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Entrepreneurial Ability, Market Selection and Setting Up an Infant Industry-Theory and Evidence from the Japanese Cotton Textile Industry

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**Entrepreneurial Ability, Market Selection, and
Setting Up an Infant Industry – Theory and Evidence from
the Japanese Cotton Textile Industry¹**

Abstract

In this paper we develop a new insight into the infant industry argument for protection, in the setting where entrepreneurs are differentiated by talent. The speed of technological progress depends on the quality of ideas and the incentives to innovate, not on the scale of the industry, and unprotected open economy competitive regime furnishes the best environment for innovation-led industrial growth even in the presence of industry-wide increasing returns to scale. Competitive market selection of ablest entrepreneurs forms a crucial condition for successful industrialization. The model is tested against the evidence of industrial revolution in Japan that presents a unique historic experiment in which an internationally competitive textile industry was eventually set up without government protection after earlier experiments with subsidized firms had failed. [JEL classification numbers F13, F14, O15.]

Chicago

2001

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1. An Outline of the Argument and the Organization of the Paper

A distinctive feature of the neoclassical model, including also the one describing industry-wide increasing returns to scale and learning by doing, is that all firms (producers) are assumed to be identical. In the conventional infant industry protection argument this then leads to the “quantitative” aspect of entry (attaining a large enough scale of output so that increasing returns to scale can set in) becoming the central point. The formation process of a new industry needs to be assisted by the government either in the form of subsidies or protective tariffs. In the presence of positive spillovers across firms increasing with larger numbers, exposure to foreign competition does indeed hurt an infant industry. In this paper we present the microfoundations for an alternative story, focusing on what an infant industry might be *gaining*, especially in the long run, from *not* being shielded from foreign competition and open markets. It should especially be noted that whether one accepts the infant industry protection argument or rejects it on the consumer welfare grounds in the conventional model, it remains true in both cases that the industry itself stands to benefit from protection. This latter conclusion no longer holds in the setting proposed in this paper.

The key feature of our model is that producers (entrepreneurs) possess different levels of ability (or entrepreneurial talent). The speed of learning (and technological progress) depends not on the scale of the industry, but on the quality of ideas and incentives to innovate. Ensuring proper functioning of competitive market selection of talent can in this setting become more important from at least a long-term prospective than attaining a large initial scale of the infant industry.

The insight is that, with heterogeneous producers, we need a mechanism that would select out better ideas generated by abler entrepreneurs in order to obtain a higher speed of technological progress, a problem that does not come up in a model with identical producers. By shielding competition, the industry loses at least part of such a mechanism. A larger pool of ideas is always better in the conventional model, but in our model, the focus is on quality, not quantity, so that a smaller pool of ideas of higher quality, selected by the market mechanism, features better. The argument is reinforced by the incentives factor that focuses on the differences in the returns to innovative activities that exist between an unprotected open economy and a protected or subsidized one.

We do not claim to have a fully general theoretical framework intended to completely replace the conventional textbook argument concerning infant industry protection. However, we believe that we do have an important new insight into how the open economy competitive regime can actually be employed to promote the development of an efficient infant industry. In the empirical part of the paper, we take up the experience of successful establishment of the cotton spinning industry in Japan from the last decades of the 19th century to the first two decades of the 20th century. The rise of this industry started the industrial revolution in Japan, and it also marked the first step in what later became known as “the Japanese miracle”: “the astonishing ascendance of Osaka over Lancashire stands as the first completely successful instance of Asian assimilation of modern Western manufacturing techniques.” (Saxonhouse, 1974, p. 150) The evidence we present in this paper shows that the driving force was the *absence* of conventional protectionist measures and exposure to open markets.

The paper is organized as follows. Section 2 spells out a two-country model of the allocation of talent developing the setup in (Murphy, Shleifer, and Vishny, 1991). Section 3 specifies the infant-industry problem in the setting characterized by differentiated entrepreneurial talent, and pits the process of its setup under protection against the competitive open economy regime. Section 4 presents empirical evidence drawing upon the experience of the set up of the Japanese cotton spinning industry in the late 19th – early 20th century. The concluding section contains additional discussion, as well as policy implications. The data are presented in the Statistical Appendix.

2. The Allocation of Talent in a Two-Country Open Economy

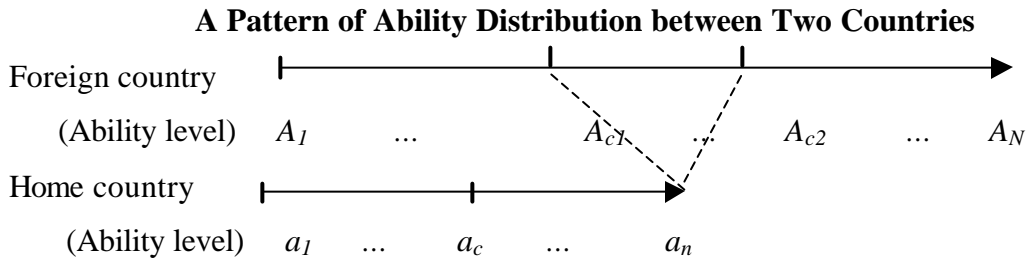
The Set-Up

The world consists of two countries labeled the “home country” and the “foreign country”. The population of the home country is denoted by n , and that of the foreign country, by N . We use small caps to denote variables relating to the home country and large caps to denote variables relating to the foreign country. The population in both countries is assumed large enough so as to meet the conditions of perfect competition.

Individuals in each country are differentiated by the amount of entrepreneurial talent (ability) they possess. Following (Murphy, Shleifer, Vishny, 1991), the

entrepreneurial talent is general, not industry-specific, and it is also given exogenously and does not change over time. Without loss of generality, assign index number n to the person with the highest entrepreneurial ability, denoted by a_n , among the home country population. We then assign numbers from $n-1$ to 1 to all other agents in the descending order, according to the levels of their entrepreneurial talent. Similar ordering applies to the foreign country, with the first agent possessing the highest ability level A_N , and so on (see Figure 1; the meaning of intermediate points A_{c1} , A_{c2} , and a_c will be made clear below).

Figure 1.



There are three goods producible in the world economy, numbered 1, 2, and 3. The preferences of the consumers in each country are identical and of a Cobb-Douglas type, with constant shares of income spent on each of the three goods. We denote spending shares by \mathbf{a}_1 , \mathbf{a}_2 , \mathbf{a}_3 respectively. All goods are produced with human capital organized into firms by entrepreneurs. The identical across countries, constant over time baseline production functions for each of the three goods are denoted by $f_1(h)$, $f_2(h)$, and $f_3(h)$, where h denotes the amount of human capital invested in producing the output. All the usual properties are assumed for the functions f_i , including differentiability and concavity. We also assume that the baseline production function $f_2(h)$ in industry 2 is more elastic with respect to the human capital input than the production function $f_1(h)$ in industry 1, and the production function $f_3(h)$ in industry 3 is more elastic than the production function $f_2(h)$ in industry 2. Formally,

$$f_1' / f_1 < f_2' / f_2 < f_3' / f_3 \quad (1)$$

The actual output produced by the firm k operated in industry i in the home country by the entrepreneur of ability a_k is denoted by $y_{k=s_i} \cdot a_k f_i(h_k)$. Similarly, for the firm K operated in industry j by the entrepreneur of ability A_k in the foreign country, the output will be $Y_{K=s_j} \cdot A_k f_j(h_K)$. The scale factor s_i represents the “state of the art

technology level” in a given industry. Thus, the output obtained from the baseline production function relationship is augmented (1) by the technology factor, common to all producers in the industry, and (2) by the factor of entrepreneurial ability, idiosyncratic to each particular entrepreneur.

Ability and Occupational Choice

Assume for a moment that only one industry (number 1) actually exists in the economy. An entrepreneur can hire wage workers at a competitive wage rate w . Given the level of ability a_k , the state of the art technology s_I and the price of the output p_I , the profit from the entrepreneurial activity is equal to

$$p_1 \cdot s_1 \cdot a_k \cdot f(h) - w \cdot h, \quad (2)$$

It is easy to see that, for any given w , s_I , and p_I , the revenue increases with ability a_k , but the cost does not. Indeed the first order condition for profit maximization is

$$p_1 \cdot s_1 \cdot a_k \cdot f'(h) = w, \quad (3)$$

so that abler people run larger firms.²

An individual becomes an entrepreneur or chooses to work as a wage worker according to whether

$$p_1 \cdot s_1 \cdot a_k \cdot f(h) - w \cdot h \stackrel{>}{<} w \cdot a_k \quad (5)$$

If (5) holds with equality, a_k can be determined as an implicit function of the technology-adjusted real wage rate $w/p_I s_I$. We denote such a_k by a_c (the “cutoff ability”, see Figure 1 above). Ignoring the integer constraint, all agents whose level of ability is greater than a_c become entrepreneurs, the rest work as wage workers.

The human capital market clearing condition requires

$$\sum_{k=c}^n h_k = \sum_{k=1}^{c-1} a_k, \quad (6)$$

so that a unique pair of an equilibrium wage rate w^* and a cutoff ability level a_c is obtained.

