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9. ABSTRACT

This volume examines the historical performance of the Japanese cotton industry with two major objectives in mind: in the first instance we try to determine the impact of changes in the quality dimension on the flexibility with which capital and labor can be efficiently combined, as well as to examine the process of technology importation, adaptation and diffusion in a particular successful historical case. We find that both the adoption of multiple shifting associated with a decline in the yarn count and the switch from a predominantly mule to a predominantly ring technology represent important examples of indigenous innovation and adaptation which can make a large difference in solving a developing economy's labor absorption problem. Secondly, we try to reach an understanding of what the environmental conditions are, in both the narrowly economic and the broadly conceived institutional sense, which yield better, i.e. more endowment-sensitive, decisions on technology choice and technology change at the individual entrepreneurial level. An examination of the contrastwith performance and conditions in the Indian textile industry permitted us to focus on the importance of imperfections in the credit markets restricting entry and managerial incentive systems restricting entrepreneurial motivation as critical to the rates of technology adoption, adaptation and diffusion.

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TECHNOLOGY CHOICE, ADAPTATION AND THE QUALITY DIMENSION IN THE JAPANESE COTTON TEXTILE INDUSTRY

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November, 1977

Technology Choice, Adaptation and the Quality Dimension In the Japanese Cotton Textile Industry

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I. Introduction

Much of the discussion in academic as well as policy-making circles over the past decade or so on the subject of LDC technology choice and technology change has focussed on two questions. First, there has been a prolonged debate on the existence or non-existence of viable alternatives in producing a given commodity; and second, assuming some alternatives do exist, much attention has been paid to the social costs of departures from the use of technologies most appropriate to a country's resource endowment, as a consequence of the distortion of relative factor prices.

We now seem to have reached a general consensus[1] with respect to the first question, that indeed a wide range of technical alternatives does exist in nature, certainly in the discrete process industries, and that the capacity to exercise choice in peripheral, plant-related activities often exists even in continuous process industries. With respect to the second question, there is still less of a consensus regarding the relative importance of factor and product price distortions as opposed to other less conventional forces at work which impinge on the technological choices actually rendered at the individual entrepreneurial level.

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[1] See for example, D. Morawetz, "Employment Implications of Industrialization in Developing Countries", Economic Journal, September, 1974 and G. Ranis, "Industrial Technology Choice and Employment: A Review of Developing Country Evidence," Interciencia, Vol. 2, No. 1, 1977.

* While this paper represents a collaborative effort, Ranis had primary responsibility for Sections I, II and V and Saxonhouse for Sections III and IV.

Much of the past research effort in either of these dimensions has been focussed on recent LDC experience mostly of the industry cross-section or the case study variety. This paper endeavors to make a contribution to our understanding in these areas via examination of the historical laboratory, that of the Japanese textile industry of the late nineteenth and early twentieth centuries, which we believe to be relevant to the problems and opportunities facing today's LDC's in terms of the comparability in the basic factor endowment situation. This rather unique opportunity is afforded us in large part by the existence of a rare set of good firm level data for the entire industry going back to 1891 (for some purposes at least to 1906) collected by the Japan Cotton Spinners' Association. (Boren)

The first topic to be dealt with in this paper (Section II) focusses on the choice of technology in Japanese cotton industry during the late nineteenth century in an effort to evaluate the relative importance of conventional and non-conventional elements of the environment governing such choice Two major technological changes in the spinning industry and their rapid diffusion will be examined in this context, the adoption of multiple shifting in 1882-1884 associated with a decline in the average yarn count, and the switch from mule to ring technology a few years later (1887-1889). It will be found that the Japanese entrepreneurial behavio in the choice of cotton spinning processes can be better understood if we examine it in the context of linked innovations in cotton mixing, in one direction of the production chain, and in weaving--as induced by changes in demand conditions--in the other direction.

The resulting changes in domestic and international competitiveness of the Japanese textile industry can be demonstrated by the overall performance of yarn and cloth production and exports over time. In exploring the importance of non-traditional as well as traditional factors in the context of Japanese technology change and diffusion, the contrast with the Indian textile industry of the same period will be found to be instructive.

The second topic to be dealt with (Section III) focusses on the issue of the additional range of technology choice opened up in nature when we permit quality variation to take place in at least two dimensions, i.e. the quality of the raw material input--in this case raw cotton--and the quality of the intermediate output--in this case yarn count. The proposition being tested here is that, regardless of how firm the belief in fixed proportion technologies still is in certain quarters, once we admit of substitutability among some attributes of a commodity defined as a homogeneous good at a certain standard level of industrial classification the substantial variability of the demand for unskilled labor per unit of capital, for example, can be demonstrated.

Put more positively, we hope to be able to demonstrate here the additional flexibility gained, in terms of the use of surplus unskilled labor, when we are able to make relatively small changes, either in the quality of the raw cotton input or in the quality of the yarn count produced. While economists have found it analytically convenient to, at least implicitly, deal with intermediate inputs and outputs of a specified quality, we know that the real world does not quite operate like that, and that, in

fact, some specification changes occur at any credible SITC level as we move, say, across large and small-scale firms, or over time. Treatment of this phenomenon is, moreover, essential if we are to get a better quantitative handle on the notion of "appropriate goods" which is but an extension of the concept of "appropriate technologies" in a given context. Once variability in the specification along some dimension of quality is permitted, at appropriately varying relative prices, the array of choice available to consumers, especially in the domestic market, can become a conscious decision variable either from the social point of view, to avoid the overspecification of goods while moving towards fuller employment of labor or, at the individual consumer level, to clarify the trade-offs among attributes within a particular relative quality and price vector.

Finally (Section IV), this paper addresses a closely related issue, namely an analysis of the quality dimensions underlying the labor market in which the Japanese textile mills were operating. Gerschenkron[1] and others have long argued that labor surplus contemporary LDC's do not necessarily have abundant supplies of reliable and disciplined workers. Conventional two factor production function analyses usually exhibit limited substitution possibilities between capital and labor when such work force traits as age, experience, and education and such job characteristics as length of shifts, injury incidence and non-wage benefits are held constant. In the absence of a general equilibrium production function in which all demand and supply variables are

[1] Alexander Gerschenkron, Economic Backwardness in Historical Perspective, Cambridge, Mass., 1962.

permitted to be simultaneously adjustable, we have, in this section, held non-labor inputs constant and explored the conditions for equilibrium in the labor market, on the assumption that the kind of modern labor-using technology employed in the Japanese cotton textile industry required the recruitment of an effective disciplined as well as qualitatively differentiated work force.

Textile industries at comparable stages of development across countries differ markedly in their rates of turnover, absenteeism and in their labor, sex and education mixes. Such differences reflect the intersection of firm demand and labor supply patterns as linked to the alternatives available in terms of alternative factor proportions, on the one hand, and alternative job opportunities, say in agriculture, on the other. What is especially interesting in the Japanese case is the unusually low overall "quality" of the labor force as conventionally measured in terms of the attributes mentioned, side by side with the undoubted competitive success--at home as well as abroad--of this very labor intensive industry. Our investigation here will hopefully shed light on some of the important non-conventional dimensions of labor quality.

Choice of Imported Technology and the Technology Diffusion Process

The problem we have set for ourselves in this section is to attempt an examination of the technology choices made in the 19th century Japanese cotton spinning industry at the individual firm level and of the associated machinery import and internal adaptation and diffusion processes.

This effort inexorably leads us not only to examine the technological choices made within the Japanese spinning industry over time but to extend our scope, on the one hand, to contrasting the behavior of Japanese cotton spinning mills with those in India and, on the other, to examining rel-- changes in cotton weaving technology and the demand for more or less "appropriately" specified final goods. The why of this behavior patte in terms of different economic and non-economic conditions in the two countries over time is, of course, of the essence in terms of the broad-- relevance and meaningfulness of the particular experience under examination. While this research is essentially in the qualitative/historical mold, its purpose is to shed important additional light on contemporary LDC problems of technology choice at the micro level.

In Section A we briefly describe the "initial" (circa 1880) technological state of the arts in cotton spinning and weaving in both Japan and India. In Section B we analyze the important technology changes and adaptations which occurred rapidly in Japan during the 1880's but were substantially delayed in India. In Section C we attempt to move towards an explanation of this divergent behavior in terms of the differential environment facing entrepreneurs in the two countries.

A. Initial State of the Arts

When referring to the "state of the arts" we shall have in mind a broad definition in keeping with the basic hypothesis of this total research effort, i.e. that changes in the quality dimensions of intermediate inputs and of outputs may be crucial to the widening of the possible choices between the use of labor and capital. Accordingly, we note that prior to 1882

a) Mule spindles were in use almost exclusively in Indian cotton spinning; Indian mills used short staple local (Indian) cotton to produce 16-20 count yarn; the Japanese still produced part of their needs (60%) by traditional garabo or domestic hand-spun methods and imported the rest mainly in the form of 20 count yarn, from India. To the extent there was machine spun production this early the Japanese used mules almost exclusively.

b) Indian spinning was characterized by the use of a single shift (11 hours) and mostly male workers. Japanese machine spinning at that time was similarly characterized by the single shift and the predominance of male workers

c) With respect to the specification of the desired final (cloth) goods the Indian home market was interested in relatively wide or "strong" cloth; the domestic Japanese market was interested in relatively narrow or "warm" cloth with a relatively modest demand for the importation of Western-style wide cloth.

B. Technology Change and Adaptation

Major changes in the cotton spinning technology in use in Japan occurred during the 1880's. Unfortunately, the data available give us a picture only for the latter half of that decade capturing the impact of only the second of two major technological shifts, as will be indicated below. As Table 1 demonstrates, the changes which were initiated after 1885 may be characterized as efficiently labor-using in character. We have here a substantial decline in the capital-labor ratio, i.e. rather dramatic capital shallowing between 1886-1890 and 1891-95, combined with an equally marked decline in the capital-output ratio. Innovational intensity was clearly sufficient to provide an increase in labor productivity in spite of strongly labor-using bias of the technology changes adopted.[1] All of this adds up to a highly favorable outcome with respect to both output and employment objectives in a labor surplus economy context. It is, moreover, quite rare in the annals of LDC industrialization efforts and thus warrants our full attention.

The overall changes in technology in Japanese cotton spinning which occurred during the 1880's, partly as the result of major innovations, partly resulting from less spectacular adaptations, can be conveniently divided into two distinct sub-phases, i.e. changes associated with the then still predominant use of the mule (1882-1884), and changes associated

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[1] For an effort to decompose the contribution of innovational intensity and bias in the context of Japanese industrialization overall see J.C.H. Fei and G. Ranis, "Innovation Intensity and Factor Bias in the Theory of Growth," International Economic Review, May, 1965.

