論　説

Product Substitutability and Industrialization Patterns†

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Abstract

We revisit the Murphy-Shleifer-Vishny (MSV) big push model in the Dixit-Stiglitz (D-S) monopolistic competition framework to study the effect of product substitutability on the industrialization process. We show that with high substitutability, industrializing monopolists will cut prices to steal sales from their competitors, leading to a business-stealing effect. Moreover, if this business-stealing effect dominates aggregate demand spillovers, the profits of industrializing monopolists will decline with the industrialization level, and the industrialization process will no longer be self-sustaining. Then it suggests two additional industrialization patterns: partial industrialization and ruinous competition, which are neglected in the big push literature.

1. Introduction

In studying the problem of industrialization, Rosenstein-Rodan (1943) indicated that if various sectors of the economy adopted increasing return technologies simultaneously, they could each create income that becomes a source of demand for goods in other sectors and thus enlarge their markets and make industrialization profitable. Therefore, the simultaneous industrialization of many sectors can be profitable for them even when no sector can break even industrializing alone.

This insight has been developed by Murphy, Shleifer and Vishny (MSV, 1989), which defined such industrialization process as the "big push". They made two major contribu-

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tions. First, they showed that if a firm contributes to the demand for other firms' goods *only* by distributing its profits and raising aggregate income, then unprofitable investments will reduce income and, therefore, the size of other firms' markets. Consequently, when profits are the only channel for spillovers, the industrializing equilibrium cannot coexist with the unindustrializing one. Second, they modeled three types of externalities generated from industrialization in which a firm's profit is not an adequate measure of its contribution to the profits of manufacturers, and both equilibriums (industrialization and unindustrialization) could coexist. These are, (i) a firm that sets up a factory pays a wage premium; so it increases the size of the market for producers of other manufacturers, even if its investment loses money. (ii) A firm that uses resources to invest at one point in time but generates the labor savings from this investment at a later point decreases aggregate demand today and raises it tomorrow. (iii) When many sectors pay for railroads, and railroads decrease effective production costs, an industrializing sector has the effect of reducing the total production costs of the other sectors. In (i) and (ii), the possibility of the big push turns on the divergence between a firm's profits and its contribution to the demand for manufacturers of other investing firms. In (iii), the possibility of the big push hinges on sharing in infrastructure investments.

To focus on the mechanism of the big push, MSV only considered these positive externalities in industrialization. Nevertheless, some historical evidence suggests that industrializing firms may cut prices to steal sales from their competitors, thereby creating a negative externality on the demands (profits) of their competitors, which may lead to ruinous competition (Lamoreaux, 1980; Jone, 1920).

Lamoreaux (1980) used the concepts of price-cutting and ruinous competition to explain a wave of mergers after a wave of investment in manufacturing during the boom of the late 1880s and early 1890s. The improvements in transport and communications made the investment in mass production become profitable and triggered simultaneous industrialization across various sectors, which created overexpansion in industries characterized by high fixed costs. When the problem of excess capacity arose, the industrializing producers set off a bout of retaliatory price cutting to increase market shares at the expense of others. Profits were reduced to ruinously low levels, and this predicament spurred manufacturers to form oligopolistic market structures (through consolidation) to maintain prices.

Jones (1920) investigated the emergence of ruinous competition.[1] He summarized seven characteristics of industrial enterprises associated with ruinous competition, which include "large fixed expenses (pp. 488–490)", "price-elastic demand (p. 494)" and "a high likelihood of price-cutting (pp. 494–496)". In "a high likelihood of price-cutting", he noted that compared with enterprises of *differentiated* goods,[2] enterprises of *homogenous* goods are more likely to conduct price-cutting to *attract the business away* from other sectors, which creates negative externalities in industrialization.

In fact, the possible price-cutting strategies of industrializing monopolists have also been noticed by MSV (Murphy et al., 1989, footnote 7, p. 1011):

> "All the models we study assume unit-elastic demand. Historically, however, price-elastic demand for manufacturers has played an important role in the growth of industry. Price elastic demand leads to price cuts by a monopolist and an increase in consumer surplus, which is an additional reason for a big push."

In a related paper, Shleifer and Vishny (1988, p. 1225) also noted that when demand is sufficiently inelastic, a cost-reducing firm will refrain from price-cutting, and when demand is elastic, the industrializing firms could cut prices to steal the sales from other sectors.

Although MSV noticed these possible negative externalities brought about by price-cutting strategies, they failed to analyze them in their models due to their ***unit-elasticity assumption***.

The above discussions concerning negative externalities in industrialization suggest the following possibility. With high product substitutability, demand becomes inelastic, so a cost-reducing (industrializing) firm could maintain its price. When product substitutability is low, demands will change dramatically with price-cutting, so a cost-reducing firm will be more likely to cut price to steal the sales from others, which creates negative externality and probably leads to ruinous competition. However, to our knowledge, the microeconomic foundation of such possibility has not been established. So, in this paper we aim to expound the mechanism underlying product substitutability, price-cutting strategy and industrialization.

In the mechanism, the price-cutting strategies and the associated negative externality hinge on product substitutability. Product substitutability measures how differentiated products are substitutable for each other. There are two frequently used measures of such substitutability. (i) The price elasticity of demand is generally defined as the percentage change in quantity demanded divided by the percentage change in price, and a large price elasticity of demand implies large substitutability across differentiated products. The price elasticity of demand also reflects a producer's monopoly power (Lerner, 1934). (ii) The elasticity of substitution is generally defined as the percentage change of the demand ratio divided by the percentage change of the price ratio between two differentiated products, and a large price elasticity of demand implies a large substitutability across differentiated products. In the Dixit and Stiglitz (D-S) model,[3] both the price elasticity of demand and the elasticity of substitution are invariant with price changes (constant elasticity of substitutability, CES afterwards) and are equal to each other.