² Explicitly, $\frac{\partial h}{\partial a_k} = -\frac{f'}{a_k f''} > 0$ ($\because f' > 0, f'' < 0$). (4)

If there are more than two industries, we must consider also the choice made by entrepreneurs as to in which industry to operate. With a later trade model in mind, assign the two industries indices 2 and 3 (with industry 3 exhibiting less diminishing returns to the human capital input than industry 2), and focus on the situation in the foreign country. Denoting the price of output of industry 2 by p_2 and that of industry 3 by p_3 , the two first order conditions for profit-maximization are:

$$p_2 \cdot s_2 \cdot A_k \cdot f_2'(h) = W \quad (7)$$

and

$$p_3 \cdot s_3 \cdot A_k \cdot f_3'(h) = W. \quad (8)$$

The free entry condition requires that

$$p_2 \cdot s_2 \cdot A_{c_2} \cdot f_2(h) - W \cdot h = p_3 \cdot s_3 \cdot A_{c_2} \cdot f_3(h) - W \cdot h, \quad (9)$$

for the entrepreneur c_2 who is just indifferent between operating a firm in industry 2 and industry 3. Condition (1) guarantees that ablest people down to the threshold ability level A_{c_2} become entrepreneurs in industry 3, the next range ability down to A_{c_1} become entrepreneurs in industry 2, and the least able people become wage workers. The intuition is that ablest people are all drawn into the sector with a more elastic baseline production function (industry 3 in this case) because they can run larger firms and earn more income there.

The Speed of Technological Progress

We assume that entrepreneurial talent covers also the ability to develop and implement better-quality technological ideas. Also, if a higher return to a successful technical innovation can be secured, all entrepreneurs will be motivated to exercise more effort at expanding “the action set” available for profit maximization (see, for example, Rose, 2000), and that will also speed up the technological progress. With these two factors in mind, we specify here the dependence of the industry-wide speed of technological progress (as represented by the increase in the common industry-wide scaling factor, s_i over time) on ability and effort by the following reduced form relation:

$$s_{t+1i} = g(\bar{a}_{ti}, v) \cdot s_{ti}, \quad (10)$$

with $\partial g / \partial \bar{a}_{ti} > 0$, and $\partial g / \partial v > 0$,

where $\bar{a}_{ii} = \left(\sum_{k=c_{i-1}}^{c_i-1} a_k / \#i \right)$ is the average ability of entrepreneurs actually operating firms in industry i at time t (c_{i-1} is the cutoff ability separating industry i from industry $i+1$, or else $c_{i-1}=n$; c_i is the cutoff ability between industry i and the next in line, or between it and wage workers; $\#i$ is the number of entrepreneurs (firms) in the industry), and v denotes the strength of incentives that those entrepreneurs face.

The dependence of the speed of increase in s_i on *average* and not total (or highest) ability is a distinctive feature of the present model. In particular, it means that a smaller pool of entrepreneurs consisting only of people of top ability would be able to develop and implement new technology more efficiently than a larger pool that contains also people of less ability. Of course, this presupposes that the overall framework of perfect competition is kept intact, either by allowing a large enough number of top ability entrepreneurs or by assuming, as we do here, an open economy regime. It would be convenient to present a more detailed discussion of the assumption linking technological progress to average ability later, after the empirical part of our present story has been laid out (see Section 5).

In the steady state, any technological improvement must be exactly offset by changes in relative prices and wage. Thus for the steady state prices p_i we must have

$$p_i \cdot s_i = \text{constant}, \quad \forall i \quad (11)$$

In particular in the steady state there are no inframarginal returns that can be appropriated by those who generate new ideas leading to an increase in the industry-wide state of the art technology level s_i . In what follows we assume that new technological ideas completely and instantaneously spill over to all domestic producers acting in the industry. Hence everybody can essentially free ride on any kind of technological innovation he or she can observe. However, we also assume that technological ideas do not spill over across the national borders, so that the state of the art technology in each particular country pertains only to that country's pool of producers.³

³ The argument below will not be affected in any substantial way if we relax this assumption allowing some time lag in technological spillover at home and also some degree of spillover between the home country and the foreign country, provided that the latter still takes more time and is more costly than the former.

A Two-Country Free Trade Model

We now return to our two-country, three-good trading model. We assume that all the three final goods are tradable at zero transportation costs. For simplicity, assume that industry 1 is a traditional industry pertaining only to the home country. There is no cross-border mobility of either human capital or the entrepreneurial factor, so that production can be carried out only in the country of origin. Immobility of human capital also prevents direct acquisition of the state of the art technology from the foreign country. Thus at the initial stage, the state of the art technology levels s_i in both industries 2 and 3 are common only to foreign producers. Potential home country producers in industry 2 have access to a state of technology s_{d2} which is significantly less than s_2 in a sense to be made precise below. s_{d2} can be improved by learning, but any such improvement generated by one home country producer can be instantaneously and costlessly imitated by all home country producers. The state of the art technology in industry 3 is totally inaccessible to home country producers.

If the initial technological gap ($s_2 - s_{d2}$) between the foreign country and the home country is large, no production of good 2 will be carried out at home in the free trade equilibrium (see (19) below). The home country will specialize in the traditional industry 1 and will export good 1 in exchange for goods 2 and 3 produced in the foreign country.

Given p_1 , p_2 , and p_3 , the output decision, the equilibrium wage rate w , and the allocation of human capital in the home country at any period of time are determined by (3), (5) and (6) above, while the output decision, the equilibrium wage rate W , and the allocation of human capital in the foreign country is determined by (7)-(9), and also

$$p_2 \cdot s_2 \cdot A_{c1} \cdot f_2(h) - W \cdot h_{c1} = W \cdot A_{c1} \quad (12)$$

and

$$\sum_{K=c2}^N h_K = \sum_{K=1}^{c2-1} A_K, \quad (13)$$

(12) corresponds to (5) for the home country, while (13) is the human-capital market clearing condition for the foreign country.

Equilibrating the world supply and demand for final goods then closes the model. Denote the total income produced in the home country by m and that in the foreign country by M . Obviously,

$$m = p_1 \cdot s_1 \cdot \sum_{k=c}^n a_k \cdot f_1(h), \quad (14)$$

and

$$M = p_2 \cdot s_2 \cdot \sum_{K=c1}^{c2-1} A_K \cdot f_2(h) + p_3 \cdot s_3 \cdot \sum_{K=c2}^N A_K \cdot f_3(h) \quad (15)$$

With identical Cobb-Douglas preferences over all three goods, setting excess world demand for goods 1 and 2 (say) equal to zero implies, respectively:

$$\mathbf{a}_1 M - (1 - \mathbf{a}_1) m = 0, \quad (16)$$

$$\mathbf{a}_2 m - (1 - \mathbf{a}_2) M = 0 \quad (17)$$

Two relative prices can then be determined from (16) and (17). We choose good 3 as the numeraire, and continue to denote relative prices of goods 1 and 2 as well as wages in the home and foreign countries in terms of good 3 by p_1 , p_2 , w and W . Note that there is no wage equalization here under free trade because of complete specialization. Also, since incentives faced by entrepreneurs in all the three industries are the same in the steady state in view of (11), their respective speeds of learning will be determined by similar functions of type (10), depending only on the average ability.

3. Market Selection versus Protection – A Qualitative Comparison

Identifying an “Infant Industry”

Let us define, as a first approximation, an industry to be a candidate for being designated an infant industry if it can attract entrepreneurs in the home country whose ability levels are absolutely higher than the average ability of entrepreneurs operating in the same industry in the foreign country. The justification is that in such a case, the home country can at least potentially attain a higher speed of technological progress in that industry and eventually capture a share of the world market.⁴ Formally,

$$\{k, K : a_k > \bar{A}_K\} \neq \emptyset, \quad (18)$$

⁴ The presence of the incentives argument in (10) indicates that an industry can (temporarily) attain a higher speed of technological progress than in the foreign country even if all home-country entrepreneurs possess lower ability than the average ability in the foreign country. However, as we show below, in the ensuing steady state incentives will be equalized across countries, so such an industry in the home country will not be viable in the long run.

for at least some k in $\{1,n\}$, where \bar{A}_k is a short-hand for the average ability of foreign country entrepreneurs in industry 2. In Figure 1 above industry 2 is a potential infant industry for the home country, while industry 3 is not.

At the initial free trade equilibrium prices, determined by the system (3), (5)-(9), (12), (13), (16) and (17), the technological level of potential home country producers in industry 2 is so low as to make operating a firm in industry 2 unattractive even for the ablest home country entrepreneur. Specifically, too low s_{d2} does not allow even the highest ability level a_n to compensate for the technological gap, given the free trade equilibrium (relative) prices p_1 , and p_2 :

$$(p_2 \cdot s_{d2}) \cdot a_n \cdot f_2(h) - w \cdot h \ll (p_1 \cdot s_1) \cdot a_n \cdot f_1(h) - w \cdot h. \quad (19)$$

The left-hand side of (19) is “much less” than the right-hand side in the sense that even the prospect of inframarginal returns to be earned for some time after entry in industry 2 (more on this below) is not enough to compensate for the opportunity cost of forgoing profits from operating in industry 1. This is, of course, the familiar infant industry problem. It can easily be shown that if (19) holds for a_n , it will *a fortiori* hold for any a lower than a_n because of increasing returns to ability.

The steady-state condition (11) suggests that there are two ways of promoting the setting up of industry 2 in the home country. One is to raise the relative price of good 2 above its free trade equilibrium level. This is tariff or subsidy protection advocated in the conventional argument. The other way is to create conditions for improving the level of domestic technology s_{d2} in industry 2 without altering the free trade environment.