Table 1

The Japanese Spinning Industry: An Aggregative View

Year (average annual)	Capital (Average working spindles per day)	Labor (Operatives, male & female)	Output (yarn in kan per day)	Capital-Labor Ratio	Capital-Output Ratio	Labor Productivity
1886-90	148,516	5,992	7,887	24.8	18.8	1.32
1891-95	406,419	29,178	42,902	13.9	9.5	1.47
1896-1900	1,013,987	57,857	105,176	17.5	9.6	1.82
1901-05	1,296,471	67,840	120,256	19.1	10.8	1.77
1906-10	1,614,581	80,852	149,419	20.0	10.8	1.85
1911-15	2,331,236	109,228	242,847	21.3	9.6	2.22
1916-19	3,354,972	147,251	303,409	22.8	11.1	2.06

Source: Nippon Teikoku Tokei Nenkan (The Japan Annual Statistical Report) No. 10-40, Japan Cabinet Stat. Bur., Tokyo.

with the shift from mule to ring (1887-1889).

Turning to the first sub-period of this overall phased technological adjustment, i.e. 1882-1884, we find the following changes taking place:

a) Adoption of two shifts of 11 hours each in replacement of one such shift, implying an almost halving of the capital-labor ratio in the core spinning process. The simultaneous shift from water to the use of the steam engine as the main motive power provided greater reliability; together with the high level of electrification already achieved and the availability of sufficient supervisory personnel, it made this dramatic intensification of capital use possible. The labor force continued to be predominantly male at this point.

b) Shifts from a mostly 20 to a lower 12-16 count yarn production. Such lower machine-produced counts gradually replaced higher counts imported from India as well as produced at home and were better suited to the more "appropriate" (for Japan's cooler climate) narrow cloth requirments. The continued use of improved domestic hand-looms in the production of wide cloth (see below) was also facilitated by this shift.

c) Given the relative decline in both garabo hand-spun domestic yarn and of high count Indian yarn imports, an improvement in the traditional weaving technology, through the adoption of Batten and Jacquard-derived improvements on the traditional hand-loom. These improvements were characterized by the addition of a roller so that the difficult task of pushing

the shuttle back and forth by hand as the weft is carried through the warp was considerably eased and made more accessible to lower quality female labor. A second, even more important, improvement, pertaining to the Japanese version of the Batten, was the substitution of wood for the metal used in France. This cut capital costs by 50% and accommodated a lower count yarn, but, due to the resulting increased vibrations, a lower quality of cloth in the strength dimension but suitable for the greater warmth dimension associated with the narrow cloth, resulted.

In India meanwhile, although much of the international equipment was the same, such domestic technological adjustments were either totally absent or much slower in diffusing throughout the industry. With per capita income levels lower than Japan's and a labor surplus more extensive than Japan's we may note (see table 2) that we encounter here no similarly marked decline in capital-labor or capital-output ratios over the same period.[1] It is true that Indian mills did not become more capital-intensive over time as is customary in contemporary development contexts. What we have instead is capital widening associated with a virtual constancy in labor productivity, i.e. a standing pat, technologically speaking.

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[1]Note that since the units and definitions differ, the absolute values of Table 1 and 2 are not comparable. We are referring only to the trend differences within each.

Table 2

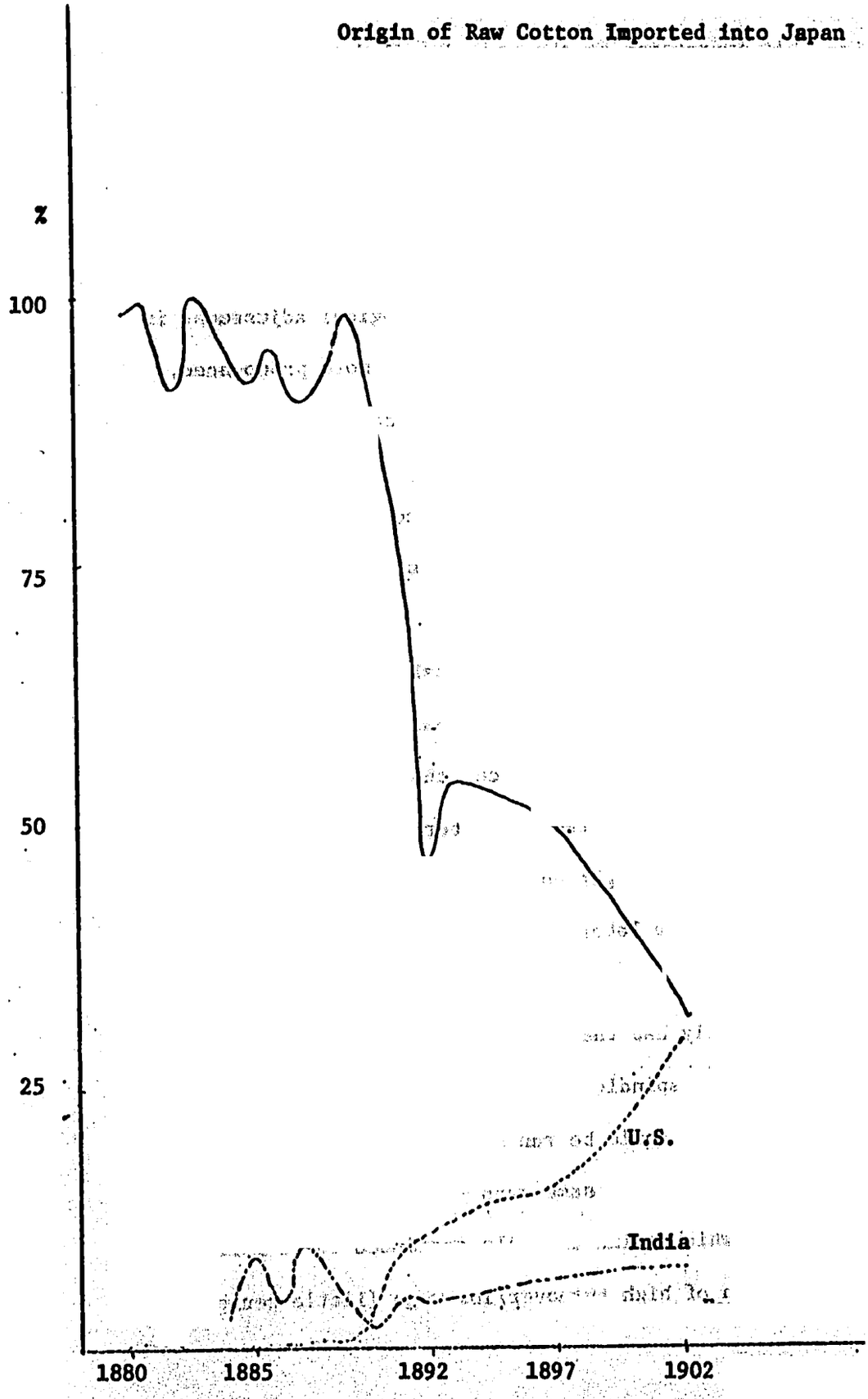
The Indian Spinning Industry: An Aggregative View

Years	Capital #spindles	Labor # workers	Output (yarn in millions of pounds)	Capital Labor Ratio	Capital Output Ratio	Labor Productivity
1895-1899	4,406,692	150,210	457.6	29.3	9,630	3.05
1899-1904	5,038,144	176,256	518.9	28.6	9.709	2.94
1904-1909	5,661,082	213,542	641.8	26.5	8,821	3.01
1909-1914	6,553,248	244,394	646.8	26.8	10,132	2.65
1914-1919	6,778,774	278,396	666.2	24.3	10,175	2.39

All figures are average annual.

Source: Report of the Indian Tariff Board (Cotton Textile Industry Enquiry) 1927 Vol. I p.94 & p. 233.

Chart 1



Source: 1888-82: "Gendai-Nihon Sangyo Haitatsu Shi" p.89
1883-02: T. Sanpei "Nihon Mengyo Hattatsu Shi" p.310

Reinforcing this impression at the more detailed or disaggregate level, we note the absence of changes equivalent to those taking place in Japan during the 1882-1884 period; the single shift was maintained in India as was the predominance of male workers. Not till after the turn of the century was the machine working day expanded to 15 hours.

In the wake of the second sub-period of technological adjustment in Japan (1887-1889) the Japan/India contrasts grew even more pronounced. Specifically, the following rather dramatic changes occurred in the Japanese cotton textile industry:

a) An almost total switch from mules to rings coupled with the maintenance of the 12-16 count yarn emphasis and of double-shifting.

b) A substantial increase in the amount of unskilled workers per machine as well as a decisive shift from male to female labor.

c) Associated with the mule-to-ring switch, the adoption of cotton mixing techniques which permitted a shorter (on the average) staple than it had been thought possible to be used on the ring machinery, with more labor to repair the additional broken ends.

The ring machinery clearly had the advantage of accommodating substantially more workers per spindle as well as requiring less brawn per worker. Moreover, the ring could be run at higher speeds, and again more labor intensively, for the same yarn count, up to a count of approximately 40, after which point the mule continued to be more efficient. Thus the pattern of high turnover/low wage (little seniority)

female labor could be increasingly adhered to (see Section IV). Moreover, the shift to cotton mixing, itself a labor intensive operation, made it possible to marry the use of the ring to a lower average staple and additional labor inputs. While cotton mixing had been employed elsewhere, the Japanese were able to avoid a substantial increase in average staple length accompanying the switch from mule to ring as a consequence of their own mixing technique innovations.

The English, for example, had established minimum average cotton staple lengths, inversely related to the yarn count, and somewhat higher for rings (both warp and weft) than for mules. We can show, for any given count, that the Japanese used average staple lengths considerably lower than what the English considered to be the absolute minimum. The overall pattern and volume of mixing carried on in Japanese mills over the years is demonstrated in Chart 1 in terms of the composition of raw cotton imports.[1]

The overall decline in the capital/labor ratio noted during this second period of technology change is thus mainly due to three factors the basic shift from mule to ring technology, the increased sophistication of cotton mixing, and the policy of machine speed-ups for given two-shift machinery use.

What is especially startling is the instantaneous character of the technology diffusion process which took place. Until 1887 mules held almost total sway in the production of the machine-made (non-garabo) yarn. Within one year the importation of additional mules-except for the small fine count yarn market-ceased completely. With the help of

[1] Given the competitive nature of the Japanese industry, the role of Boren, and the extremely rapid diffusion of changes in the state of arts, it is fair to assume that import ratios correspond reasonably well to average mill mixing practices.

some "convenient" fires which destroyed a substantial portion of the existing mule population a virtually instantaneous switch to rings can be recorded.[1]

In contrast, in the Indian cotton spinning industry the new ring technology was adopted and diffused much more slowly.