To analyze the role of product substitutability in the industrialization process, we introduce the D-S monopolistic competition model, where the monopolist optimizing prices hinge on substitutability, into the simplest model in MSV,[4] where an industrializing firm contributes to the demand for other firms' products ***only*** by distributing its profits and raising aggregate income. Specifically, after presenting the basic model of MSV in Section 2, in Section 3, the D-S monopolistic competition model is introduced into it to illustrate how product substitutability determines monopoly pricing strategies. Section 4 unveils the following industrialization possibilities and clarifies the role of product substitutability. (a) When substitutability is low, even if industrializing firms achieve higher productivity, they will not cut their monopolistic prices to steal the sales from others, and the industrialization process will be self-sustaining. (b) When substitutability is high, industrializing firms will cut prices to steal the sales from their competitors, leading to a business-stealing effect. Regarding this effect, if aggregate demand spillovers dominate it, the profit of industrialization will *rise* with the industrialization level, and the industrialization process will be *self-sustaining*. Conversely, if the business-stealing effect dominates aggregate demand spillovers, the profits of industrializing firms will *decline* with the progress of industrialization. These two possibilities suggest the following four potential industrialization patterns. (i) *Complete industrialization*: the profits remain positive until all sectors industrialize. (ii) *Unindustrialization*: the profits are negative at the beginning of the industrialization process. (iii) *Partial industrialization*: the first industrializing firm has a positive profit, and the industrialization process stops when the profit of industrialization becomes zero. (iv) *Ruinous competition*: if the profits of industrialization are positive at the beginning and turn negative when all producers industrialize, and the producers are all myopic (they only consider their own short-term profits), so they will simultaneously industrialize at the beginning and end up with negative profits.

2. The Basic Model of MSV

In this section, we present the basic industrialization model of MSV[5] to show that if profits are the only channel of spillovers, the industrialization process will be *self-sustaining* (i.e., once the first industrializing firm has a positive profit, the profits of industrialization will increase as the industrialization progress). For this purpose, we use many original expressions used in the basic model.

Suppose that a one-period economy has a representative consumer who has the following Cobb-Douglas utility function defined over a unit interval of goods ($x_{(q)}$) indexed by q, $q \in [0, 1]$.

$$U = \int_0^1 ln x_{(q)} dq \quad (1)$$

Equation (1) implies that all goods have the same expenditure shares. Thus, when the representative consumer's income is denoted as Y, he can be thought of as spending Y on every good $x_{(q)}$.[6] The consumer is endowed with L units of labor, which he supplies in an inelastic way, and he owns all the profits of the economy. If his wage is taken as the *numeraire*, his budget constraint is given by:

$$Y = \Pi + L \qquad (2)$$

where Π is the aggregate profits, and Y is the aggregate income (or aggregate demand).

Each good is produced in its own sector, and each sector consists of the following two types of firms. First, each sector has a competitive fringe of firms that convert one unit of labor input into one unit of output with constant returns to scale (or, the cottage production) technology. Second, each sector also has a special firm with access to increasing return (or, the industrializing production) technology. This firm is alone in having access to that technology in its sector and thus will be referred to as a monopolist. Industrialization requires the input of F units of labor and allows for each additional unit of labor to produce $\frac{1}{C^I}(>1)$ units of goods for consumption. C^I is a constant parameter, which represents the reciprocal of marginal productivity of labor; thus, a smaller C^I implies a higher productivity of industrializing production.

The monopolist in each sector decides whether to industrialize or not. The monopolist can maximize his profit by taking the demand curve as given. And, he industrializes only if he can earn a profit at the price he charges. That price equals *one* since the monopolist loses all his available profit to the fringe if he charges more, and he would not want to charge less since he is facing a *unit-elastic demand curve*. When income is Y, the profit of a monopolist who spends F units of labor to industrialize is given by:

$$\pi = (1 - C^I)Y - F \qquad (3)$$

When a fraction n of the sectors in the economy have industrialized, the aggregate profit becomes:

$$\Pi_{(n)} = \int_0^n [(1 - C^I)Y_{(n)} - F]dq = n[(1 - C^I)Y_{(n)} - F)] \qquad (4)$$

By substituting Equation (4) into Equation (2), aggregate income can be expressed as a function of the industrialization level n:

$$Y_{(n)} = \frac{L - nF}{1 - n(1 - C^I)} \qquad (5)$$

As MSV indicated, the numerator of (5) is the amount of labor used in the economy for the actual production of output after investment outlays. One over the denominator is the multiplier showing that an increase in effective labor raises income by more than one since the expansion of low-cost sectors also raises profits. To show how the progress of industrialization can contribute to aggregate demand, one can differentiate aggregate demand with respect to n:

$$\frac{dY_{(n)}}{dn}=\frac{\pi_{(n)}}{1-n(1-C^{I})} \tag{6}$$

where $\pi_{(n)}$ is the profit of a monopolist when a fraction n of the sectors in the economy have industrialized. Equation (6) implies that an industrializing firm earns a positive profit when a fraction n of the sectors in the economy have industrialized $(\pi_{(n)}>0)$, and it distributes the profit to shareholders, who in turn spend it on products of a whole series of production sectors $\left(\text{i.e., if } \pi_{(n)}>0, \text{ then} \frac{\partial Y_{(n)}}{\partial n}>0\right)$ and thus raise profits in all industrialized firms in the economy. The effect of this firm's profit is therefore enhanced by the increase in profits of all industrializing firms, resulting from increased spending.[7]

Due to the *aggregate demand spillovers*, if the industrialization process begins (i.e., the first industrializing firm makes a positive profit), it will be *self-sustaining*, i.e., the profits of industrialization increase as the industrialization progresses. To see this, from (3) one can have:

$$\frac{d\pi_{(n)}}{dn}=(1-C^{I})\frac{dY_{(n)}}{dn} \tag{7}$$

Equation (6) shows that if $\pi_{(n)}>0$, then $\frac{dY_{(n)}}{dn}>0$,[8] and equation (7) means that if $\frac{dY_{(n)}}{dn}>0$, then $\frac{d\pi_{(n)}}{dn}>0$.[9] So, if $\pi_{(n)}>0$, then $\frac{dY_{(n)}}{dn}>0$, and then $\frac{d\pi_{(n)}}{dn}>0$. That is, if it is profitable for one monopolist to invest in industrialization, it will be more profitable for additional monopolists to do so due to the aggregate demand spillovers.