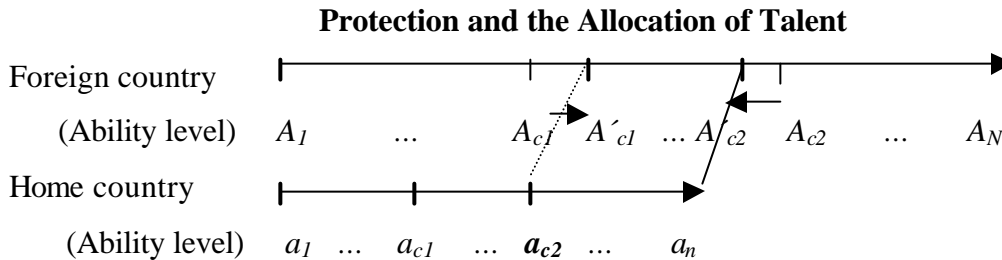
Negative Effects of Protection

Imposing a protective tariff or subsidizing home country producers reverses the sign of inequality (19) by raising the price of good 2 in the home country with unchanged technological level s_{d2} . Let us specifically consider the case where the tariff (or subsidy) rate is set so high as to shut out competition from imports completely.⁵ The demand for

⁵ For example, List advocated increasing import duties “until they are high enough to assure the industry of a dominant position in the home market.” (List, 1983, p. 115). The imposition of prohibitive import tariffs seems to be a natural policy choice in the conventional model, where the ability of all entrepreneurs is the same, so the tariff (subsidy) rate that enables entry into the infant industry is also uniform. The results in

good 2 in the home country will have to be met by domestic supply. The economy will accomplish an immediate transition to a new steady state with a new cut-off ability a_{c2} in the ability distribution of the home-country agents, determined by the free entry condition.

Figure 2.



It is now a straightforward consequence of our assumption (10) above that industry 2 in the home country may never catch up. The jump in the scale factor ($p_2 s_{d2}$) leads to entry by home-country producers en masse. Moreover, an immediate transition to a new steady state in which condition (11) ($p_2 s_{d2} = \text{const.}$) is satisfied, does not give home country producers in industry 2 any additional incentives to carry out innovative activity.⁶ The eventual outcome might thus well be that the average ability of entrepreneurs in industry 2 in the home country will end up being lower than the new average ability of entrepreneurs in industry 2 in the foreign country (the case depicted in Figure 2), while incentives are similar. The technological wedge between the home country “infant industry” and the corresponding industry in the foreign country will continue to widen despite the fact that industry 2 initially satisfied the condition (18).⁷ High domestic price and protection from foreign competition cause too many less than enough able entrepreneurs to prematurely establish their firms in the infant industry,

our model, in which entrepreneurs possess differentiated levels of ability, will not be invariant with respect to different tariff rates. See the concluding section for more on this.

⁶ In contrast, there will be one-time windfall gains accruing immediately after the imposition of protective duties or subsidies. This may lead to additional deadweight loss of rent seeking aimed at capturing those windfall rents. Our argument does not depend on the presence of rent-seeking behavior, but, of course, if there is such a behavior, the argument is reinforced.

⁷ Figure 2 shows industry 2 in the foreign country shrinking in size because of reduced world demand. This will cause both the ablest and the least able entrepreneurs to leave the industry in favor of switching to industry 3 or becoming wage workers. There is no reason to believe that as a result of this, average ability in industry 2 in the foreign country will fall.

“polluting” the pool of ideas and reducing incentives for innovative activity in the home country.⁸

The Infant Industry under the Open Economy Competitive Regime

Consider now the case, in which entrepreneurs in the home country are provided with a chance to observe and learn the state of the art technology in industry 2 without altering the prices or otherwise interfering with the market mechanism. In the example of the Japanese industrialization in the 19th century, such a chance was provided by the government subsidizing a small number of “model firms”. Although the quality of ideas in the public domain might be (and indeed was, as we show in the empirical story below) quite poor in this case, the ablest home country entrepreneurs can learn how to improve the domestic state of the art technology in proportion to their ability levels by observing the experience of those model firms. They will also be motivated to exercise maximum effort in pursuing this learning opportunity because of the prospect of earning inframarginal returns, as explained below. With the same exogenous opportunity for learning, and similar incentives faced by all entrepreneurs, the speed of learning will be the highest for the ablest entrepreneur (with the ability level a_n). This agent will be closing the gap between the right-hand side and the left-hand side of inequality (19) at a maximal speed:

$$s^{n}_{t+1d2} = a_n \cdot s^{n}_{td2}, \tag{20}$$

where s^{n}_{td2} denotes the knowledge about the state of the art technology in industry 2 pertaining to the ablest home country entrepreneur. As long as condition (18) is satisfied, the speed of growth of s^{n}_{td2} will be higher than that of s_{t2} determined by the average ability of foreign country entrepreneurs in industry 2.⁹ We will now informally

⁸ We are not arguing here that such an outcome will *necessarily* happen. All what we are doing here is contrasting this case with the outcome under the competitive regime, under which a situation like that depicted in Figure 2 can never occur.

⁹ If the initial identification of the infant industry was mistaken ((18) was erroneously believed to have been satisfied), no private-sector entry into industry 2 will ever occur, and the maximum social cost the home country will have to incur would be the sunk costs of the learning opportunity provided in vain. Large as this cost may be, it will probably never run as high as maintaining a whole inefficient industry for an indefinite period of time. In what follows we assume that (18) is always satisfied for industry 2.

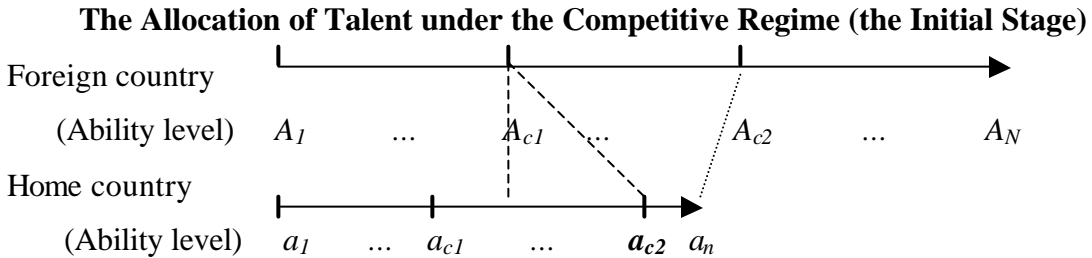
sketch the ensuing dynamic catch-up process that reveals some non-trivial features of the competitive solution to the infant-industry problem.

The most important feature is that entry by private entrepreneurs occurs in this case sequentially over time, *in the order entirely determined by ability ranking*. With the dynamics of the world price of the good 2, p_2 , determined by (11), the ablest home country entrepreneur will enter the industry when s_{td2} , which grows for him (or her) according to (20), becomes large enough so that (19) is reversed in sign. Denoting this moment in time by t_1 ,

$$(p_2 \cdot s_{td2}) \cdot a_n \cdot f_2(h) - w \cdot h + E(V) \geq (p_1 \cdot s_{h1}) \cdot a_n \cdot f_1(h) - w \cdot h, \quad (19^*)$$

where $E(V)$ is a short-hand for the (appropriately discounted) prospective inframarginal returns. Note that (19*) is not satisfied for any other entrepreneur at this moment, so that the ablest entrepreneur is indeed the only one operating a firm in the infant industry. Of course, his or her entry does not affect either the relative prices or wages. The inframarginal returns earned thereby are a non-trivial consequence of the assumption, according to which absolute advantage in terms of ability over the average foreign country entrepreneur constitutes the case for the infant industry.

Figure 3.



With the ablest home country entrepreneur now in the industry 2, his or her innovative ideas are added to the pool of ideas in the public domain, and this greatly improves the process of learning by other potential home country entrants.¹⁰ Over time, (19*) thus becomes satisfied for more home country entrepreneurs. As entrepreneurs n-1,

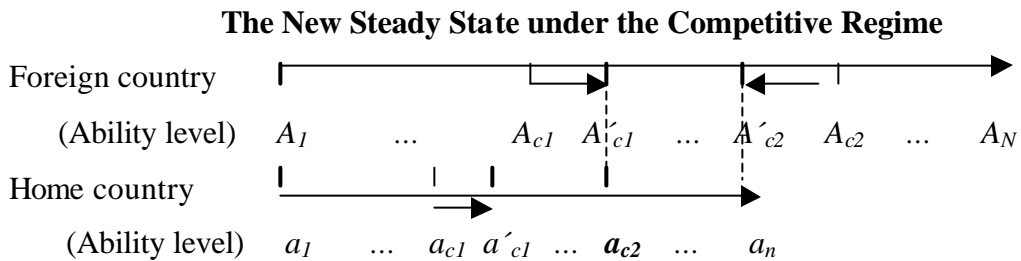
¹⁰ For example, almost all government-sponsored firms in the Japanese cotton spinning industry that had existed before the entry of the first purely private firm employed water power and just 2000 spindles. The first purely private company employed steam power and 10,000 spindles. No new mills using water power have ever been set after that, and most subsequent entrants also employed 10,000 or more spindles per spinning mill.

n-2, and so on enter the market, the average ability still remains higher than in the foreign country, and the general equilibrium value of p_2 will also still be affected only marginally. Technological progress in the infant industry thus continues to outpace that in the foreign country. This initial situation is illustrated in Figure 3. It should be noted that “model firms” become redundant already after the first private firm is set up. The best policy for the government would thus be to liquidate them all immediately after the first private entrepreneur goes in.