Table 3

Indian Spindleage (millions)

	1884	1894	1914	1923	1929	1939
Mules	2.0*	2.2	1.6	1.1	0.9	0.5
Rings	—	1.2	5.2	6.8	7.9	9.6
Total	2.0	3.4	6.8	7.9	8.8	10.1

Source: Compiled by Toru Yanagihara from Takamura, Kiyokawa and Pearse.

*Including throstles, thus an upper bound figure.

As Table 3 indicates, the number of rings did increase steadily and their adoption was viewed as the most significant technical development of th 1880's.[2] Nevertheless, twenty years after their first introduction 1 million or approximately 1/3 of the total spindleage was still in rings. Even more significant for our purposes is the substantial divergence in practice maintained in India, with the Tatas and other entrepreneurial Ahmedabad firms switching to rings, while less well connected Bombay and Bengal

[1] For more details, see G. Saxonhouse "A Tale of Japanese Technological Diffusion in the Meiji Period", Journal of Economic History, March 1974.

[2] See S. D. Mehta The Cotton Mills of India, 1854-1954.

mills lagged behind.[1] Platt's records indicate that between 1883 and 1900 2 million new mules were exported to India--a figure which we are unfortunately not able to check against Indian data. This period is also characterized by the entry of substantial numbers of new and inexperienced entrepreneurs tending to construct mills rather slavishly on the older U.K. model. Mules and male labor were retained here. Cotton mixing while obviously practiced[2], was viewed rather traditionally, i.e. in association with the avoidance of a higher average staple as the switch from mules to rings occurs. In the absence of the same technology bundle, which consisted of judicious cotton mixing cum additional labor cum shift to females, it was apparently believed that the predominance of the short staple Indian cotton required substantial retention of the mule.

With respect to weaving, the Japanese industry continued to concentrate on the lower counts/narrow cloth portion of the spectrum, with improvements patterned on the Batten and Jacquard permitting the hand loom technology to survive. In reference to the initially small market for Western style wide cloth, moreover, imports were gradually being replaced by domestic power loom production. This is where import substitution was most clearly in evidence. Here again, if over a somewhat longer period of time, important labor-using innovations were in evidence. The combination of the adoption of a lower

[1]Even much of the Tata replacement was of old throstles rather than modern mules. See a Tata letter of August 31, 1888 to the Bombay Millowners Association, "the [ring frames] are now steadily replacing the old throstles in many mills, and even the mules in certain cotton factories..." D. E. Wacha; The Life and Life Work of J.N. Tata, Madras, 1915. p. 93.

[2]The Victorian Jubilee Technical Institute, established in 1882, provided formal technical education, including on cotton mixing. Mehta (op. cit.) has an illustration of a lecture on mixing given in 1896.

warp/weft ratio with a lower weft/yarn count ratio--for essentially the same definition of final product--resulted in successful, i.e. cost effective, import substitution plus the beginnings of export substitution into Chinese, Indian and U.S. markets.[1] Unfortunately, we were unable to obtain separate data for spinning and weaving operations in Indian mills, in particular with respect to labor.

We intend to examine below the approximate causes of this differential behavior with respect to technology choice and change. Longer term trends in the pattern of development of the cotton textile industry in Japan, while they are not central to our objectives here, would similarly yield to the same type of causal analysis. Some of these longer term changes may be summarized as follows:

1) Given that the "warmth" characteristic of cloth is an inferior good, a gradual reversal, with higher per capita incomes, of the domestic markets' preferences for the lower yarn count/narrow cloth attributes should be expected. While export markets in the developing countries of the region continue to be characterized by lower counts and lower

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[1] There were additional lower density/increased sizing types of technology change, unique to Japan, which kept the weight the same but reduced costs by saving raw cotton.

quality cloth, this becomes less and less true over time of the Japanese domestic and other foreign markets

b) In cotton mixing we may note a tendency towards a gradually higher average staple quality, but at a much slower rate than would have taken place in the absence of the adoption of the initial bundle of technology change

c) Near-constancy in the low male/female labor ratio but with a gradual increase in the skilled and supervisory to unskill labor ratio followed.

d) The increased use of power looms to serve both the domestic market and, with time, the higher income export markets can observed. These are phenomena to be anticipated as Engel's Law combined with the Linder thesis of representative demand makes itself felt.

C. An Attempt at Explanation

In the previous section we have described the interestingly divergent behavior pattern of the Indian and Japanese cotton textile industries. With Platt's of London providing much of the technical information and advice, and virtually all the machinery in the case of Japan, how can we explain the observed behavior: India only gradually abandoning her mule/skilled-male-labor/one shift technology, and Japan moving through two distinct phases of marked technological change. A number of hypotheses present themselves in culling the general

literature on the subject. While it is necessarily difficult, if not impossible, to come up with any single fully satisfactory causal explanation of this interesting set of historical phenomena, our objective here must be to arrive at the best possible approximation.

There exists a considerable literature stressing the importance of cultural differences between the two settings.[1] Emphasis is placed, for example, on poor Indian work habits, long, irregular tea breaks etc.--as opposed to the more highly disciplined, harder working Japanese. Visiting Japanese missions also made much of the ennervating influence of Indian weather conditions, while Indian writers stress the low level of labor productivity associated with low levels of nutrition and health. The much lower proportion of female labor in the case of India is, moreover, related to the much greater reluctance of both Muslim and Hindu women to enter the labor force. And finally, the unwillingness to go to double shifting is blamed in large part on the unreliability and individualism of the Indian worker when contrasted with his more disciplined and cooperative or community-oriented Japanese counterpart. Such differences in the inherent quality of unskilled labor would be enough to constitute a relative bias in favor of capital-intensity (and thus the longer retention of mules) in the case of India.

Economists have a natural tendency to discount this type of explanation. Undoubtedly, their disregard of social, cultural and geographic

[1] See for example, Yukihiko Kiyokawa "Technology and Formation of Markets in the Indian Cotton Textile Industry", for some of the leading references.

factors goes too far--especially since the danger of keeping institutional *ceteris paribus* conditions in check are larger in the developing economy context. Nevertheless, to the extent that differential technology choice and innovative behavior can be explained by differences in the economic environment facing the individual entrepreneur, the effort should be made to do so--even if some of the dimensions of that environment considered are non-conventional in character.

Even though such comparisons are always risky, India's per capita income in 1880 was probably somewhat lower than Japan's. Moreover the endowment of unskilled labor relative to capital likewise indicates a more severe relative surplus of labor in India. Why then do we find a greater responsiveness in terms of labor-intensive technology choices statically and labor-using technology change dynamically in Japan? There are clearly at least two parts to the answer: first, that the relative market prices of factors in India did not represent as true a reflection of relative factor availabilities as in Japan; and second, that the overall access to information and capital, coupled with the competitive pressure to seek out the best technique and the best direction of technology change, were much more pronounced in Japan than in India. Let us examine each of these dimensions in turn in somewhat greater detail.

In Japan wage levels in the textile industry were very much tied to the low renumeration of unskilled labor on the land. All the available evidence indicates that renumeration was set at some relatively narrow margin above subsistence, with spinning mill wage rates varying

mostly in relation to the opportunity cost of the relevant agricultural hinterland.[1] The "overall" supply curve of labor may thus be viewed as composed of a series of perfectly elastic segments with important local monopsony characteristics. Indian wages were generally 10% to 15% lower than their Japanese counterpart at the outset. When we next look at the ratio of capital goods prices to the wage index over time, (available since 1887, see Table 4) we note that the relative price of capital was on the rise in Japan during the 19th century; and when we examine similar--if more sketchy, less trustworthy--evidence for India we find the opposite result to be holding. Yet we know that, at the margin, savings rates were higher and population growth rates lower in Japan. We may thus conclude that, for a number of reasons, the relatively more abundant endowment of unskilled labor in India--and probably increasingly so, relative to Japan--was not permitted to be "heard" in the same way. One reason was the greater volume of government and other interventions in the Indian case. Labor organizations and strikes, for example, imitations of the U.K. mother country, were not discouraged early on in sharp contrast to the Japanese case. There is evidence of much more credit rationing in India--usually associated with artifically low interest rates in official markets. The imperial trading system within which the Indian textile industry was assigned a colonial role encouraged the import of U.K. final goods, assigned particular export markets to it, but mainly

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[1] Also see our evidence below (Section IV) dealing with the characteristics of the Japanese cotton labor force in detail.

TABLE 74—RELATIVE FACTOR PRICES

	Capital Goods Price Index[a] (1928–32=100)	General Wholesale Price Index[c] (1928–32=100)	Capital Goods Price Index Deflated by the General Price Index (1928–32=100)	Money Wage Index[d] (1928–32=100)	Cost of Living Index[e] (1928–32=100)	Real Wage Index (1928–32=100)	Ratio of Capital Goods Price to Money Wage Index	Ratio of Rea Capital Goods Price to Real Wage Index
1887	29.5[b]	32.2	91.6	11	—	—	2.68	—
1888–92	33.4	37.1	90.1	12	—	—	2.78	—
1893–97	43.7	41.7	105.0	14	32.8	42.7	3.13	2.46
1898–02	59.1	53.1	110.1	18	44.1	40.8	3.28	2.70
1903–07	63.8	63.5	100.4	19	50.5	37.6	3.35	2.64
1908–12	65.0	68.5	95.0	27	55.8	48.4	2.41	1.96
1913–17	89.9	81.2	110.7	29	60.4	48.0	3.10	2.31
1918–22	170.2	150.4	113.0	74	119.3	62.0	2.30	1.82
1923–27	148.1	139.6	106.0	108	118.3	91.3	1.37	1.16
1928–32	100.0	100.0	100.0	100	100.0	100.0	1.00	1.00
1933–37	100.1	107.4	93.2	93	98.8	94.1	1.08	.99

[a] *Hompo Keizai Tokei* (Economic Statistics of the Bank of Japan), annual. Also see Shozaburo Fushino, *Senzen Ni Okeru Shihonjikeisiki* (Capit Accumulation in Japan in the Prewar Period), (Tokyo, 1955), Appendix II. Converted from an October 1900 bas

[b] Available from 1887 only.

[c] As developed by Ohkawa at Hitotsubashi University.

[d] Yuzo Yamada, *Nippon Kokumin Shotoku Suikei Shiryo, op. cit.*, p. 154.