3. Monopolistic Competition and Pricing Strategies

In this section, the D-S monopolistic competition framework, where the monopolist-optimizing prices depend on product substitutability, is introduced into the basic model of MSV to show how pricing strategies of industrializing firms depend on substitutability. That is, (a) with low substitutability, the monopolists will refrain from price-cutting, and, (b) with high substitutability, they will conduct price-cutting.

Similar to the MSV basic model, a one-period economy with a representative consumer is considered. However, we assume that the consumer has a more general D-S type of CES utility function[10] over a unit interval of goods, indexed by i, $i \in [0, 1]$, as follows:

$$U = \left[\int_0^1 x_{(i)}{}^{\rho} di \right]^{1/\rho} \qquad 0 < \rho < 1 \tag{8}$$

where $[0, 1]$ is the range of varieties produced, and $x_{(i)}$ denotes the consumption of each available variety. Define $\sigma = 1/(1-\rho)$, which represents the price elasticity of demand or the elasticity of substitution between any pair of varieties. Concerning σ and ρ, five points are noteworthy as follows. (i) $\frac{d\sigma}{d\rho} > 0$. (ii) When ρ is closer to 1, σ approaches infinity, which implies a large demand elasticity, and the differentiated goods are nearly perfect substitutes for each other (high substitutability). (iii) When ρ is closer to 0, σ approaches 1, which means that the demand for each variety is inelastic, and the desire to consume greater variety of goods is high (low substitutability). (iv) If $\rho = 1$, Equation (8) becomes the Cobb-Douglas utility function as defined in Equation (1). And, (v) $0 < \rho < 1$ means that the varieties are substitutes for each other.

Given income Y and a set of prices $p_{(i)}$, $i \in [0, 1]$, the consumer's problem is to maximize his utility under the budget constraint, which can be expressed as followings:

$$\text{Max } U = \left[\int_0^1 x_{(i)}{}^{\rho} di \right]^{\frac{1}{\rho}}$$

$$\text{s.t. } \int_0^1 p_{(i)} x_{(i)} di = Y \tag{9}$$

When a fraction n of the sectors in the economy industrialize, the solution of this problem yields the following compensated demand function for the ith variety of goods:

$$x_{(i)} = p_{(i)}{}^{-\sigma} Y_{(n)} G_{(n)}{}^{\sigma-1} \tag{10}$$

$G_{(n)}$ is frequently called the "price index"[11], which consists of the prices of all differentiated goods and represents the real price of the differentiated goods as a whole. Its expression is:

$$G_{(n)} = \left[\int_0^1 p_{(i)}{}^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} \tag{11}$$

Similar to the MSV basic model, the representative consumer is endowed with L units of labor, which he supplies in an inelastic way, and he owns all the profits of the economy. If his wage is taken as the numeraire, his budget constraint is given by:

$$Y_{(n)} = L + n\pi_{(n)} \tag{12}$$

where $\pi_{(n)}$ is the profit of an industrializing firm when a fraction n of the sectors in the economy have industrialized.

Similar to the basic model, each good is produced in its own sector, and each sector consists of two types of firms. Setting the monopolistic price as p^I, the profit of a monopolist who spends F units of labor to industrialize can be written as follows:

$$\pi_{(n)}=(p^I-C^I)x_{(n)}{}^I-F \tag{13}$$

where $x_{(n)}{}^I$ denotes the output (or demand) of each industrializing sector when a fraction n of the sectors in the economy have industrialized.

Taking the price index G as given and perceiving the price elasticity of demand to be σ, the monopolists prefer to set the monopolistic price as:

$$p^{I\prime}=C^I/\rho \tag{14}$$

where $p^{I\prime}$ represents the *preferred* monopolistic price. However, as discussed before,[12] the range of prices that the monopolist can set is *bounded above by one* (the price set by cottage firms), so, the pricing strategies for the monopolists to take must be as follows: *if* $C^I/\rho\geq 1$, *then* $p^I=1$; *if* $C^I/\rho<1$, *then* $p^I=C^I/\rho$, where p^I is the *final* (or realized) monopolistic price set by each monopolist.

It is worth noting that product substitutability now plays an important role in the determination of monopolistic price: if ρ is relatively larger than C^I (i.e., there is high substitutability), monopolists will cut prices; if ρ is relatively smaller than C^I (i.e., there is low substitutability), monopolists will maintain the prices. Note that the price-cutting strategy attracts more demand in the case of high substitutability than that in the case of low substitutability. So, when products have high substitutability, the monopolists are more likely to cut their prices to steal sales from others. This corresponds with the following conjecture in Murphy et al. (1989, p. 1011, footnote 7):

> "Price-elastic demand leads to price cuts by a monopolist".

All the models outlined in MSV are under the unit-elasticity assumption, i.e., ρ equals 0; therefore, in their study, only the case "$C^I/\rho\geq 1$, $p^I=1$" can exist, i.e., monopolists will always refrain from price-cutting. Taking product substitutability into consideration enables the discussion of the following two cases, Case (I) $C^I/\rho\geq 1$, $p^I=1$ (low substitutability) and Case (II) $C^I/\rho<1$, $p^I=C^I/\rho$ (high substitutability), which will be done in the next section.