The model also leads us to expect a gap in time between the entry of the first and all other non-subsidized entrepreneurs. The reason is that the first entry raises the speed of learning in the home country, while later entries do not have this effect. Thus the first entrant, anticipating that his entry will generate a new stream of inframarginal returns, will be prepared to switch to the infant industry even before the actual profits he can earn there are higher than those he can earn in industry 1. Subsequent entrants will enter only when the state of the technology has been raised to the level at which they can actually be better off in industry 2 than in industry 1. As we will see in the empirical section below, this matches the facts of the Japanese cotton textile industry pretty well.

As the home country state of the art technology continues to improve relative to the foreign country due to its superior speed of learning, the scale of the infant industry starts affecting the free-trade relative world price of good 2 pushing it down more than implied by the speed of the technological progress in the foreign country. That is, (p_2s_2) , the common scale factor faced by foreign country entrepreneurs, begins to fall, shifting the cutoff ability A_{c2} between industry 2 and industry 3 to the left, and the cutoff ability A_{c1} (between entrepreneurs in industry 2 and wage workers) to the right (see Figure 4).

Figure 4.



In the home country, meanwhile, new entry continues, pushing the cutoff ability between industries 1 and 2 further to the left. Also, as the fall in p_2 accelerates,

inframarginal returns become eroded diluting incentives to innovate. Eventually, a new steady state is reached, in which both the average ability levels and incentives are equalized across the two countries, and so is the speed of technological progress.

Indeed, as long as this is not the case, the state of the art technology improves faster in the home country, so its scale factor ($p_2 \cdot s_{d2}$) also rises faster under a common free trade price of good 2. Less and less able entrepreneurs will then find it profitable to set up new firms in the home country. Thus the steady state implies the above-mentioned equality.

The steady state depicted in Figure 4 contrasts sharply with the steady state under protection illustrated in Figure 2 above. The market-selected sequential order of entry under the common world price has resulted in improved state of the domestic technology. The new state of the art technology in the home country may be absolutely higher or lower than in the foreign country¹¹, but, regardless of that, the newly established infant industry is competitive and it does not require any support from the government.

It should be stressed here that the emergence of the infant industry at home increases the speed of technological progress in the foreign country. As free riding on innovations is not possible across the borders, producers in each country as a whole gain from a successful innovation in their home country. Although in the steady state the speed of technological progress is equal across the two countries, the presence of an international competitor makes this free trade steady state a “high-incentive” (and hence more innovating) one, while the corresponding steady state under protection is “low-incentive” (and less innovating). In both cases the average ability determines the speed of learning, but under free trade, it is amplified by higher incentives working on the margin.

To sum up, the formation process of an internationally competitive industry slows down or even completely fails under protection in our model. The speed of learning is hindered by protective measures, and the “infant industry” can end up requiring virtually

¹¹ The new steady-state state of the art technology in the home country is determined endogenously by the free entry condition $(p_1 \cdot s_1) \cdot a_{c2} \cdot f_1(h_{a_2}) - w \cdot h_{a_2} = (p_2 \cdot s_{d2}) \cdot a_{c2} \cdot f_2(h_{a_2}) - w \cdot h_{a_2}$. In the foreign country it is determined by the free entry condition $(p_2 \cdot s_2) \cdot A_{c1} \cdot f_2(h_{A_d}) - W \cdot h_{A_{c1}} = W \cdot A_{c1}$. Accordingly, s_{d2} may be greater than, less than, or equal to s_2 , depending on the value of the parameters p_1, s_1, w and W .

permanent protection. In contrast, if easy ways of making profit by relying on subsidies or tariff-protected prices are not available, such a failure cannot occur. The government may still find it necessary to provide an external opportunity for learning for a limited period of time (for example, by bearing the sunk cost of what we call “model firms”), but it should not tamper with the competitive regime in the private sector.

4. The Role of Market Selection of Entrepreneurial Ability in the Technological Catch Up in the Cotton Spinning Industry in Japan: Some Evidence from Industry-wide and Firm-level Data

As mentioned in the introductory section, it was an attempt to account for the success story of the Japanese industrialization in the late 19th-early 20th century - a unique experience among non-white nations - that motivated the theoretical framework presented in this paper. In this section we present evidence from this episode in economic history that our model seeks to explain.

- Japan was a late-comer in industrialization, but it set up a competitive cotton spinning industry, which became a major player in the world market, under an open economy regime, with the driving force clearly coming from increased efficiency of production propelled by various kinds of technological and managerial innovations.
- The government started the set-up process by creating and/or subsidizing a number of model factories. However, it was left for later non-subsidized entrants whose management was selected by the market and not by the government, to raise the industry to a competitive level. Former government-promoted firms consistently underperformed market-selected firms even after all protectionist measures and all kinds of regulation with respect to them had been repealed, despite having been “learning by doing” in the industry for a much longer period of time.
- The entry of non-subsidized firms occurred with a considerable time lag after the model firms, and it was sequential over time. There was also a time lag between the first market-selected entry and the second one, and the first non-subsidized firm to start operating created a totally new technological and managerial paradigm in the industry that had not been present there before. A clear pattern shows up among

market-selected entrants, according to which those of them who entered earlier enjoyed better long-term performance on the average than later entrants.

- Upon reaching the export stage, the industry underwent several contractions, during which prices and profit rates fell sharply. In response, larger and more efficient firms (the bulk of which was market-selected early entrants) took over and restructured smaller and less efficient ones (all former government-promoted firms, and some later market-selected entrants). This reduction in the number of independent firms helped the industry recover its growth momentum.

Some Stylized Facts

Japan closed its borders to foreigners and prohibited its own nationals from leaving the country in the early 17th century. It was forced to open up to the outside world again in 1854 in the face of the United States' warships. In 1866 Japan had to sign a tariff agreement with the major powers that limited the rate of both export and import tariffs to no more than 5%. This waiver of tariff sovereignty had remained effective till 1899 when it was revised for the first time, and it was completely repealed only in 1911 (Graph A-1).

More than two hundred years of a basically closed economy resulted in the conservation of a preindustrial stage in the Japanese manufacturing industries. In particular, in the cotton spinning industry, domestic output of cotton yarn was mostly produced by manual labor, while spinning mills already dominated the industry in Europe and America. As the country lacked opportunity to rely on protectionist measures, large quantities of imported cotton yarn flooded the market immediately after opening up. Domestic output basically stagnated until the late 1880's, remaining well below the level of imports (Graph A-2).

However, the picture started changing dramatically over the last two decades of the 19th century. The domestic output of cotton yarns (adjusted to the 20s count) rose from 1.4 million kan in 1888 to over 30 million kan in the early 1900s to 83.3 million kan in 1914.¹² It thus increased more than 20 times during 1888-1900, and 2.8 times after the turn of the century and until 1914. Exports began in 1890, and the value of exports exceeded that of imports in 1897 (in terms of quantity exported and imported this

¹² 1 kan = 3.75 kilograms.

happened a year earlier: Graph A-3). This upward trend continued after the end of the period we consider here, so that by 1934 the three largest cotton spinning firms in the world were all Japanese (Miwa and Ramseyer, 2000, p. 178).

The increase in output was accompanied by a marked increase in efficiency. During 1890-1914 the output of cotton yarns (adjusted to the 20s count) increased 18.4 times, while total labor input and the number of spindles were each up 9.6 times. Accordingly, both labor productivity and output per spindle increased more than 90% over the period, and the price of cotton yarns relative to the overall producer price index in manufacturing industries declined by 29.4% from 1890 to 1914. Real wages (relative to the CPI) in the cotton spinning sector rose by 82.7%, almost in line with the increase in labor productivity. This in particular, allows us to dispel the once popular myth that the main source of international competitiveness of the Japanese cotton spinning industry was overexploitation of its underpaid mostly female labor force.¹³

The increase in efficiency was due to broadly defined industry-wide increasing returns to scale, not to increasing technological returns to scale. During the period (1890-1914), the number of spinning mills rose five-fold, from 32 to 152, and the average size of the mill increased from approximately 10,000 spindles in the early 1890s to about 16,000 spindles in 1914. An authoritative source estimates labor costs decreasing by about 22% when a 10,000-spindle mill is expanded to a 20,000-spindle mill, and total costs declining about 15% (see Seki, 1954, p. 204). Thus although increased average size of the mill did lead to lower production costs at that period, it accounts for only a very small fraction of the total cost reduction (see also Miwa and Ramseyer, 2000, p. 186-187).

Competitive Japanese producers did not simply mimic existing technological practices from advanced countries but actively generated innovations themselves. While trying to learn whatever they could from the British, they were also alert to the fact that “what was useful for the world’s leader might not be appropriate for the human and non-human resource endowment of late nineteenth-century Japan” (Saxonhouse, 1974, p.

¹³ Cheap labor was in abundant supply also in China and India, but the performance of cotton spinning industries in those countries did not even remotely match the Japanese performance. The cotton spinning industry in Japan at the time operated under conditions of almost perfect competition, and that also applied to its hiring and wages policy.