[e] Tsutomu Noda, "Meiji Iko Seikei Shisu No Suikei" (An Estimate of Cost of Living Indices in Japan, 1893–1954), *Econ. Rev.*, Apr. 1955, VI, 10. Converted from a 1934–36 base.

supported the expansion of the domestic market. Japan was equally constrained in its pursuit of an import substitution policy, thanks to the imposition of the Unequal Treaties System which limited tariff levels to 5% until late in the century. But the relative absence of direct interventions by such units as the East India Co. greatly facilitated the shift to a competitive market-oriented export substitution strategy at that point.[1]

For a comparison of the two countries' textile tariff schedules during that period, see Charts 2 and 3. We may note that, certainly by contemporary LDC standards, tariff protection was extremely low in both industries and both countries, especially the early period. Given the near uniformity of the nominal rates for both the final and intermediate good, the effective protection of cloth can be assumed to be close to the nominal. To the extent, therefore, that import substitution was "milder", i.e. less distoring, in Japan this was due more to differences in non-tariff barriers or direct interferences as between a colonial and a non-colonial context.

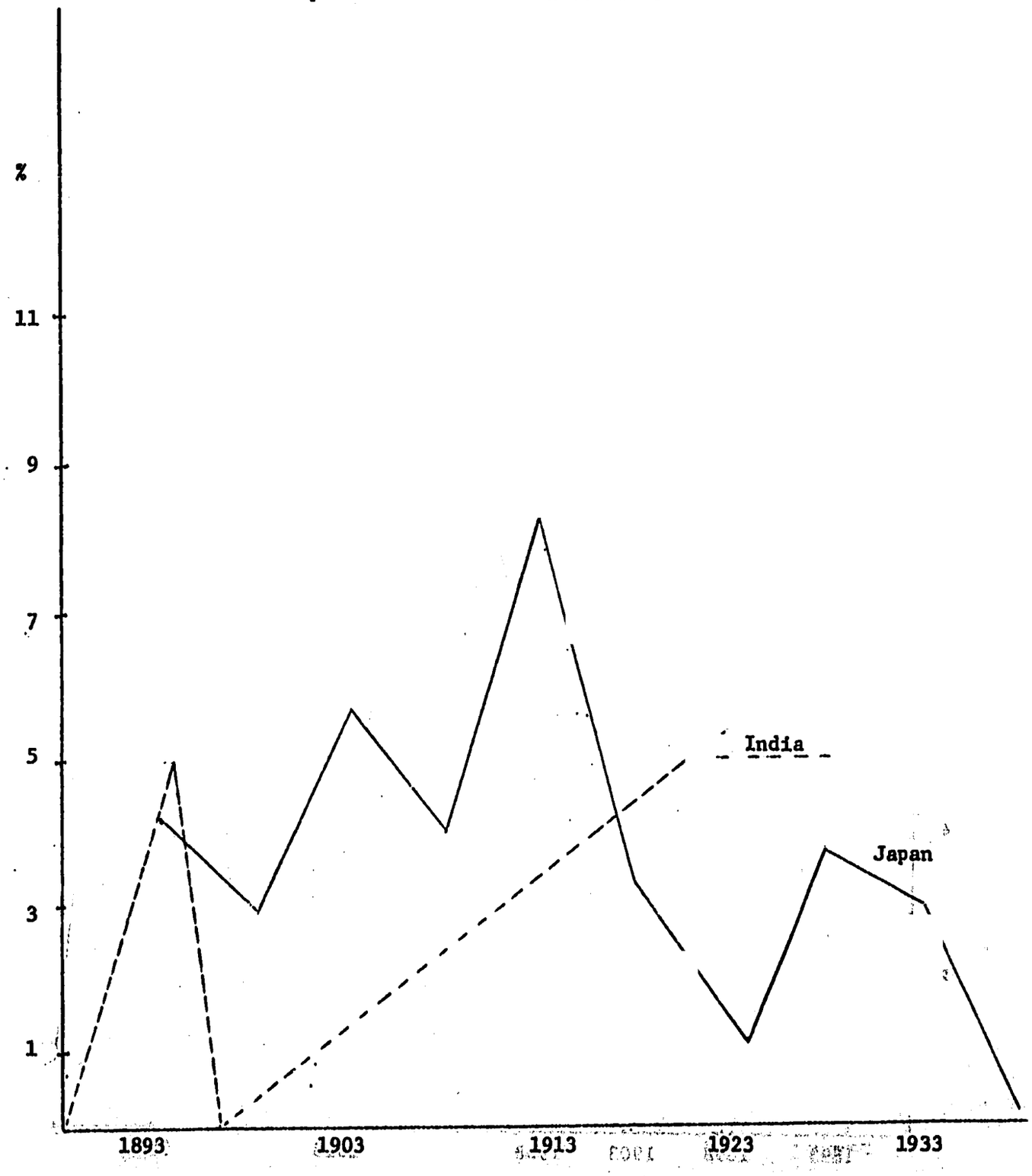
For example, in addition to the effects of a substantial divergence in the overall level of factor price distortions, the contrast in the extent of overall competitiveness of the two industries is quite marked. Japanese cotton spinning was characterized by relatively free entry and the almost instantaneous diffusion of technical information via Boren

[1]See Baba and Tatemoto "Foreign Trade and Economic Growth in Japan: 1858-1937" in Economic Growth: The Japanese Experience Since the Meiji Era, L. Klein and K. Ohkawa, editors, 1968.

Chart 2

Japan and India

Comparison of Tariffs on Cotton Yarn

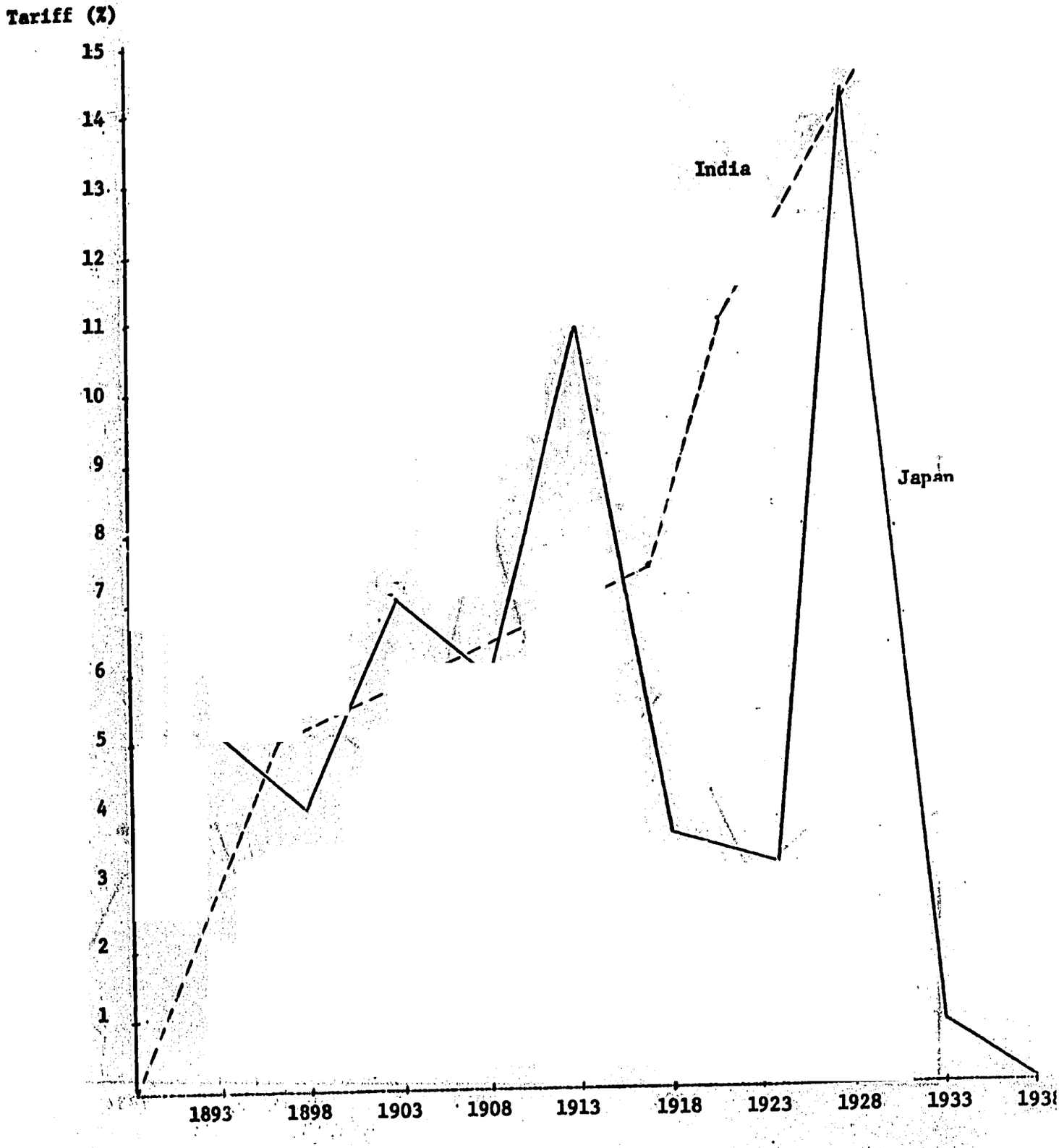


Source: Indian Textile Journal, (ed). Centenary of the Textile Industry in India (1954) p. 685; Yamazawa, Ippei "Industrial Growth of Trade Policy in Prewar Japan" Developing Economies XIII-I (March 1975) p. 62.

Chart 3

Japan and India

Comparison of Tariffs on Cotton Fabrics



Source: Indian Textile Journal (ed) Centenary of the Textile Industry in India (1954) p. 685 and Yamazawa, Ippei "Industrial Growth of Trade Policy in Prewar Japan" The Developing Economies XIII-I (March 1975) p.62.

(the Japanese Cotton Spinners' Association). Profit maximization can be said to have been a good approximation to reality.

Indian mills, on the other hand, were mainly established under the so-called managing agency system. The principal function of such system seems to have been to obtain the necessary financing and to contract out the actual management of the productive enterprise. The Indian founders of the industry, such as Tata, could escape the credit bind by financing their own expansion out of reinvested profits. They also managed their own mills and have a record of relatively greater receptivity to new ideas. The British managing agents on the other hand, customarily represented the great merchant houses and were in a position to alleviate the credit shortage among individual would-be Indian mill operators. The managing agency system was thus based largely on the initial unavailability of sufficient numbers of domestic investors willing to go into industrial ventures in the absence of British capital. Consequently the participation of the British managing agent who at first was an industrial pioneer, later a promoter and still later only an intermediary was often required in order to mobilize the necessary capital within India. But the price in thus effecting a deep schism between management and ownership was high. The managing agent became typically less and less well equipped technically and, even more importantly, his renumeration was not adequately related to the net profitability of the enterprise. Management commissions were at first calculated on the basis of production targets, later on the basis of gross profit before depreciation, both certainly biased indices in terms of normal profit maximization related signals.