4. Substitutability and Industrialization

This section investigates the industrialization process and shows that in the case of low substitutability, industrializing firms will not cut prices, and the industrialization process will be similar to that discussed in MSV, and in the case of high substitutability, industrializing firms will cut prices to steal business sales from the others, leading to the so-called business-stealing effect. Moreover, regarding this effect, it will be shown that if it is dominated by aggregate demand spillovers, the profit of industrialization will increase with the industrialization level, and the industrialization process will be self-sustaining. Conversely, if the business-stealing effect dominates aggregate demand spillovers, the profits of industrializing firms will decline with the progress of industrialization.

These two additional possibilities in the profits of industrialization suggest the following four possible industrialization patterns. (i) *Complete industrialization*: the profits remain positive until all sectors industrialize. (ii) *Unindustrialization*: the profits are negative at the beginning of industrialization process. (iii) *Partial industrialization*: the profits are positive at the beginning and the industrialization process stops when the profits become zero. And, (iv) Ruinous competition: the profits are positive at the beginning of industrialization but become negative after the simultaneous industrialization of all sectors.

By taking product substitutability into consideration, we can illustrate that the conditions for individually profitable investment to raise the profitability of investment in other sectors are more stringent than those expressed in MSV. That is, aggregate demand spillovers should be large enough to dominate the business-stealing effect. Such kind of consideration also unveils two possible industrialization patterns, partial industrialization and ruinous completion, which are neglected in MSV.

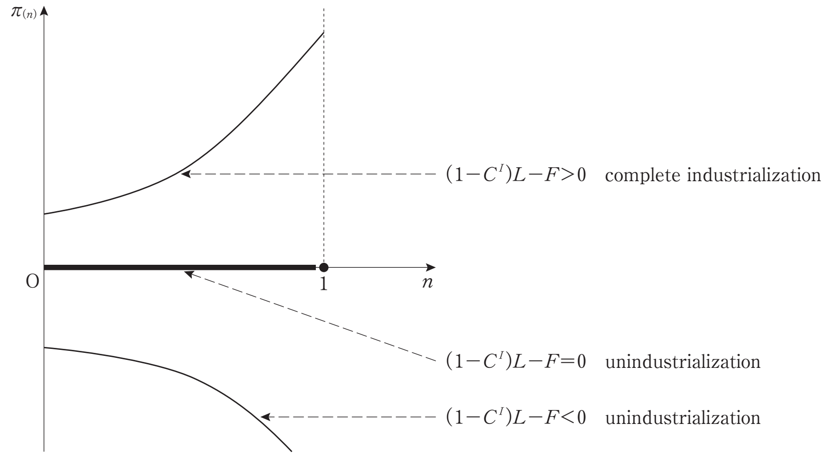
In the following, we begin to examine the industrialization process with the case of low substitutability.

4.1 Case (I): $C^I/\rho \geq 1$, $p^I = 1$ (low substitutability)

In this case, as discussed above before, both the industrializing and cottage firms set the price to one; so the business-stealing effect does not exist, and the industrialization process is similar to that indicated in MSV, which could be expressed by the following proposition.

Proposition 1. *When product substitutability is low (i.e., $C^I/\rho \geq 1$), industrializing firms will not cut prices, so the business-stealing effect will not exist. As long as the first industrializing firm has a positive profit, the industrialization process will be self-sustaining.*

Fig. 1 Industrialization process for Case (I)



To further examine this proposition, we can substitute $p_{(i)}=1$ into Equation (11) and obtain:

$$G=1 \tag{15}$$

which means that the price index does not depend on the industrialization level (n), so the business-stealing effect will not occur.

By substituting $p_{(i)}=1$ and G=1 into Equation (10), the demand for the ith variety of goods becomes:

$$x_{(n)}=Y_{(n)} \tag{16}$$

Regarding the profit of the first industrializing firm, one can substitute $x_{(0)}=Y_{(0)}$ and $Y_{(0)}=L$ into equation (13) and obtain:[13)]

$$\pi_{(0)}=(1-C^I)L-F \tag{17}$$

Due to the existence of aggregate demand spillovers,[14)] the condition of self-sustaining industrialization is $\pi_{(0)}>0$, i.e.,:

$$(1-C^I)L-F>0 \tag{18}$$

Equation (18) illustrates the necessary condition for the patterns of complete industrialization indicated. If $(1-C^I)L-F\leq 0$, industrialization will not happen or continue, which means the unidustrialzation pattern. Through investigation about the relations between $\pi_{(n)}$ and n for these two patterns, we can show their industrialization processes in Fig. 1.

Note that $\frac{d[(1-C^I)L-F]}{dL}>0$, $\frac{d[(1-C^I)L-F]}{dC^I}<0$, and $\frac{d[(1-C^I)L-F]}{dF}<0$. We can conclude that in the case of low substitutability, a large market, high productivity of industrializing production,[15] and small investment cost of industrialization will contribute to the self-sustaining industrialization.

4.2 Case (II): $C^I/\rho<1$, $p^I=C^I/\rho$ (high substitutability)

When product substitutability is relatively high (i.e., $C^I/\rho<1$), monopolists will cut prices to steal business away from other sectors (i.e., $p^I=C^I/\rho<1$).

In this case, by using Equation (11), when a fraction n of the firms in the economy industrialize, the price index $G_{(n)}$ becomes:

$$G_{(n)}=\left\{\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1\right\}^{\frac{1}{1-\sigma}} \tag{19}$$

Comparing Equations (19) with (15), we can see that in the case of with high substitutability, the industrialization level (n) affects the price index, which implies that the business-stealing effect occurs. This can be confirmed by differentiating the price index $G_{(n)}$ with respect to n, which yields:

$$\frac{dG_{(n)}}{dn}=\frac{1}{1-\sigma}\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]\left\{\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1\right\}^{\frac{\sigma}{1-\sigma}}<0 \tag{20}$$

and by differentiating the demand function (Equation (10)) with respect to $G_{(n)}$, which yields:

$$\frac{dx_{(i)}}{dG_{(n)}}=(\sigma-1)\left(\frac{C^I}{\rho}\right)^{-\sigma}Y_{(n)}G_{(n)}{}^{\sigma-2}>0 \tag{21}$$

