the colony, the more likely farmers and workers will migrate to the colony. Thus, the colony can be industrialized more likely, resulting in its higher initial physical and human capital stocks.

[12] p.158 in Skinner [1983]

However, to obtain more credits on the above implications, we should provide empirical findings that support these implications. For this, it will be very important, as well as difficult, to find the exact proxy for the variable d representing the agricultural productivity. This variable also represents the market size of the colony, representing the composite idea of the colony's average income times its population size within the accessible areas.

Here, the worker's migration can be interpreted as FDI (foreign direct investment). Thus, the above conditions for the worker's migration can be interpreted as the conditions for obtaining FDI.

Another avenue to extend this model is to research on the further dynamics of the model after initial migration of farmers and workers to the colony. This needs more exact descriptions of some parts of the model, such as the relationship between the change in the wage and the level of migration, and so on. This analysis of dynamics will provide us multiple equilibria and may need computer simulation techniques as in Krugman.

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