149). The choice of the best technology was by no means trivial, which made the working of the market selection mechanism vital for the success of the industry.

The most dramatic (but by no means the only) episode to illustrate this is the introduction of ring spinning frames to replace mules in the early 1890s (see Graph A-4). Mules were still the prevailing type of cotton spinning frames at the time in England, but the Japanese engineers correctly perceived the comparative advantage of ring spinning frames which were much easier to operate and also more productive for lower counts of cotton yarns. The first feature neutralized the disadvantage Japan had in lower quality of the labor force, while the second feature eventually enabled Japan to gain its niche in the export markets. The speed of ring diffusion shown in Graph A-4 was truly remarkable by world standards: in 1910 98.5% of the Japanese spinning frames were ring as compared to 82.4% in the United States, 51.6% in Russia, and only 16.6% in Great Britain (Saxonhouse and Wright, 1984, p. 280).

Market Selection of Ability versus Accumulated Learning by Doing

For almost 30 years after opening up there was just one, unsuccessful attempt by a private entrepreneur to set up a cotton spinning mill unassisted by the government in 1872. Japan's ablest entrepreneurs were still operating firms in traditional sectors like silk manufacturing and mining, while it was left for the central and local governments to set up or promote "model" cotton spinning firms. Although those firms turned out to be a failure from their own narrow objective, they did play a role of providing a low-cost opportunity for learning the new technology.

The presence of those government-sponsored firms allows us to assess whether market selection of entrepreneurial ability was more or less important than accumulated learning by doing in a straightforward fashion. Soon after the success of the first non-subsidized entrant, the government lifted all support and regulation measures for its former model firms, thus placing them under the same market conditions and incentives that purely private firms faced from the outset.¹⁴ Table A-2 lists 19 central and local

¹⁴ According to (Takamura, 1971, Vol. 1, p. 113), the last protective and regulative measures extended to public-sponsored firms were lifted in 1886, the year when only the second unsubsidized firm was established, and several years before the entry by unsubsidized firms began en masse.

government-owned and government-sponsored firms that were set up in Japan during the period from 1866 to 1888 (the whole sample). Ten of those had entered the market before the first unsubsidized firm started operating in 1883, and 18 out of 19 public-owned and sponsored firms had started operating before the second unsubsidized firm was launched in 1886 (compare the setup dates for firms in each category in Tables A-2 and A-4).

If accumulated learning by doing, or the first mover advantage were more important than market selection of entrepreneurial ability, we would expect formerly subsidized firms to have attained a non-negligible advantage over other firms from just having a longer experience in operating their businesses. Even if we heavily discount the experience gained by them during the period in which they had been subsidized and regulated (the period before 1886), they still stood on the starting line earlier than all but one firm among the market-selected entrants. If, on the other hand, market selection was more important than the first mover advantage, then the fact that the management of former subsidized firms had been picked up by the government and not by the market would lead to those firms underperforming market selected firms despite being around in the industry for a longer period of time.

The latter happens to be the case empirically. In testing our model, we measure the difference in ability by looking at the differences in firms' sizes at a given point in time for a given industry-wide level of technology.¹⁵ Graph A-5 compares the sizes achieved by 1898 by former public-promoted firms and firms whose management had been selected by the market. The firms are arranged from left to right in the order of entry. The results are striking: the sizes of the firms whose entrepreneurs had not been subject to initial market selection remained well below the sizes of most firms whose entrepreneurs had to pass the market selection test at the start of their careers. The average size of former public-promoted firms is approximately equal to the average size of market-selected firms that entered the industry as late as in 1895-96!

¹⁷ "A cardinal measure of quality or talent must rely on measurement of actual outcomes." (Rosen, 1981, p.848). In our model, this actual outcome is most explicitly expressed as the coefficient multiplying the common baseline production function, and affecting the firm's size of output and also profit (see (4)). The fact that the state of the art technology was common to all producers in the cotton spinning industry in Japan at the time is documented in (Saxonhouse, 1974).

At the end of the day, none of 19 formerly government-promoted firms was able to achieve any significant business success, and only two of them managed to survive until after the Russo-Japanese war of 1904-05 (the last former public-promoted firm went bankrupt in 1911). The market selection of entrepreneurial ability in our test case turns out to be the most important factor in the success of a business.

Ability Selection in the Private Sector

Turning now to the non-subsidized part of the industry, we first observe that the very fact that entry by competitive firms was spread over time (see Table A-4) cannot probably be satisfactorily explained without referring to some kind of differentiated entrepreneurial ability. The first non-subsidized firm was set up in 1882, the second one in 1886. Ten firms entered the industry in 1887, two more in 1888, five more in 1889. The next wave occurred in 1892 (a recession temporarily halted the expansion of the industry in 1890-91), after which the industry continued to expand until 1898, when the number of independent firms reached the all-time peak of 83.

It is not surprising in view of our model that the first entrepreneur to launch a serious enterprise in the cotton spinning industry in Japan without government assistance or protection in 1882 was Eiichi Shibusawa, whose activity spanned various industries and whose very name is a legend in the history of Japanese entrepreneurship. As predicted by our model, he had waited and learned for a number of years from the experience of the “model firms” in the cotton spinning industry before deciding to move in (the evidence of the intensity of his learning is contained, for example, in the letters he wrote at the time). And when he finally did move in, he created an entirely new paradigm in the industry as compared to what the former subsidized firms had been doing prior to that. In addition to employing steam power and 10,000-spindle mills already mentioned above, he also implemented numerous managerial innovations. For example, he appointed the first native chief engineer in the history of the Japanese cotton spinning industry, and he paid that engineer a salary higher than even that of a company’s president. He was also the first entrepreneur to introduce a two-shift system, operating his factory day and night to raise the productivity of the capital stock. As can be seen from

Table A-1, Shibusawa's firm recorded double-digit rates of return on total capital employed for 5 out of its first 7 years in business.

All these innovations were mimicked by later entrants, and, remarkably, also by former subsidized firms which had been in the industry for many years before Shibusawa. Also in line with our model is the fact that despite Shibusawa's immediate success, the entry of the next group of non-subsidized private firms occurred only several years later after he set up his venture. Shibusawa entered the industry knowing that he would create a new technological paradigm, while this was not true for subsequent entrants.

Table A-3 presents a summary of the ultimate "survival test", similar to the one applied to comparing the ability of entrepreneurs running formerly government sponsored against purely privately established firms. It can be seen that an earlier set up is positively related to the length of survival. For example, 1/3 among the 12 earliest firms established from 1882 to 1887 have survived till the present day, and only 50% of those had been shut down before 1910. In contrast, 71.4% of the firms established in 1888-89 and in 1896, and 83.3% of those established in 1894-95 could not survive beyond 1910. Once again, this evidence pertains only to the entrants whose time of entry was initially selected by the market, and it does not pertain to those entrants who had entered the market much earlier, but who were not subject to the market selection mechanism.

It also should be emphasized that a relatively better average performance of earlier entrants compared to later entrants cannot be accounted for by factors that are usually associated with the presence of a first-mover advantage. For example, a glance back at Graph A-4 should satisfy the reader that far from having an advantage of accumulated capital stock, early entrants (those that started operating back in the 1880s) faced a severe *disadvantage* of having to invest heavily in revamping their capital equipment as the technological revolution swept across the industry in the first half of the 1890s (later entrants could and actually did start with the state-of-the-art ring spinning frames). There is also no evidence of the importance of persistent client relationships. Some early entrants did initially employ the method of selling their cotton yarn through exclusive contracts with particular wholesalers. However, exclusive wholesalers were permanently late on delivering payments, so that by the early 1890s all major producers were selling cotton yarn through an open competitive market.

The Number of Firms and the Quality of the Pool of Entrepreneurs

Our model predicts that toward the end of the infant-industry period, both price and profits would fall sharply as general equilibrium repercussions become a serious issue for the first time. As already mentioned, the price of cotton yarns relative to the overall producer price index in manufacturing industries declined by almost 30% over the period from 1890 to 1914. Graph A-6 shows that almost all of that decline occurred in 1897-99 and coincided with the completion of import substitution and rapid increase in exports of Japanese cotton yarns. There is also a sharp decline in industry-average profit rates (measured as rates of return on shareholders' capital) in the second half of 1890s (we have eliminated former "model" firms from the sample to obtain an untarnished picture that includes only market-selected firms). The clear cause is rapid expansion of the industry and the effects it had on prices and the balance of payments. The share of imports in domestic consumption of cotton yarns went down from 13.6% in 1896 to 3.5% in 1899, while the share of export in output soared from 9.8% to 43.4% for the same period of just 3 years. The immediate effect, according to our theory, should be a decrease in the number of independent producers at the expense of the lower tail of ability distribution, which should consist of later entrants and also former government-promoted firms.

The number of independent firms indeed went down sharply after 1900 (Graph A-7). Despite the fact that new entry resumed each time business condition tended to become better (which, among other things, allows us to dismiss the contention that higher profits were driven by some kind of increased monopoly factor), the number of independent producers decreased by about one half from the late 1890s to around 1910, mainly due to takeovers and acquisitions. Remarkably, in 43 out of the total of 60 cases of takeovers that took place over the period of 1898-1917 (71.7%), target firms either entered the industry later than did the acquiring firms or else were the former government-promoted firms.