As a consequence, many Indian textile firms may be accurately characterized as following a satisficing rather than maximizing pattern of behavior. In the absence of a sufficiently large class of indigenous industrial entrepreneurs guiding the future of their own enterprises the drive to "build a better mousetrap" or at least adapt one was clearly missing. What we have here is another, this time historical, example of the possible consequences of a managerial preference for "the quiet life".

The overall quantitative consequence of this difference in the economic and institutional environment in the two country cases is illustrated both by the relative lag in the adoption of the new ring technology in the case of the Indian spinning industry[1] as well as, more broadly, by the lower level of labor intensity at the outset and the lower tendency to use more labor effectively at the margin in India. We have already noted the evidence of capital shallowing, i.e. a substantial actual decline in the capital-labor ratio, in Japanese spinning between 1886 and 1895, with a gradual reversal thereafter when the pressure at the margin of relative endowment and relative factor price changes began to reverse itself.[2] Virtually constant levels of capital-intensity from initially higher levels (see the Tables 1 and 2)have been recorded for the case of India

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[1] Kiyokawa characterizes the shift from mule to ring spindles as "incredibly slow"(see his Technology and the Formation of Markets in the Indian Cotton Textile Industry, op. cit. April, 1976.

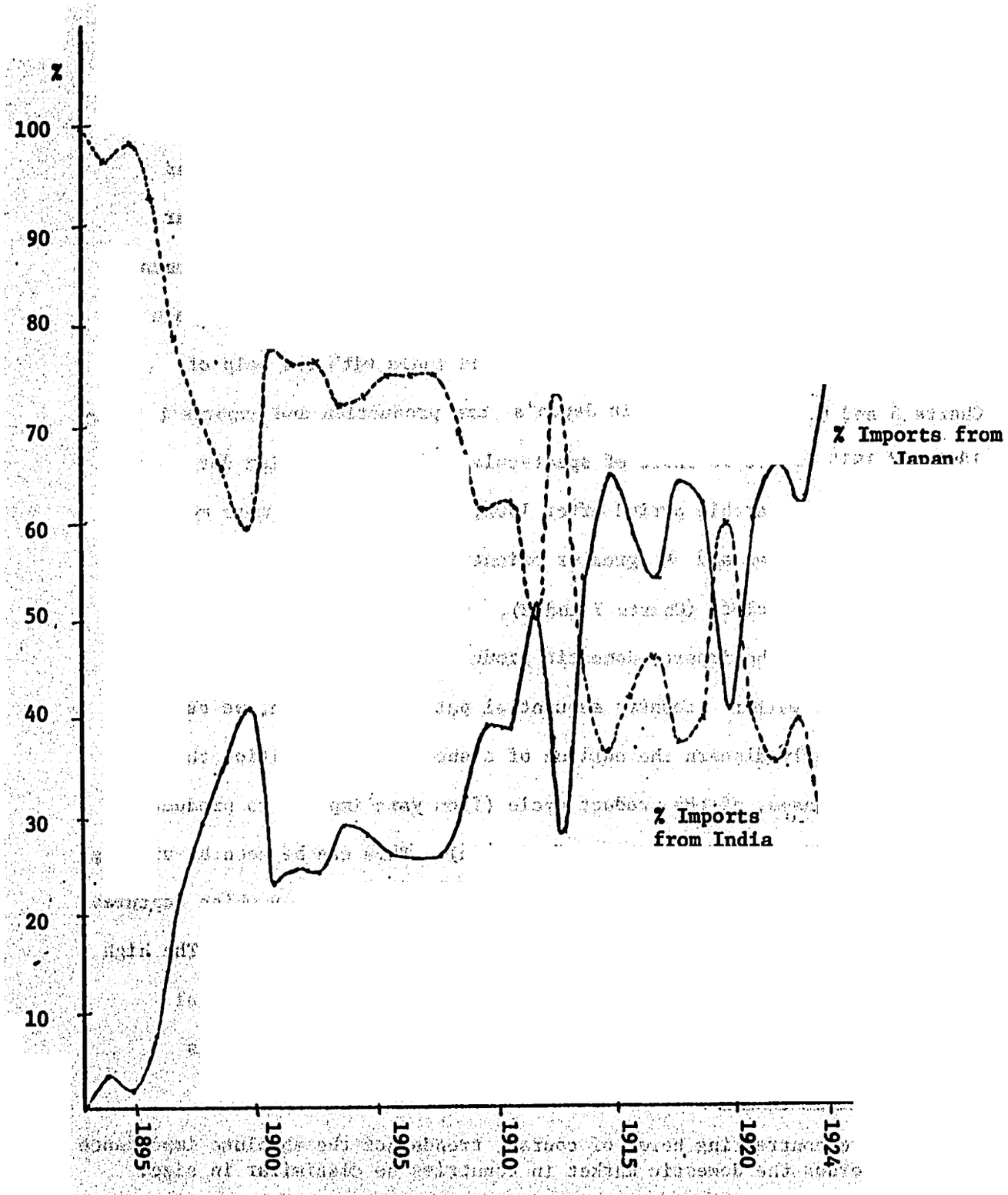
[2] See G. Ranis, "Factor Proportions in Japanese Economic Development American Economic Review, September, 1957.

he broader repercussions of this differential performance with respect to technology choice at the micro level can, of course, be discerned in a number of ways. For one, we can see Japan's much greater success in the expansion of, first, competitive yarn, then cloth exports. This is demonstrated most forcefully in terms of the marked displacement of Indian by Japanese cloth yarn exports in a particular important third market, such as China (see Chart 4). The same phenomenon can be seen more generally when we contrast the trends in cotton yarn imports, production and exports in Japan and India with the help of Charts 5 and 6. The spurt in Japan's yarn production and exports betwee 1890 and 1915 is little short of spectacular, while the Indian data, at least for the comparable period after 1902, indicate a much more modest growth of production and a greater orientation to the domestic market. Turning to cotton cloth (Charts 7 and 8), we see the same contrast, a bit delayed, in the import, domestic production and export patterns.[1] Looking at the within country sequential pattern for Japan, we can moreover, clearly discern the outline of a successful transition through the various phases, of the product cycle (from yarn imports to production to export and ditto, with a delay, for cloth). This can be seen by viewing Charts 5 and 7 together, as well as with the help of Chart 9 which captures the pattern of development in this important industry over time. The high level of technological flexibility at the individual entrepreneurial level which will be demonstrated more fully in the next section was

[1] We are contrasting here, of course, trends, not the absolute importance of trade versus the domestic market in countries so dissimilar in size.

Chart 4

Breakdown of China's Major Yarn Imports



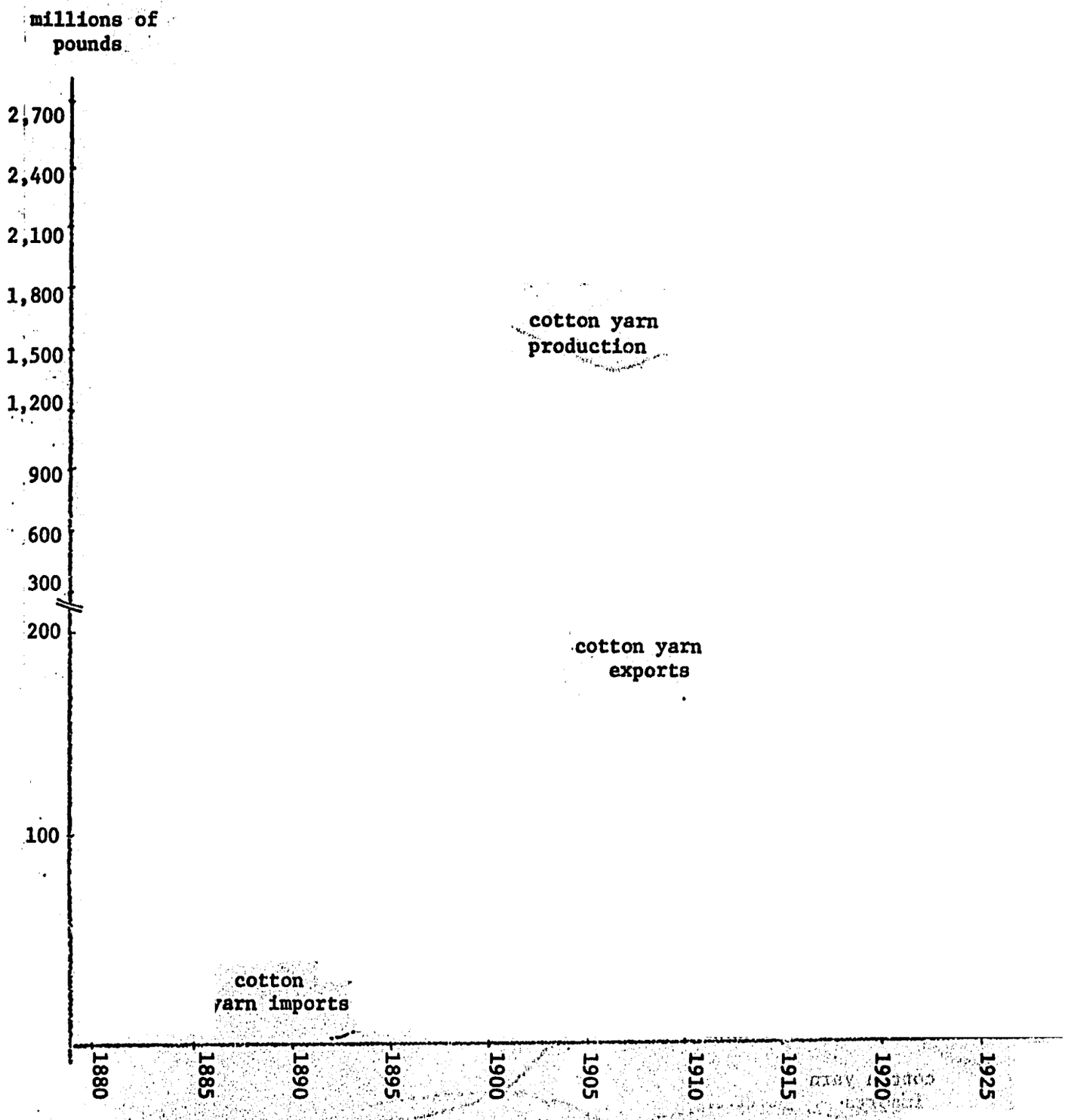
Source: Report of the Indian Tariff Board (1927) p.96.