Equations (20) and (21) present the mechanism of the business-stealing effect. That is, with weak monopoly power relative to product substitutability, an industrializing monopolist will cut its price $(p^I=C^I/\rho<1)$ to raise the demand for its product $\left(\text{since } \frac{dx_{(i)}}{dp_{(i)}}>0\right)$. This price-cutting strategy then lowers the price index $\left(\text{since } \frac{dG_{(n)}}{dn}<0\right)$ and enables monopolist to steal demand from others $\left(\text{since } \frac{dx_{(j)}}{dG_{(n)}}>0,\ for\ j\neq i\right)$. So, we obtain the following proposition:

> Proposition 2. *With high substitutability (i.e., $C^I/\rho<1$), industrializing monopolists will cut prices to steal business away from others, leading to the business-stealing effect.*

Substituting the monopolistic price $p^I=C^I/\rho$ and the price index of (19) into Equation (10) yields:

$$x_{(n)}{}^{I}=\frac{Y_{(n)}\left(\frac{C^{I}}{\rho}\right)^{-\sigma}}{\left[\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}-1\right]n+1} \tag{22}$$

where $Y_{(n)}$ in the numerator represents the aggregate demand spillovers, and n in the denominator reflects the business-stealing effect.[16] The comparison between the demand equations of the two cases (i.e., Equations (22) and (16)) suggests that aggregate demand spillovers exist in both cases, while the business-stealing effect appears *only* in the case of high substitutability.

Next, by substituting Equations (12), (14) and (22) into Equation (13), the profit of an industrializing firm when a fraction n of the sectors in the economy industrialize becomes:

$$\pi_{(n)}=\frac{(1-\rho)\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}L-F\left\{\left[\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}-1\right]n+1\right\}}{\left[\rho\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}-1\right]n+1} \tag{23}$$

To see how this profit changes with the progress of industrialization, we can differentiate it with respect to n, and obtain the following expression:

$$\frac{d\pi_{(n)}}{dn}=\frac{\left[1-\rho\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}\right]}{\left[\rho\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}-1\right]n+1}\pi_{(n)}-\frac{F\left[\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}-1\right]n+1} \tag{24}$$

Equation (23) and differential equation (24) determine the main characteristics of the industrialization process of Case (II). Some mathematical analyses about (23) and (24), which are given in the Appendix, yield the following proposition.

Proposition 3. *If* $F<\left[1-\rho\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}\right]L$, *the profits of industrialization will rise with the progress of industrialization, so the industrialization process will be self-sustaining. If* $F=\left[1-\rho\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}\right]L$, *the profits of industrialization will be a constant during the progress of industrialization. And, if* $F>\left[1-\rho\left(\frac{C^{I}}{\rho}\right)^{1-\sigma}\right]L$, *the profits of industrialization will decline with the progress of industrialization.*

Given that positive profits can be expected, the monopolists will industrialize, and given that profits change *monotonically with the progress of industrialization* (except for the constant profit[17]), we can naturally deduce the following four possible industrialization patterns. (i) When $\pi_{(0)}>0$ and $\pi_{(1)}>0$, all sectors will industrialize since the industrialization profits continue to be positive until the last sector industrializes, which can be called as *complete industrialization;* (ii) When $\pi_{(0)}<0$, the industrialization process will not start since the first industrializing firm makes a negative profit, and the profits of industrialization will only decline with the progress of industrialization. So, we call this as unindustrialization. (iii) When $\pi_{(0)}>0$ and $\pi_{(1)}<0$, the industrialization process could start but will stop when the profit of industrialization becomes zero, which can be named as *partial industrialization.* (iv) When $\pi_{(0)}>0$, $\pi_{(1)}<0$ and the producers are supposed to be all myopic (i.e., they only consider their own short-term profits), they may simultaneously industrialize at the beginning and end up if profits become negative, which lead to the so-called *ruinous competition.*

Concluding the two cases on low and high substitutabilities discussed so far, we can obtain the following Proposition 4. More detailed mathematical analyses can be found in the Appendix.

Proposition 4. *If* $F<(1-\rho)L$, *all sectors will industrialize (pattern (i) complete industrialization). If* $(1-\rho)L<F<(1-\rho)\left(\frac{C^I}{\rho}\right)^{1-\sigma}L$ *and a full-information economy is supposed, the industrialization process will stop half way when the profits of industrialization fall to zero (pattern (iii): partial industrialization). If* $(1-\rho)L<F<(1-\rho)\left(\frac{C^I}{\rho}\right)^{1-\sigma}L$ *and the producers are supposed to be all myopic (i.e., they only consider their own short-term profits), they will simultaneously industrialize at the beginning but end up when their profits become negative (pattern (iv): ruinous competition). And if* $(1-\rho)\left(\frac{C^I}{\rho}\right)^{1-\sigma}L<F$, *the industrialization process will not start (pattern (ii): unindustrialization).*

It is worth noting that patterns (i), (ii), and (iii) are stable equilibrium, while pattern (iv) is unstable, which could turn into pattern (i) through the consolidation and acquisition of monopoly power as described by Lamoreaux (1980) or turn into pattern (iii) with the increasing of information efficiency.