Firm-level data available for those takeovers clearly show that the driving motive for acquisitions was restructuring of less efficient firms by more efficient managers of acquiring firms. Graph A-8 presents a summary of the profitability data for acquiring

firms versus target firms for the 38 cases for which these data are available. Note first that the 3-year average profit rates of acquiring firms before takeovers were more than 2.5 times higher on the average than the 3-year averages of profit rates of target firms.¹⁶ From our model we would also expect that if the ability factor was more important than diminishing returns to scale in the baseline production function, profit rates of new integrated firms after takeovers should be significantly higher than profit rates of target firms before acquisitions, but also should be lower than profit rates of acquiring firms alone before takeovers because of diminishing returns for a given ability level.

There are two measures of profit rates of integrated firms after takeovers in Graph A-8. One is a simple three-year average, and the other eliminates the upward trend in profits that set in after 1902 and became especially pronounced after 1915 due to the disruption in the Far Eastern market caused by the World War.

These two series represent an upper and a lower bound, respectively, for what is a proper estimate of a true change in profitability due to takeovers. Using the raw data overestimates the gains in efficiency from mergers, especially for the periods during which profit rates rose sharply due to exogenous factors (like after 1914). However, using detrended data clearly underestimates those gains as the upward trend in profits itself was at least partly due to the increase in the weights attached to firms run by abler entrepreneurs in the industry-wide average. Taking the middle ground, we can plausibly conjecture that the profitability of integrated firms after takeovers was indeed significantly higher than that of target firms before being taken over, though it fell short of the profitability of acquiring firms before takeovers.

Some supplementary evidence is obtainable also from the firm-level data on the rates of growth in output before and after takeovers. With technological returns to scale unimportant, takeovers did not change factory size, only factory management (Miwa and Ramseyer, 2000, p. 187). We examined 28 cases of takeovers for which we could compute three-year averages of output in acquiring and target firms separately before takeovers, and also the three-year averages of output in the integrated firm, with the former target firm listed as a separate production facility within the integrated firm. Giving abler managers control over production facilities that used to be run by less able

¹⁶ (Miwa and Ramseyer, 2000, p. 184) obtain similar results by using a different measure of profitability.

managers should in our theory lead to output growing faster in that part of the production facility of the integrated firm which is comprised of the former target firm than in its other production facilities. If, however, factors other than entrepreneurial ability (like the quality of the capital stock itself, or the amount of accumulated learning by doing of the labor force) were more important, this effect need not be observed. We find the relationship predicted by our model in 19 cases out of 28 (68%): see Graph A-9.

To conclude: the evidence we obtain from the formation and growth years of the cotton spinning industry in Japan broadly supports the view that the speed of learning (technological progress) depended more on the *quality* of the pool of entrepreneurs (and thus on the effectiveness of the market selection mechanism of entrepreneurial ability) than on the number of independent firms (and thus on the scale of the industry regardless of the strength of market selection) or on accumulated learning by doing.

5. Some Further Discussion and Policy Implications

The “Pollution” Story Once Again

We have emphasized the difference between our approach and the conventional one focusing on the “first mover advantage” and accumulated learning by doing. We begin our discussion in this section by giving an example of how the two theories can actually be reconciled, yielding also a rationale for the assumption that the average ability determines the speed of technological progress in the infant industry.

Suppose now that in addition to ability differentiation there does exist a first mover advantage. We normalize the total “amount” of this advantage to be equal to 1 and we assume that it is distributed to the entrants in the proportion that decreases with the time of entry. If more than two entrepreneurs are in the market at the same period, the amount of the advantage pertaining to that period is equally shared among all of them. This simple formulation captures two important features in the concept of the first mover advantage: firstly, that those who enter the industry earlier receive a larger advantage than later entrants, and, secondly, that the share each entrepreneur receives depends only on the timing of entry and nothing else. To be more specific, let the availability of the first mover advantage decline at the rate of $1/2^t$ ($t=1,2,3,\dots$), over time so that if there are k entrepreneurs in the industry at period t , each of them has a claim to $(1/k)(1/2^t)$ share of

the first mover advantage. The numbers are chosen so that the total amount of the advantage that all entrepreneurs taken together receive from period 1 to infinity will sum up to $\sum_{t=1}^{\infty} 1/2^t = 1$. Note that we are definitely *not* saying here that every entrepreneur will use his or her amount of advantage with equal efficiency.

Let the contribution of the entrepreneur with ability level a_k at period t to the speed of technological progress of the home country infant industry be proportional to his or her ability level, times the amount of his or her share of the first-mover advantage. By the above, if there are t entrepreneurs in the industry at time t , the size of the contribution is $m_k = (1/t) \cdot (1/2^t) \cdot a_k$. The total contribution of all entrepreneurs is just the sum of their individual contributions.

Under tariff protection or uniform price subsidy all entrepreneurs up to the steady-state cutoff ability level q will enter the market in the first period (see Section 3). Hence their total accumulated contribution to the technological progress will sum up to

$$T = (1/q) \left(\sum_{i=n}^{n-q} a_i \right) \left(\sum_{t=1}^{\infty} 1/2^t \right) = \bar{a}_i, \text{ where } \bar{a}_i = \sum_{i=n}^{n-q} a_i / q \text{ denotes the average ability up to}$$

the cutoff ability level q as in (10). In contrast, if entry occurs sequentially in the order of ability selected by the competitive market mechanism, only the entrepreneur with the highest level of ability a_n will enter the industry in period 1 . This person will thus alone capture the amount of the first mover advantage equal to $(1/2)$. Assuming for simplicity that just one more person enters the market in each subsequent period, the contribution of all entrepreneurs active in the industry at any period t will be equal to

$$(1/t) \cdot \left(\sum_{i=n}^{n-t} a_i \right) \cdot (1/2^t). \text{ With the new steady state is reached in period } q, \text{ the total}$$

contribution over time will in this case sum up to:

$$C = a_n \cdot (1/2) + (1/2) \cdot (a_n + a_{n-1}) \cdot (1/2^2) + \dots + (1/q) \cdot \left(\sum_{i=n}^{n-q} a_i \right) \left(\sum_{t=q}^{\infty} 1/2^t \right) \gg \bar{a}_i = T, \text{ because}$$

earlier entrants with higher ability get higher weights in the allocation of the first mover advantage for the whole period before the economy reaches the new steady state.

Intuitively, the industry-wide speed of learning (the quality of ideas adopted) is enhanced when higher ability entrepreneurs are allocated a larger (earlier) part of the first mover advantage without having to share it with others.

This result seems plausible, bearing in mind that uncertainty surrounding the selection of technological and other ideas is a more serious problem at the initial stage of the set up of an infant industry than at later stages when it is already well established. If the initial first mover advantage is allocated without regard to ability, the industry is more likely to mistakenly adopt a wrong (more costly) path of development which it will then find hard to displace. In this blend of the “pollution” and “first mover advantage” stories, the weights attached to inefficient innovations are reduced to almost zero if the entrants are selected by the market mechanism in the ability order, while they tend to be significantly larger if both able and less able entrepreneurs enter the industry from the outset. Of course, the outcome will be still worse if the entrepreneurs in a protected industry are picked up according to the rules of a political game or entirely at random.

The question of whether it is the number of experiments or the average quality of ideas that is more important for the speed of technological progress thus becomes a totally empirical one. For the Japanese cotton spinning industry, as shown above, there is compelling evidence to allow us to conclude that the first mover advantage, if it existed at all, was not strong enough to pit “model firms” in any position to compete against later market-selected entrants possessing higher ability. We strongly suspect that this may also turn out to be true in many other settings where conventional thinking used to emphasize the positive effects of having more firms in the industry and not paying enough attention to what kind of firms were getting an advantage.

Incentives to Innovate in a Small Open Economy

The second argument in the relation (10) is incentives. When those are strong, they augment the average ability and result in a higher speed of technological progress. Although the idea that protection somehow dampens incentives is not new (see Baldwin, 1969, and Krueger, 1993 for just a few examples), it has mostly been discussed within the context of rent seeking and related issues. As noted in Section 3, the argument of our model hinges upon the insight that an open economy regime gives better opportunities to capture inframarginal returns.

Innovative activity, even if we think of it as pure learning by doing, still requires effort (one must at the very least forgo “the costs of comprehending”, as defined in

Demsetz, 1995). It is assumed in the literature that some kind of market imperfection or product differentiation is required to secure enough such effort. This role is played in our model by the assumption that new technological ideas do not spill over to the foreign country.¹⁷ In this case perfect competition at home no longer presents any problem, as higher speed of technological progress than abroad translates itself in inframarginal returns accruing to all home country entrepreneurs. The outcome is as if for the whole “infant industry” period, the home country entrepreneurs did not compete against each other at all, but rather all of them taken together competed against the foreign country producers. In particular if an exchange of ideas and/or the coordination of effort to implement the best innovation as quickly as possible are beneficial to the industry as a whole, then our model predicts that this chance will definitely be taken up.

As noted by (Saxonhouse, 1974), the All Japan Cotton Spinners Association (Boseki Rengokai) did indeed function as an institution that made such an exchange of ideas and technical assistance among firms possible.¹⁸ Interestingly enough, the perceived benefits of a common pool of ideas were so strong that prominent managers would sit on the boards of several cotton spinning firms without giving rise to a clash of interests which would be inevitable under different circumstances (Miwa and Ramseyer, 1999). We examine this “neighboring farmer effect” in more detail both theoretically and empirically in (Braguinsky, Rose, and Ohyama, 2001).