Chart 5

Japan

Production, Imports and Exports of Cotton Yarn

(5 year moving average)



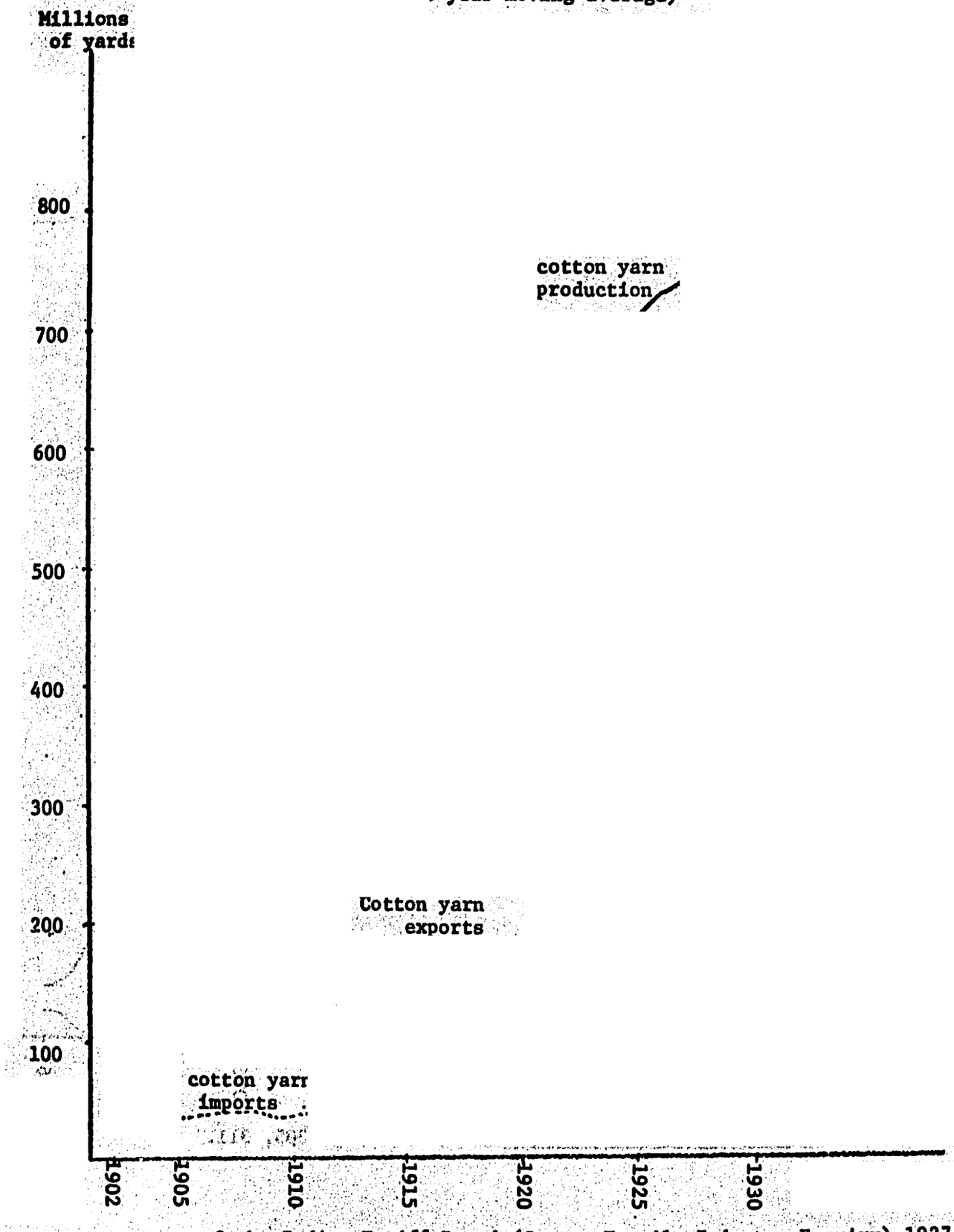
Source: Seki, K., The Cotton Industry of Japan (Tokyo:1956) p. 305, 311

Chart 6

India

Production, Imports, and Exports of Cotton Yarn

5 year moving average)



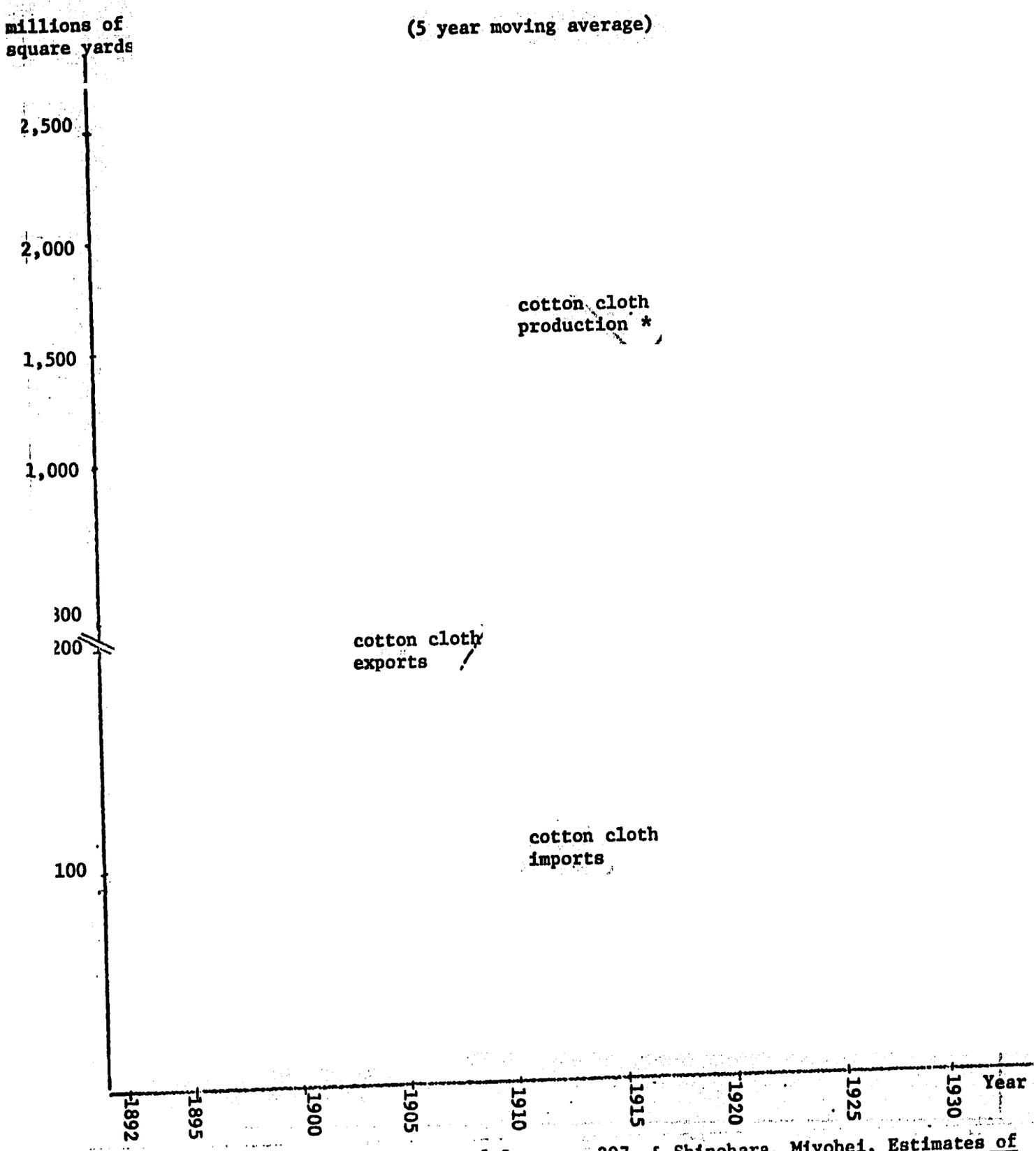
Source: Report of the Indian Tariff Board (Cotton Textile Industry Enquiry) 1927, 1932.

Chart 7

Japan

Production, Imports and Exports of Cotton Cloth

(5 year moving average)



Source: Seki, K., The Cotton Industry of Japan p. 307, & Shinohara, Miyohei, Estimates of Long-term Economic Statistics of Japan Since 1868 (Vol. 10:Mining and Manufacturing, 1972

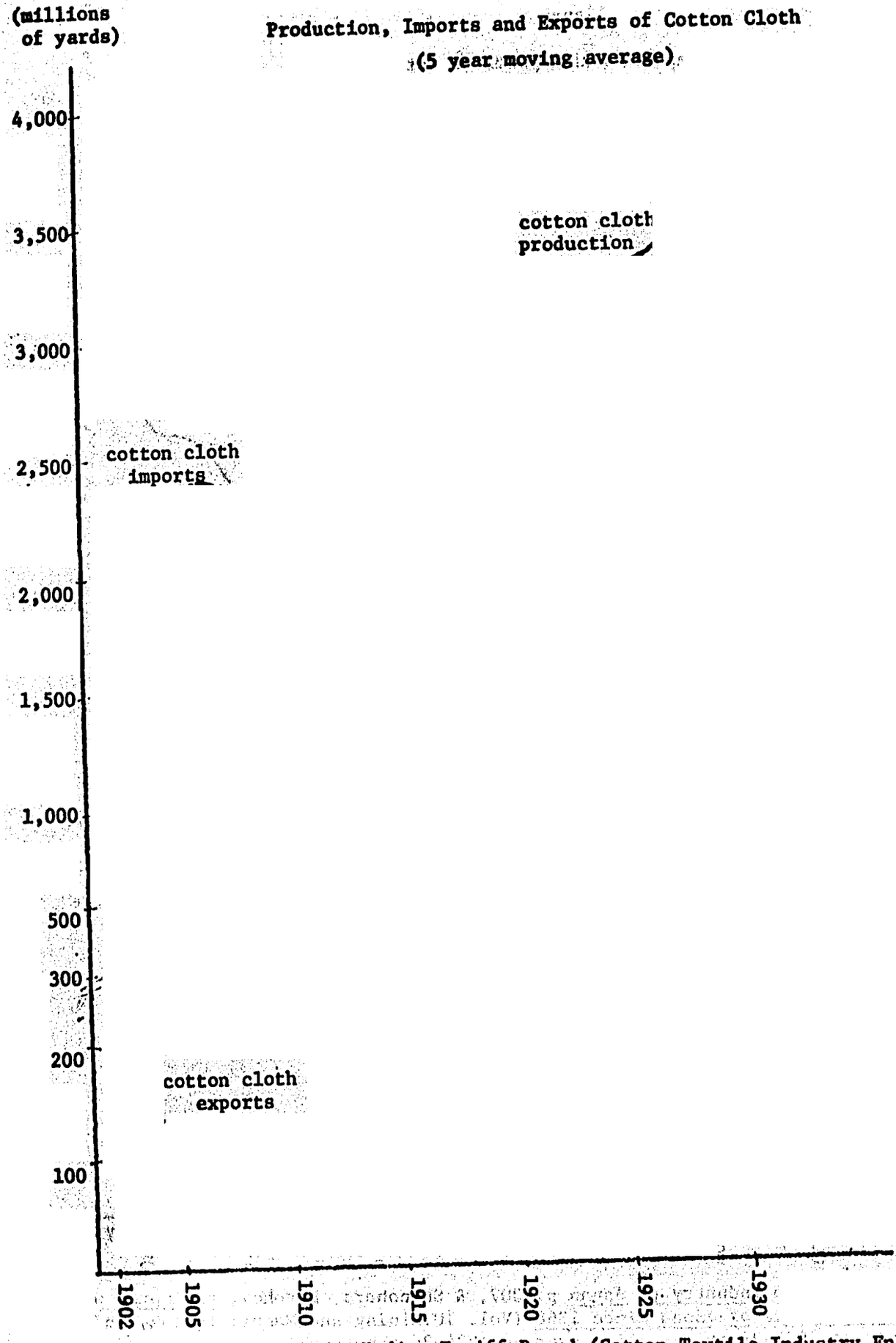
*computed from constant 1934-36 prices using average 1934-36 export price.