Finally, substituting $\pi_{(n)}=0$ into Equation (23) yields:

$$\frac{(1-\rho)\left(\frac{C^I}{\rho}\right)^{1-\sigma}L-F\left\{\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1\right\}}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}=0 \tag{25}$$

from which the fraction of industrializing sectors in partial industrialization can also be expressed as a function of the model's parameters as follows:

Fig. 2 Industrialization process for Case (II) in which $1-\left(\frac{C^I}{\rho}\right)^{1-\sigma}\leq 0$

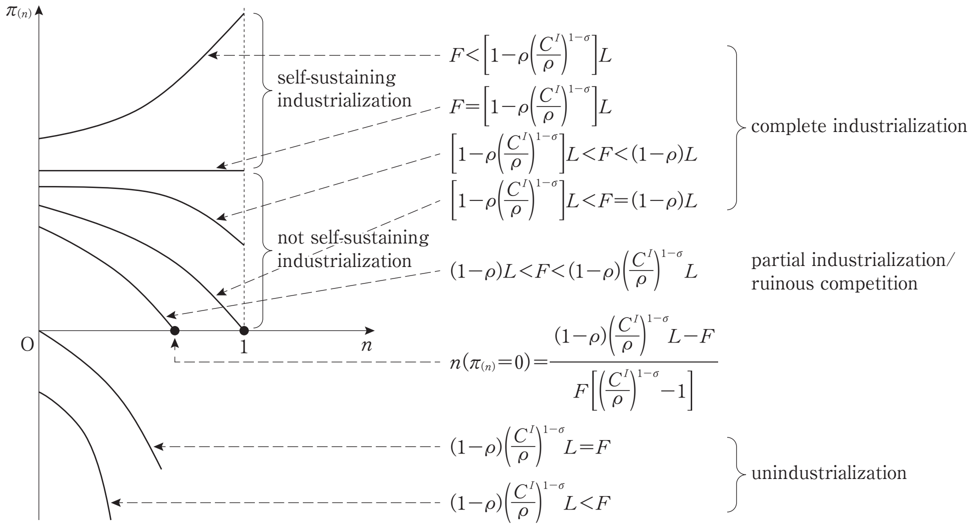
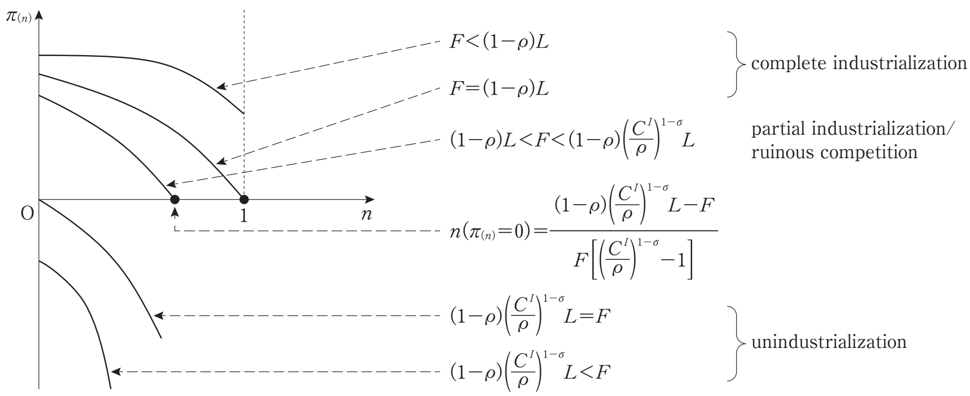


Fig. 3 Industrialization processes for Case (II) in which $1-\left(\frac{C^I}{\rho}\right)^{1-\sigma}>0$



$$n(\pi_{(n)}=0)=\frac{(1-\rho)\left(\frac{C^I}{\rho}\right)^{1-\sigma}L-F}{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]} \tag{26}$$

Regarding these industrialization patterns obtained, we can investigate the necessary conditions for them to appear, some of which are proven in the Appendix. Based on the investigation results, we can present these conditions in Figs. 2 and 3.

So far, by taking product substitutability into consideration, we uncovered the neglected industrialization patterns (iii) and (iv) and showed how high substitutability could lead to price-cutting and the business-stealing effect, which makes the industrialization process not self-sustaining even when the first industrialized sector has a positive profit. The findings of business-stealing effect and the pattern of partial industrialization and ruinous competition in the industrialization process can be considered as a contribution to the MSV model. They have an important policy implication that in addition to market size, productivity of industrialization and investment cost, product substitutability should be one more critical factor that could maintain prices and the positive profits of industrialized sectors during the industrialization process.

Similar to MSV, we also showed that large market, high productivity of industrialization production and small investment cost lead to industrialization. That is, (a) as shown in the three figures, the necessary condition for complete industrialization is $F<(1-C^I)L$, which implies that large market, high productivity of production and small investment cost contribute to such industrialization. (b) Figs. 2 and 3 illustrated that the necessary condition for partial industrialization is $(1-\rho)L<F<(1-\rho)\left(\frac{C^I}{\rho}\right)^{1-\sigma}L$, and that for unindustrialization is $F>(1-\rho)\left(\frac{C^I}{\rho}\right)^{1-\sigma}L$, which imply that industrialization is more likely to start with a larger market, higher productivity of the production and smaller investment cost. (c) Figs. 2 and 3, the industrialization level in the partial industrialization, i.e., $n(\pi_{(n)}=0)$ increases with the market size $\left(\text{since } \frac{dn(\pi_{(n)}=0)}{dL}>0\right)$. (d) In Fig. 2, the necessary condition for the self-sustaining industrialization is shown to be $F<L\left[1-\left(\frac{C^I}{\rho}\right)^{1-\sigma}\right]$, which implies that large market and small investment cost contribute to the realization of self-sustaining industrialization.

5. Conclusion

The analysis in this paper illustrated the role of product substitutability in the industrialization process and discussed the mechanism underlying product substitutability, price-cutting strategy and industrialization patterns. The main findings are as follows. (a) When product substitutability is relatively low, the cost-reducing firms will not cut prices to steal the sales from other sectors, and the industrialization process will be self-sustaining. (b) When product substitutability is relatively high, industrializing firms will conduct the price-cutting strategy to steal business away from other sectors, and the business-stealing effect will occur. Regarding this effect, if the aggregate demand spillovers dominate it, the profits of industrialization will *rise* with the progress of industrialization, and the industrialization process will be self-sustaining. Conversely, if the business-stealing effect dominates aggregate demand spillovers, the profits of industrializing firms will *decline* with the progress of industrialization, and industrialization will no longer be a self-sustaining process.