In contrast, if the industry is protected during its setup period, the home country entrepreneurs inevitably compete against each other, and the degree of competition will rise with the degree of protection. Without some kind of protection from the free rider problem, incentives to spend more effort on developing new ideas will be much lower,

¹⁷ This assumption is particularly appealing in the context of a late-coming industrializing country. Every country in the world may be watching the industry leader (like the 19th century England), but nobody will be watching the technological innovations in Japan until its cotton spinning industry makes its presence felt in the world market, that is, until it is no longer an infant industry, but is quite mature.

¹⁸ This Association has been too many times quite mistakenly treated as a price-fixing cartel in the Japanese literature based on Marxist dogmas, and this mistake was repeated in English-language literature uncritically citing those biased studies. Incidentally, we owe most of the rich data available on the Japanese cotton spinning industry of the time to monthly and semi -annual bulletins of this Association.

and coordination to increase the speed of diffusion for the benefit of the industry in general would be impossible.

Of course, the inframarginal returns accrue to home country producers only for a limited period while the integrated world economy is still out of its long-term steady state. Under the presence of persistent surpluses new entry will be limited only by the amount of time (and resources) needed to build up additional capital capacity. The quasi-rents will be progressively wiped out as a new steady state is approached. However, as already noted in Section 3, even in the eventual steady state the “stick” if not the “carrot” part of the above argument will still be effective; falling behind the pace of innovations in the foreign country will result in losses and bankruptcies, prompting the remaining firms to put more effort into the innovative activity. All these implications can readily be observed in the Japanese cotton spinning industry of the late 19th-early 20th centuries, as described in Section 4.

To recapitulate: the “pollution” aspect of our model captures search and comprehension costs that have to be incurred within the industry, while the incentives aspect captures the erosion of inframarginal returns stemming from increased general equilibrium repercussions. A competitive open economy regime leads to an infant industry starting with both higher average ability of entrepreneurs, and higher incentives to innovate and share the new technology than does shielding it from competition. It is the combination of these two factors that explains the success of a competitive regime in setting up a viable infant industry, where protection may fail to do so.

Policy Implications

The process of learning started in the unprotected infant industry by the government establishing (and bearing the costs) of model firms while maintaining the overall free trade competitive environment in the private sector. Those model firms were inefficient if considered as commercial enterprises on their own, so that their costs should be treated as industry-wide sunk cost of learning by doing. We will now briefly compare this way of providing the economy with an opportunity to learn the new technology with some alternatives to argue that “model firms” probably represented a minimum social cost of the infant-industry setup process.

As already mentioned, in the framework of our model the outcome of tariff protection would not be independent of the rate of import duties. If the government possessed perfect information about the level of ability of private agents, it could “fine tune” the tariff rate so that $(p_2 \cdot s_{id2})$ would just enable the first-ranking entrepreneur to enter industry 2 while shutting off less able home country entrepreneurs while the level of technology is too low for their entry to be justified. The effect would be similar to that of market selection, and, arguably, the new industry would be established quicker in time. However, if the technological gap between the home country and the foreign country is large enough, the initial tariff rate will have to be quite high, so that even ignoring possible incentive effects, a loss of consumer surplus can easily become larger than the costs of operating model firms. More fundamentally, the government has no means of verifying the true ability levels of individual entrepreneurs, and since higher tariffs mean higher profits, there is no incentive to report one’s ability truthfully.

Subsidies to home country producers, another commonly advocated infant-industry promotion policy, feature even worse than protective tariffs in our framework. The process by which those subsidies are given out should be specified to spell out the details, but the nature of the market failure can be seen quite easily. For example, if the allocation of subsidies and the amount of subsidy provided to each home country producer is governed by a political process, the expected ability of entrepreneurs who set up firms in the infant industry will be much lower than even under tariff protection. The intuition is that arbitrary subsidies distort the allocation of resources more than do tariffs in the model in which ability matters, because tariff protection at least preserves the market selection mechanism inside the home country itself.¹⁹

Finally, if investment decisions made at the point of entry are at least to some extent irreversible, the sequential order of entry determined by ability ranking under the competitive regime will produce benefits in its own right, as later entrants would be able to avoid hard-to-reverse mistakes made by the pioneers. It seems that this aspect of the

¹⁹ In contrast, direct investment by multinationals can have the same effect as setting up model firms, and it does not involve the sunk costs entailed by the latter. In the modern context, stimulating such direct foreign investment and maintaining the overall free trade competitive regime is probably the first best way of promoting the infant industry, as implied by our model.

interaction between ability and learning by doing is also extremely important from the empirical point of view.

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We have examined in this paper the changes that need to be introduced into the conventional understanding of the infant industry problem when account is taken of different levels of entrepreneurial ability of the agents populating the economy. When all producers are alike, the main problem is whether they can all profitably enter a new industry at the same time. In that setting, the attention becomes focused on the problem whether the change in resource allocation as a result of policy targeting the development of an infant industry is Pareto-improving over time or not.

In our model, the potential entrants are *not* the same in the sense that they possess different levels of entrepreneurial ability. This plays an important and independent role, as the level of ability of entrepreneurs actively operating in the infant industry at each moment in time determines the speed of technological progress and the ultimate success or failure of the catch up process. Although the problem of entry into the new industry itself still attracts our attention, ensuring the correct order of entry becomes the most important issue. We conclude that a combination of unfettered open economy competition with an exogenous provision of some minimum opportunity for learning nurtures an infant industry in what is probably the optimal path in time.

We have assumed that entrepreneurial talent is general, not industry specific throughout this paper. In the real world, the abilities of entrepreneurs are different not only in general terms, but also across industries. However, it is not obvious why taking this factor into consideration should justify the adoption of protectionist policies any more than it does in the case of general ability. We thus feel comfortable not to consider this possible complication.

Second, it is assumed that only one new industry exists in the economy. When there are several possible new industries, private entrepreneurs will enter that one which presents the lowest initial barrier to entry, not necessarily the industry with the largest long-term potential for technological progress. This may be the kind of problem faced by countries like Russia which have enough accumulated human capital that can be

employed in various uses. However, for most developing nations the situation is much simpler and similar to that faced by Japan in the 19th century.

Finally, it should be mentioned that the success story of the Japanese cotton textile industry was not limited to cotton spinning. After they had reached the export stage, cotton spinning firms turned their attention to cotton fabrics and to producing finer cotton yarns. The driving force for the success of this second stage of development of the Japanese textile industry came again from the same firms, run by ablest entrepreneurs, that had laid down the foundation for the competitive cotton spinning industry (starting again with Osaka Cotton Spinning Company). We present this story, together with a modified theoretical model, in (Murphy, Braguinsky and Ohyama, 2001).

References

- Baldwin, Robert, 1969. "The Case against Infant-Industry Tariff Protection". *The Journal of Political Economy*, Vol. 77, No. 3, 295-305.
- Braguinsky, Serguey, Rose, David C., with Ohyama, Atsushi, 2001. *Incentives to Innovate in Small Clusters of Firms*. Unpublished.
- Dai-Nippon Boseki Rengokai, ed., April 1889-December 1902. *Dai-Nippon Boseki Rengokai Geppo* (Monthly Report of the All Japan Cotton Spinners Association). Osaka, (Geppo).
- Dai-Nippon Boseki Rengokai, ed., 1903-1918. *Menshi Boseki Jijo Sankosho* (Reference Materials on Cotton Spinning), Osaka, (Sankosho).
- Demsetz, Harold, 1995. *The Economics of the Business Firm*. Cambridge University Press, Cambridge, Massachusetts.
- Fujino, Shozaburo, et al., 1979. *Choki Keizai Tokei* (Estimates of Long-Term Economic Statistics of Japan), Vol. 11, *Sen'i Sangyo* (Textile Industry), Toyo Keizai Shimposha, Tokyo.
- Ishida, Kohei, 1973. *Nihon keizai-no hatten* (Japanese Economic Development). Minerva Publishers, Tokyo.
- Japan Statistical Association, ed., 1988. *Nihon Choki Tokei Soran* (Historical Statistics of Japan), Vol. 1-4.

Kanebo Inc., ed., 1988. *Kanebo. Hyakunen-shi* (100 Years of Kanebo), Osaka (Privately Printed).

Krueger, Anne, 1993. "Vicious and Virtuous Circles in Economic Development". *American Economic Review, Papers and Proceedings*, Vol. 83, No. 2, 356-361.

List, Friedrich, 1983. *The Natural System of Political Economy*. Frank Cass, London.

Miwa, Yoshiro, and Ramseyer, J. Mark, 2000. "Corporate Governance in Transitional Economies: Lessons from the Pre-War Japanese Cotton Textile Industry." *The Journal of Legal Studies*, Vol. 29, No. 1, 171-203.

Miwa, Yoshiro, and Ramseyer, J. Mark, 1999. *The Value of Prominent Directors: Lessons in Corporate Governance from Transitional Japan*. CIRJE-F-63 Discussion paper series, University of Tokyo.

Murphy, Kevin M., Braguinsky, Serguey, and Ohyama, Atsushi, 2001. *Allocation of Talent in a Diversifying Infant Industry*. Unpublished.