Chart 8

India

Production, Imports and Exports of Cotton Cloth

(5 year moving average)



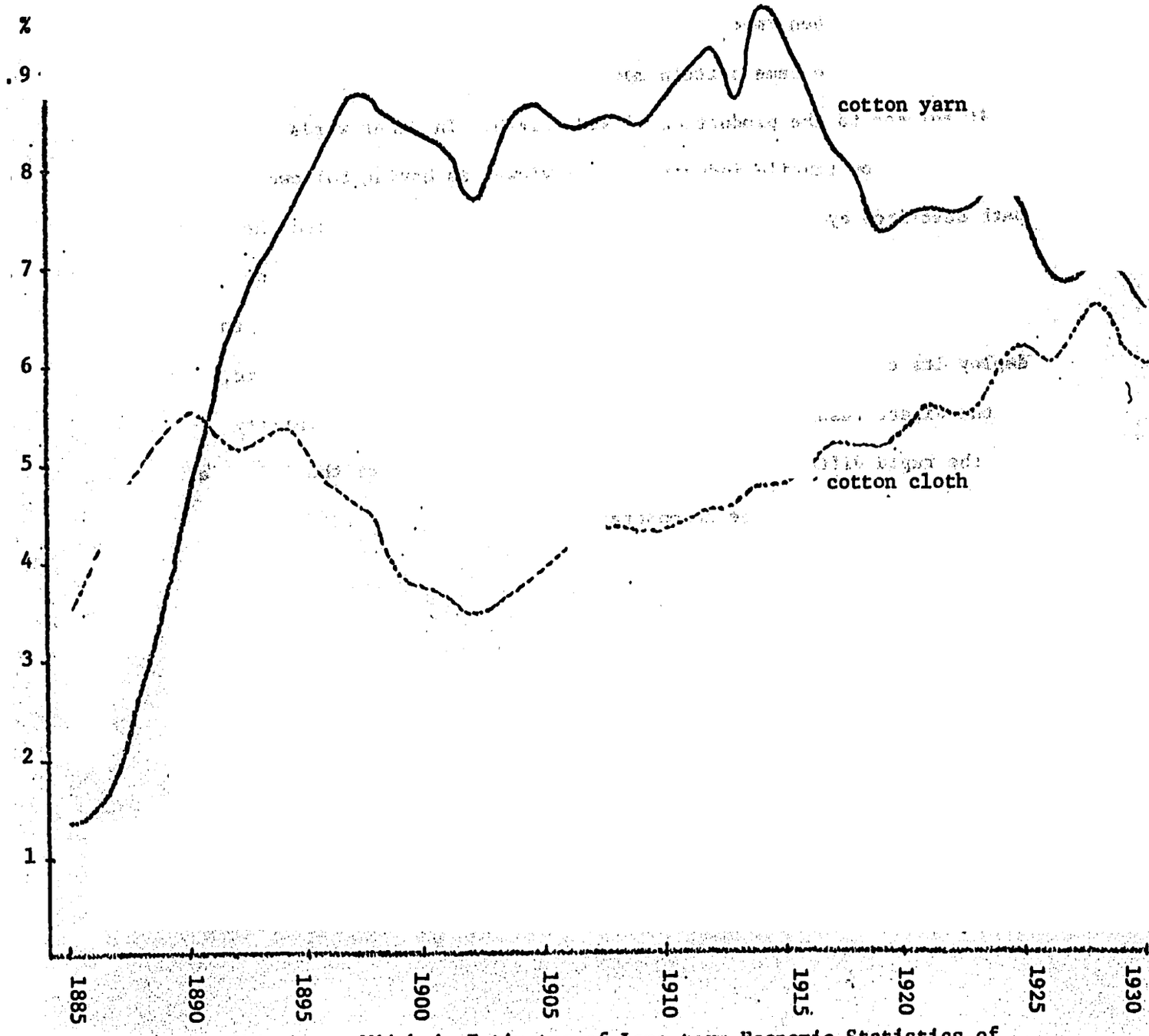
Source: Report of the Indian Tariff Board (Cotton Textile Industry Enquiry) 1927, 1932.

Chart 9

Japan

Production of Cotton Yarn & Cotton Cloth
As Percent of Total Manufacturing Productic

(5 year moving averages)



Source: Shinohara, Mijohei, Estimates of Long-term Economic Statistics of Japan Since 1868 Vol. 10: Mining & Manufacturing Toyo Keizai Shinposha (1972: Tokyo).

responsible in large part for the system's success in effectively deploying its changing comparative advantage in this fashion over time. In the dynamic case it is clearly such technological flexibility at the individual entrepreneurial level which permitted Japan to transit smoothly through various phases of the product cycle as far as the cotton textile industry is concerned. As indicated in Charts 5 to 8, Japan was initially a net importer of cotton yarn (abstracting for the moment from quality differentials), then import substituted, and finally became a sizable net exporter. The same pattern may be observed in weaving, especially as it relates to the production of wide cloth. In other words, the Japanese cotton textile industry can be viewed as having followed a path described by the product cycle theorists, something which the Japanese themselves have long called the "flying geese" pattern of industrialization. Such a pattern, permitting an economic system to deploy its changing comparative advantage effectively through time, is the direct result of the high level of technological flexibility and the rapid diffusion of new technology at the level of the individual entrepreneur, which will be demonstrated below.

III. Output Quality, Input Quality, Resource Saving and Labor Absorption

A. Introduction

Economists usually neglect the quality dimensions either on th input or the output side when dealing with technology choice. The assumption of homogeneity in these dimensions considerably simplifies the analytical apparatus, so much so that when evidence on differences in quality cannot be ignored, an attempt is made to homogenize the output index, using price or, as in cotton spinning, yarn count as the converter.

Quality variation, either in output or in the use of primary or intermediate inputs, may occur unintentionally, as in the absence of quality control, or intentionally, as in the effort to import from a different source or supply a different market. Especially adjustments to such planned variations in input or output quality may be accompanied by substantial variations in the quantities of the primary factors, capital and unskilled labor, which can be efficiently deployed.

A single product with many characteristics may fulfill a variety of needs. In the same way that technology developed in advanced countries is often inappropriate for the LDC factor endowment, many of the characteristics built into particular products by advanced countries may be inappropriate for LDC's incomes, real consumption preferences and othe conditions.[1] The shedding of inappropriate product characteristics,

The analytical implications of this view of consumer demand were first taken up systematically in K. Lancaster, "A New Approach in Consumer Theory," Journal of Political Economy, 74 (April 1966), 132-5(An early explicit application of Lancaster's work to LDC's appears in F. Stewart, "Choice of Technique in Developing Countries," Journal of Development Studies, 9 (October, 1972), 99-121.

by itself, can represent a significant resource saving for LDC's. Additional social saving can be achieved if a downward adjustment in quality also means using a production process which uses more of LDC-abundant inputs.

If products may be usefully viewed in terms of their quality characteristics, the same is true for inputs. Unlike product attributes, it has long been understood that input attributes are most important for interpreting manufacturing phenomena in LDC's in general and in particular the disappointing contribution of the industrial sector to employment growth. As early as 1957, Hirschman argued that capital may not be the only scarce factor of production in LDC's and that capital-labor choices have to be made with consideration for scarce managerial talent.[1] With a somewhat different slant on the same general problem, Gerschenkron, writing even earlier, observed that the stable, reliable, disciplined labor force required by industrialization was not the kind found in abundance by most late developing countries and that therefore capital-intensive industrialization strategies were not inappropriate.[2] For all the importance of these early insights, there has been curiously little work done within the LDC's to test them or equally cogent alternative hypotheses. What little work has been done on these topics

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[1] A. Hirschman, The Strategy of Economic Development (New Haven, Connecticut: Yale University Press, 1958).

[2] A. Gerschenkron, "Economic Backwardness in Historical Perspective" in B. Hoselitz (ed.), The Progress of Underdeveloped Countries (Chicago: University of Chicago Press, 1952).

anywhere has been inconclusive. A 1968 study using international data supported Hirschman's and Gerschenkron's finding that higher quality labor is complementary with unskilled labor and a substitute for capital.[1] By contrast, a more recent study using exclusively American data finds skilled and unskilled labor to be highly substitutable and skilled labor and capital to be highly complementary.[2] These most recent findings do challenge what is now the conventional, if untested, wisdom on the subject for the LDC's.

This section will examine the relationship between technology choice and the various dimensions of input and output quality in LDC's by analyzing the historical experience of the Japanese cotton textile industry.[3] Using market generated data, it will be shown that there exist tradeoffs among a variety of quality dimensions of the commodity cotton cloth and that these tradeoffs are closely related to the demand for inputs of varying

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[1] M. Yahr, "Human Capital and Factor Substitution in the CES Production Function" in P. Kenen and R. Lawrence (eds.), The Open Economy (New York: Columbia University Press, 1968).

[2] E. Berndt and L. Christensen, "Testing for the Existence of a Consistent Aggregate Index of Labor Inputs," American Economic Review, 64 (June, 1974), 391-404.