Moreover, these two possibilities of industrialization profits suggest that there are four industrialization patterns: (i) *complete industrialization*, (ii) *unindustrialization*, (iii) *partial industrialization*, and (iv) *ruinous competition*. Patterns (iii) and (iv) were not mentioned in MSV because they neglected the role of product substitutability and the associated business-stealing effect.

The policy implication of this paper is that in addition to the important roles of market scale, the productivity of production, and investment cost as has been noted in MSV, raising product differentiation is also critical in the realization of self-sustaining industrialization.

The major conclusion of this paper is also useful for the understanding of the productivity gap across regions and/or countries. First, since the substitutability is relatively high for raw materials,[18)19)] this paper sheds light on the formation of the so-called resource curse.[20)] Second, since the substitutability is relatively low for high-tech goods, high-tech industries always act as the engines of economic growth (Moretti, 2013). Third, since a low level of per capita income is always associated with high substitutability,[21)] this model can also be useful to understand the formation of the so-called low-level equilibrium trap.[22)]

Although this paper unveiled the role of product substitutability in the industrialization process, the *social welfare aspect* remains unclear. Shleifer and Vishny (1988, p. 1225) indicated that once substitutability is considered in the industrialization process, social welfare analysis would become very complex. They wrote:

> "The situation becomes more complex when *demand is elastic*, and the *cost-reducing* firm raises consumer surplus and so may raise welfare even when its investment does not break even. However, it also *steals sales and profits* from cost-reducing firms in other sectors to recoup its fixed cost and thus may reduce welfare even when its own investment is profitable. The interplay of these two opposing effects can lead to either too little or too much investment by potential cost-reducing firms."

That is, on one hand, cost-reducing firms lower market price and raise consumer surplus, and on the other hand, they also steal sales and profits from the other sectors, which can lead to too little investment. This issue is left for future work.

Appendix: Derivation of Proposition 3 and Proposition 4

To derive Propositions 3 and 4, we need to investigate the sigh of $\frac{d\pi_{(n)}}{dn}$. For the purpose, we note that a monopolist raises the demand (profits) of other sectors *if and only if* it makes a positive profit itself. In other words, unprofitable investment reduces income and then the size of other sectors' markets. That is, (a) if $\pi_{(n)}<0$, then $\frac{d\pi_{(n)}}{dn}<0$. Additionally, we also know that even if the monopolist's profit is zero, it also reduces the size of other firms' markets through its price-cutting strategy, i.e., (b) if $\pi_{(n)}=0$, then $\frac{d\pi_{(n)}}{dn}<0$. (a) and (b) can be concluded as: if $\pi_{(n)}\leq 0$, then $\frac{d\pi_{(n)}}{dn}<0$ for $n\in[0,1]$ which means the following Lemma:

Lemma 1. Given that $C^I/\rho<1$, if $\pi_{(0)}\leq 0$, then $\frac{d\pi_{(n)}}{dn}<0$ for $n\in[0,1]$, *and then*, $\pi_{(n)}\leq 0$ for $n\in[0,1]$,

This lemma can be proven as follows.

Step (Ⅰ). Given that $n\leq 1$, $\sigma>1$, $0<\rho<1$ and $C^I/\rho<1$, the subtrahend in differential equation (24) is positive, i.e., $\left(\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}\right)>0$.

Step (Ⅱ). Given that $\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}>0$, if $\pi_{(n)}=0$, (24) $\frac{d\pi_{(n)}}{dn}=-\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}<0$ for $n\in[0,1]$.

Step (Ⅲ). Given that $\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}>0$, if $\pi_{(n)}<0$, one necessary condition for $\frac{\left[1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}\pi_{(n)}-\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}>0$ will be $\left[1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}\right]<0$. So, if

$\pi_{(n)}<0$, then the condition of $\dfrac{\left[1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}\pi_{(n)}-\dfrac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}\geq 0$ will be $\pi_{(n)}\leq\dfrac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}\right]}$. However, from Equation (23), one can obtain $\pi_{(n)}>\dfrac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}\right]}$, which contradicts the necessary condition under $\dfrac{d\pi_{(n)}}{dn}\geq 0$. Therefore, if $\pi_{(n)}<0$, then $\dfrac{d\pi_{(n)}}{dn}<0$ for $n\in[0, 1]$.

Finally, the results of Steps (Ⅱ) and (Ⅲ) can be combined to yield the following: if $\pi_{(n)}\leq 0$, then $\dfrac{d\pi_{(n)}}{dn}<0$ for $n\in[0, 1]$.

Using Lemma 1, differential equation (24) and the inequality $\dfrac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}>0$, we can obtain the following lemma.

Lemma 2. *Given* $C^I/\rho<1$, *if* $1-\rho\left(\dfrac{C^I}{\rho}\right)^{1-\sigma}\leq 0$, *then* $\dfrac{d\pi_{(n)}}{dn}<0$ for $n\in[0, 1]$.

This lemma can be obtained as follows.

Step (Ⅰ). Given that $1-\rho\left(\dfrac{C^I}{\rho}\right)^{1-\sigma}<0$ and $\pi_{(n)}>0$, since $\dfrac{\left[1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}\pi_{(n)}<0$ and $\dfrac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}>0$, then we have $\dfrac{d\pi_{(n)}}{dn}=\dfrac{\left[1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}\pi_{(n)}$
$-\dfrac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{\left[\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]n+1}<0$ for $n\in[0, 1]$.

Step (Ⅱ). Given that $1-\rho\left(\dfrac{C^I}{\rho}\right)^{1-\sigma}<0$ and $\pi_{(n)}\leq 0$, then $\dfrac{d\pi_{(n)}}{dn}<0$ for $n\in[0, 1]$ (due to Lemma 1).