Murphy, Kevin M., Shleifer, Andrei, and Vishny, Robert, 1991. "The Allocation of Talent: Implications for Growth". *The Quarterly Journal of Economics*, Vol. 106, Issue 2, 503-530.

Nisshinboseki Inc., ed., 1969. *Nisshinboseki rokujunen-shi* (60 Years of Nisshin Boseki), Tokyo (Privately Printed).

Noshomusho, ed., 1896-1912. *Noshomu Tokeihyo* (Statistics on Agriculture, Commerce, and Industry), Noshomusho, Tokyo, (Tokeihyo).

Ohyama, Atsushi, 1999. *The Allocation of Talent: Implications for Infant Industry Protection*. Master Degree Dissertation. Keio University, Tokyo.

Ohkawa, Kazushi, et al., 1967 *Choki Keizai Tokei* (Estimates of Long-Term Economic Statistics of Japan), Vol. 8, *Bukka* (Prices), Toyo Keizai Shimposha, Tokyo.

Rose, David C., 2000. "Teams, Firms, and the Evolution of Profit Seeking Behavior", forthcoming in *The Journal of Bioeconomics*.

Rosen, Sherwin, 1981. "The Economics of Superstars", *American Economic Review*, Vol. 71, No. 5, 845-855.

Saxonhouse Gary, and Wright Gavin, eds., 1984. *Technique, Spirit and Form in the Making of the Modern Economies: Essays in the Honor of Willam N. Parker*. JAI Press, London.

Saxonhouse, Gary, 1974. "A Tale of Japanese Technological Diffusion in the Meiji Period", *The Journal of Economic History*, Vol. 34, No. 1, 149-165.

Seki, Keizo, 1954. *Nihon mengyo-ron* (Japanese Cotton Industry). Tokyo University Press, Tokyo.

Takamura, Naosuke, 1971. *Nihon boseki sangyoshi josetsu* (Introduction to the History of Cotton Spinning Industry in Japan), in 2 volumes, Koshobo, Tokyo.

Toyoboseki Inc., ed., 1986. *Hyaukunen-shi. Toyobo* (100 Years of Toyobo), in 2 volumes, Osaka (Privately Printed).

Ushijima, Toshiaki, and Abe, Takeshi. *Mengyou* (Cotton Industry), 1996. In *Nihon keizai, 200 nen* (200 years of the Japanese Economy), p. 225-255.

Yamazawa, Ippei, and Yamamoto, Yuzo, 1979. *Choki Keizai Tokei* (Estimates of Long-Term Economic Statistics of Japan), Vol. 14, *Boeki-to Kokusai Shushi* (Foreign Trade and the Balance of Payments), Toyo Keizai Shimposha, Tokyo.

Statistical Appendix²⁰

Table A-1. The Profitability of Osaka Cotton Spinning company

Year	Profits/Sales Ratio	Return on Capital Employed	Return on Shareholders' Capital
1883	30.8%	5.7%	8.4%
1884	34.5%	17.5%	28.4%
1885	13.7%	6.0%	7.7%
1886	23.4%	15.4%	20.0%
1887	33.6%	35.0%	54.3%
1888	30.1%	28.7%	43.9%
1889	22.3%	16.5%	27.1%
1890	9.8%	6.3%	12.7%
1891	5.9%	6.4%	11.7%
1892	8.9%	9.2%	17.8%
1893	10.6%	9.3%	16.3%
1894	9.1%	9.4%	19.5%
1895	11.9%	14.5%	28.9%
1896	7.7%	9.1%	18.3%
1897	5.5%	6.6%	13.6%
1898	3.2%	4.3%	8.5%
1899	5.0%	7.8%	15.1%
1900	-3.2%	-2.7%	-7.4%
1901	3.5%	4.4%	8.2%
1902	1.1%	1.2%	2.7%
1903	2.8%	4.0%	8.3%
1904	10.8%	12.9%	30.7%
1905	11.5%	16.1%	41.5%
1906	9.6%	15.6%	37.1%
1907	11.0%	15.6%	33.6%
1908	5.9%	7.5%	15.8%
1909	6.9%	9.0%	19.1%
1910	4.4%	5.9%	14.3%
1911	3.6%	4.9%	11.9%
1912	5.5%	7.7%	19.3%
1913	7.4%	11.3%	27.2%
1914	8.4%	9.9%	29.9%

Source: Toyoboseki Inc., ed., 1986.

²⁰ The main sources for the data are Fujino, et al., 1979, Geppo (Dai-Nippon Boseki Rengokai, ed., April 1889-December 1902), "Sankosho" (Dai-Nippon Boseki Rengokai, ed., 1903-1916). These are supplemented whenever appropriate by Japanese Statistical Association (1988), Ishida, 1973, Ushijima and

Table A-2. Government-owned, “model” and other subsidized firms

#	Names	Set up	Shut down	#	Names	Set up	Shut down
1	Kagoshima	1866	1897	11	Hiroshima	1883.7	? (before 1905)
2	Senshu	1870.4	1903	12	Maekawa	1883.12	1899
3	Doshima	1880.8	? (before 1905)	13	Shimada	1884.1	? (before 1905)
4	Okayama	1881.7	1907	14	Miyagi	1884.4	? (before 1905)
5	Aichi	1881.12	1896	15	Enshu	1884.11	1893
6	Tamashima	1882.1	1899	16	Nagasaki	1884.12	1899
7	Kuwahara	1882.2	1903	17	Shimotsuke	1885.1	1911
8	Watanabe	1882.3	? (before 1905)	18	Nagoya	1885.4	1905
9	Mie (Kawashima)	1882.6	1886	19	Himeji	1888	1899
10	Shimomura	1882.10	1903				

Source: Fujino et al., 1979, Takamura, 1971, etc.

Table A-3. Set-up Dates and Survival Rates among Private Firms

Set up in:	Shut down before 1910	Survived into the 1910's	Of which: Still operating today
1882-87 (12 firms)	50.0%	50.0%	66.6%
1888-89 (7 firms)	71.4%	28.6%	50.0%
1892-93 (15 firms)	53.3%	46.7%	42.8%
1894-95 (12 firms)	83.3%	16.7%	0.0%
1896 (14 firms)	71.4%	28.6%	50.0%
Total (60 firms)	62.9%	17.7%	19.4%

Source: computed from the data in Table A-4.

Abe, 1996, Takamura, 1971, “Tokeihyo” (Noshomusho, ed., 1896-1912), and the published histories of individual firms (Toyoboseki Inc., ed., 1986; Kanebo Inc., ed., 1988; Nisshinboseki, Inc., ed., 1969).

Table A-4. Private firms set up in 1882-96

#	Names	Set up	Shut down	#	Names	Set up	Shut down
1	Osaka	1882.5		31	Koriyama	1893.5	1911.3
2	Mie	1886.5		32	Kumamoto	1893.5	1899.7
3	Tenma	1887.3	1905.10	33	Tsujimoto	1893	1893
4	Owari	1887.3	1900.6	34	Kashiwazaki	1893.7	1901
5	Tokyo	1887.4	1914.8	35	Tsushima	1894.3	1906.7
6	Kanegafuchi	1887.5		36	Kyoto	1894.7	1901.1
7	Naniwa	1887.5	1898.8	37	Kasaoka	1894.10	1908.11
8	Hirano	1887.6	1902	38	Ise	1894.10	1900.11
9	Fujii	1887.7	1902.8	39	Shokuma	1895.4	1917.4
10	Wakayama	1887.9	1911.3	40	Takaoka	1895.5	1914.12
11	Uwa	1887.11	1902	41	Awaji	1895.6	1899.12
12	Kurashiki	1887.12		42	Sanshugumi	1895.8	1900.10
13	Kofu	1888.8	1907.5	43	Nihon boshoku	1895.8	1904
14	Kanekin	1888.8	1906.9	44	Heian	1895.9	1905
15	Settsu	1889.4	1918.6	45	Ichinomiya	1895.11	1907.7
16	Miike	1889.5	1902	46	Fushimi	1895.12	1900.12
17	Amagasaki	1889.6		47	Kashu	1896.2	?before 1905
18	Kurume	1889.6	1899.7	48	Fuji	1896.3	
19	Ozushima	1889.7	1898.6	49	Tokyo gasu	1896.3	
20	Fukushima	1892.3		50	Bizen	1896.3	1907.4
21	Asahi	1892.10	1900.1	51	Kuwana	1896.3	1907.8
22	Kishiwada	1892.11		52	Ise chuo	1896.3	1897
23	Sakai	1892.11	1917.2	53	Harima	1896.4	1912.5
24	Yamashiro	1892.11	1905.6	54	Yamato	1896.4	1902
25	Matsuyama	1892.12	1913.6	55	Nakatsu	1896.6	? before 1905
26	Iyo	1892.12	1918.4	56	Saidaiji	1896.6	1898
27	Noda	1892.12	1898.4	57	Sanuki	1896.7	1913.3
28	Meiji	1893.1	1902.12	58	Yawatahama	1896.8	? before 1905
29	Nihon	1893.2	1916.2	59	Chugoku	1896.8	1902.8
30	Wakayama shokufu	1893.3		60	Chita	1896.12	1907.8

Firms in bold: still continue operating today (some of them under different names). Source: Fujino et al., 1979; Ushijima and Abe, 1996; Geppo, 1889-1897.