Steps (Ⅰ) and (Ⅱ) means the following: if $1-\rho\left(\dfrac{C^I}{\rho}\right)^{1-\sigma}<0$, then $\dfrac{\partial\pi_{(n)}}{\partial n}<0$ for $n\in[0, 1]$.

Moreover, substituting $n=0$ into differential equation (24), we can obtain the following lemma.

Lemma 3. Given that $C^I/\rho<1$ and $1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}>0$, if $\pi_{(0)}>\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}}$, *we have* $\frac{d\pi_{(n)}}{dn}>0$ for $n\in[0,1]$. If $\pi_{(0)}=\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}}$, we have $\frac{d\pi_{(n)}}{dn}=0$ for $n\in[0,1]$. And if $\pi_{(0)}<\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}}$, we have $\frac{d\pi_{(n)}}{dn}<0$ for $n\in[0,1]$.

Finally, combining Lemmas 2 and 3 together, we can summarize the following lemma on how monopolistic profits change with the industrialization level.

Lemma 4. Given that $C^I/\rho<1$ and $1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}>0$, if $\pi_{(0)}>\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}}$, then $\frac{d\pi_{(n)}}{dn}>0$ for $n\in[0,1]$; if $\pi_{(0)}=\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}}$, then $\frac{d\pi_{(n)}}{dn}=0$ for $n\in[0,1]$; and if $\pi_{(0)}<\frac{F\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]}{1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}}$, then $\frac{d\pi_{(n)}}{dn}<0$ for $n\in[0,1]$. On the other, given that $C^I/\rho<1$, if $1-\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}\leq 0$, then $\frac{d\pi_{(n)}}{dn}<0$ for $n\in[0,1]$.

In addition we can see that both $\pi_{(0)}$ and $\pi_{(1)}$ can be determined by parameters ρ, F, C^I and L. In fact, substituting $n=0$ and $n=1$ into Equation (23) separately, we can obtain the following:

$$\pi_{(0)}=(1-\rho)\left(\frac{C^I}{\rho}\right)^{1-\sigma}L-F \tag{A.1}$$

$$\pi_{(1)}=\frac{(1-\rho)\left(\frac{C^I}{\rho}\right)^{1-\sigma}L-\left(\frac{C^I}{\rho}\right)^{1-\sigma}F}{\rho\left(\frac{C^I}{\rho}\right)^{1-\sigma}} \tag{A.2}$$

Using Lemmas 1, 2, 3, and 4 and Equations (A.1) and (A.2), we can derive Propositions 3 and 4.

Notes

1) In Jones (1920), the ruinous competition of a railroad was defined as "competition among railroads, unless restrained, tends to become 'ruinous,' that is, fails to establish a normal level of rates sufficiently remunerative to attract the additional investments of capital that recurrently become necessary." Also, Knauth (1916, p. 245) defined ruinous competition as "that which forces prices to a point where the capital invested receives no return, and even fails to maintain its value intact."

2) Jones (1920, p. 494) classified the goods with a marked development of brands and trademarks, the goods wherever competition is on a quality or style basis, e.g., tobacco, sugar, harvester, gunpowder, whisky, starch, bicycle, silverware, and aluminum ware businesses, into the category of differentiated goods, and staples into the category of homogenous goods.

3) See Dixit and Stiglitz (1977).

4) It is the model outlined in Murphy et al. (1989), Section III.

5) See Murphy et al. (1989), Section III, pp. 1007–1010.

6) The Cobb-Douglas utility function implies that the representative consumer expend equally on every good. Denote the expenditure as y; we have $Y=\int_0^1 lny\, dq=1y-0y=y$.

7) Similar descriptions of aggregate demand spillovers can be found in Murphy and Vishny (1988, pp. 1224–1225) and Matsuyama (1992, p. 354).

8) Since in equation (7), $1-n(1-C^I)>0$.

9) Since in equation (6), $1-C^I>0$.

10) In Dixit and Stiglitz (1977), there are two groups or sectors or industries, one of which is composed of varieties, and the other of which represents the rest of the economy, consisting of homogenous goods. Adding another homogenous goods industry will not change the main result.

11) The expression is borrowed from Krugman (1991, p. 492) and Fujita, Krugman, and Venables (1999, p. 47).

12) See the discussion before Equation (3).

13) Substituting $n=0$ into Equation (12) yields $Y_{(0)}=L$.

14) See the discussion following Equation (7).

15) Note that C^I is the constant marginal input of labor to produce one additional unit of output. So, smaller C^I means higher productivity of industrialization production.

16) The denominator increases with n since $\left[\left(\frac{C^I}{\rho}\right)^{1-\sigma}-1\right]>0$.

17) See the analysis in the Appendix, Lemma 4.

18) Rauch (1999) divided goods into three categories—commodities, reference-priced goods, and differentiated goods—based on whether they were traded on organized exchanges, were listed as having a reference price, or could not be priced by either of these means. Commodities and reference-priced goods are probably correlated with more substitutable goods. Generally, most raw materials are classified into these two categories.

19) Broda and Weinstein (2006) estimated elasticities of substitution for a large number of internationally traded goods based on the D-S model and showed that raw materials (i.e., crude oil from petroleum or bituminous minerals, iron and steel flat-rolled products, clad, etc.) have high substitutability; meanwhile, high-tech goods (i.e., thermionic, cold cathode, photocathode valves, etc.; motor cars and other motor vehicles; telecommunications equipment, n.e.s. and pts,

n.e.s.; and automatic data process machs and the units thereof) and branded goods (i.e., footwear) have low substitutability.

20) One of the influential papers related to the resource curse is Jeffrey and Andrew (1995).

21) For example, Gossen (1983, p. 157) illustrated that for each individual, the sphere of necessities widens as income increases (in Gossen's work, necessities mean goods with low substitutability).

22) Nelson (1956, p. 894) defined the low-level equilibrium trap as a stable equilibrium level of per capita income at or close to subsistence requirements. Only a small percentage, if any, of the economy's income is directed toward net investment.

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