[3] Some historical background and analysis of the Japanese cotton spinning industry can be obtained from G. Saxonhouse, "A Tale of Technological Diffusion in the Meiji Period," Journal of Economic History 36 (March, 1974), 149-165; G. Saxonhouse, "Country Girls and Communication Among Competitors in the Japanese Cotton Spinning Industry" in Hugh T. Patrick (ed.), Japanese Industrialization and Its Social Consequences (Berkeley, California: University of California Press, 1976); G. Saxonhouse, "Productivity Change and Labor Absorption in Japanese Cotton Spinning 1891-1935," Quarterly Journal of Economics, 91 (May, 1977), 195-219; and G. Ranis, "Factor Proportions in Japanese Economic Development," American Economic Review, 47 (September, 1957).

scarcity and quality. The nature of the tradeoffs among these inputs of varying quality will also be identified.

The Japanese textile industry created a range of cotton cloth products which were of lower quality than had been generally hitherto manufactured in India, Europe, and America, but which were well suited to East Asian markets and to the demands of the lower income classes elsewhere. The Japanese were successful in profitably producing this cloth, in large measure because they creatively explored the complementarity and substitution possibilities between varying grades of raw cotton and between varying grades of labor. They became capable of producing cotton cloth of a particular quality using lower quality raw cotton and lower quality labor than had previously been thought possible or desirable.

In the sub-section which follows, the analytical framework for examining the choice of output quality and input mix will be presented. A third sub-section will discuss the data to be used in the estimation of this framework. A fourth will present a regression analysis explaining the pricing between 1906 and 1935 of various brands of Japanese cotton cloth in terms of their quality attributes. This analysis will identify the implicit market evaluation of these various attributes. In the fifth sub-section these estimated implicit attribute prices will be used to help estimate the derived product attribute supply functions and derived input demand functions. With this estimated framework it will be possible in a final sub-section to explore in some detail the relationship between technology choice and the various dimensions of input and output quality in Japan's pre-war cotton textile industry.

B. The Analytical Framework

Assume Japanese textile firms between 1906 and 1935 maximized a variable profit function of the following form:

$$(1) \quad \Pi(P; -X) = \sum_{i=1}^{I} \sum_{j=1}^{I} \sum_{j-1}^{I} a_{ij}(1/2P_i^{\,2} + 1/2P_h^{\,2})^{1/2} X_j$$

$$+ \sum_{i=1}^{I} \sum_{j=1}^{J} c_{ij} P_i X_j + \sum_{i=1}^{I} \sum_{j=1}^{\breve{}} \sum_{j=1}^{\breve{}} b_{jk} X_j^{\,1/2} X_k^{\,1/2} P.$$

where $P \equiv$ vector of prices of variable outputs and inputs

$X \equiv$ vector of fixed inputs

$\Pi \equiv$ profit operator

and where $a_{ih} = a_{hi}$, $b_{jk} = b_{kj}$, $a_{ii} = 0$, $b_{jj} = 0$.

The variable profit function Π gives us the maximum profits the firm can obtain, allowing a subset of inputs and outputs to be variable while another subset of inputs is held fixed.[1]

[1]The concept of a variable profit function is first presented in P. Samuelson, "Prices of Factors and Goods in General Equilibrium," Review of Economic Studies, 21 (1953-54), 1-20. W. Gorman in "Measuring the Quantities of Fixed Factors" in J. Wolfe (ed.), Value, Capital and Growth (Chicago: Aldine Publishing Company, 1968), rigorously determined many of its properties. The profit function's use in econometric work is presented in W. Diewert, "Functional Forms for Profit and Transformati... Functions," Journal of Economic Theory (1973). Econometric work using profit functions is most analogous to Nerlove's early work with cost functions. In "Return to Scale in Electricity Supply" in C. Christ et al. (eds), Measurement in Economics (Stanford, California: Stanford University Press, 1963), Nerlove solves for the derived demand for input functions from the first order conditions of cost minimization and the production function. He then substitutes these derived demand equations into the definition of total costs to obtain a cost function where cost

The form of the profit function in (1) is such that if Π is differentiated with respect to the prices of output and variable inputs, then for positive prices and positive values of the fixed inputs the solution to (2)

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is a function of fixed output and the prices of the variable inputs. Nerlove notes in 1963 that no one seems to have done this before. Had Nerlove used the definition of profit and the first order conditions for profit maximization, he would have anticipated later econometr ork with the profit function.

Given that firms are making both a quantitative and qualitative choice with respect to output, the optimization problem here is slightly different from what is routinely encountered. Solution to the problem begins by forming a cost function with quantity, quality of output and factor prices of inputs as arguments. This function may be derived by minimizing input costs subject to production function constraints relating quantity and quality of output and inputs. The resulting cost function is used as data by the profit maximizing firms in choosing the optimal quality and quantity of output. In this context note that firms are competitors and not monopolists even though the marginal costs of attributes are not constant because all establishments observe the same prices and cannot affect them by their individual production decisions: price is independent of quantity. The firm will make a decision on the optimal quality and quantity of production by adding attributes until the marginal revenue from additional attributes equals their marginal cost of production per unit sold and by increasing quantity of production up to the point where unit revenue equals marginal cost evaluated at the optimal bundle of attributes. The first order conditions from this profit maximization problem can be solved for amounts of the attributes in the cloth chosen by the firm to produce and the quantity of this cloth actually produced in terms of the implicit attribute prices and the product price. Given that the quantity and quality of output has now been determined, by Sheperd's lemma the optimal inputs can be determined from the cost function previously derived. It is the process of choosing optimal values of quantity and quality of output and inputs characterized here which is embedded in the profit function in (1). For more on this optimization process, see S. Rosen, "Hedonic Prices and Implicit Markets," Journal of Political Economy, 82 (January/February, 1974), 34-55.

$$(2) \qquad \frac{\partial \Pi}{\partial P_i}(P; -X) = U_i(P; -X)$$

$$= \sum_{h=1}^{I} \sum_{h=1}^{J} a_{ih}(1/2P_i^2 + 1/2P_h^2)^{1/2} P_i X_j$$

$$+ \sum_{j=1}^{J} c_{ij} X_j + \sum_{j=1}^{J} \sum_{k=1}^{J} b_{jk} X_j^{1/2} X_k^{1/2}$$

$$\text{for } i = 1, 2, \ldots, n$$

where U_i is the operator for the profit maximizing derived product attribute supply function or the profit maximizing derived input demand function

may be obtained.[1] There will be one derived product attribute supply function or derived input demand function for each of the variable quantities. When the parameters of (2) are estimated, it is possible to fully characterize production relationships. This is because by duality theory it is possible to show that there is a unique relationship between an underlying production function and Π.[2] Note that the particular functional form chosen for Π provides a second order approximation to an arbitrary, twice continuously differentiable, variable profit function which satisfies the necessary conditions for this unique relationship and for (2) to hold.[3]

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[1]The general form of this result is known as Hotelling's Lemma and is proved in Gorman, op. cit.

[2]Diewert, op. cit.

[3]Ibid.

It will be noted that, other than symmetry, no a priori conditions are imposed on (1) and (2). Product attributes and inputs are not treated as separable groups.[1] This is because output mix is hypothesized to be closely related to raw cotton mix and labor mix. This is a central concern of the analysis here.

C. The Data

The price vector P in (1) and (2) includes fifteen elements:

$P \equiv$ price of cloth

$P_1 \equiv$ price of cloth attribute - weight

$P_2 \equiv$ price of cloth attribute - warp yarn count

$P_3 \equiv$ price of cloth attribute - weft yarn count

$P_4 \equiv$ price of cloth attribute - ends per inch

$P_5 \equiv$ price of cloth attribute - picks per inch

$P_6 \equiv$ price of cloth attribute - plain weave (categorical variable)

$P_7 \equiv$ price of cloth attribute - twill weave (categorical variable)

$P_8 \equiv$ price of cloth attribute - width

$P_9 \equiv$ wages

[1] A [illegible] of the concept of separability is given in P. Geary and M. Morishima, "Demand and Supply under Separability" in M. Morishima et al., Theory of Demand: Real and Monetary (Oxford: Clarendon Press, 1973).

$P_{10} \equiv$ price of Chinese cotton

$P_{11} \equiv$ price of East Indian cotton

$P_{12} \equiv$ price of American cotton

$P_{13} \equiv$ price of Egyptian cotton

$P_{14} \equiv$ price of other cotton

The eight cloth attributes being treated as variables do not exhaustively characterize each type of cloth, but, given the limited number of degrees of freedom, they do account for much of the variance between most brands.[1] It should be noted that the threads running the length of a bolt of cloth are called warp threads and those lying cross-wise are called weft threads A bolt of cloth is woven by pulling the weft threads through the prepared warp. The weft fills in the warp structure to create cloth. The thread itself is referred to as yarn. Each type of yarn is given a count number equal to the number of hanks of that yarn (1 hank = 840 yards) necessary to equal one pound. The higher the count, the finer the yarn. The number of warp threads per inch or ends and the number of weft threads per inch gives a measure of the denseness with which yarn is laid in the cloth.

The weave is another important product attribute. The theoretical variety of weaves is limited only by the permutations and combinations

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[1] Discussions of different attributes of cotton cloth are given in J. Hunter, Cloth and the Cloth Trade (London: Sir Isaac Pitman and Sons); J. Haye, Staple Cotton Fabrics (New York: McGraw Hill, 1942); and A. Whiteside, Whiteside's Textile Information and Conversion Tables (Bloomfield, New Jersey: Morse Press) among many other places. See als the very useful dissertation on the American cotton textile industry by D. Doane, "Regional Structure of the Cotton Textile Industry" (Purdue University, 1969).

which can be worked out in the positions of such groups of warp and weft threads as can be changed relative to each other on the loom. In practice there are two major options--interweaving every thread at every opportunity or skipping threads here and there. The first option is the plain weave. Under the second option, most non-plain Japanese cloth produced during the period of this study was either twill or satin. In the twill weaves the thread, after passing under one crossing thread, rides on top of two or more others and when this step is arranged in a regular rotation, diagonal ridge or twill is produced. In the satin weave, also produced by floating one thread across several others, the formation of a rib is avoided. The weave attributes will be represented in the analysis here by two dummy variables which take on the value 1 if the weave is plain or twill respectively. If the weave is satin or some other type, both categorical variables will take on the value 0.

The cloth-width attribute primarily defines whether the output will be used to make traditional or Western-style clothing. Japanese kimono are made from bolts of cloth no more than twelve to fifteen inches wide. Western-style clothing and other Western-style cloth products are cut from cloth which is double to triple these widths.

Given the other cloth attributes, an extra variable for weight may seem unnecessary. In fact, the Japanese textile industry was extremely successful in effecting wide variations in the weight (and therefore the quality) of cloth of given dimensions by the addition of starch to the warp yarns. Starch might account for as much as six percent of British or American cloth weight. Some Japanese brands of cloth contained as much as twenty-three percent starch![1]

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[1] W. Clark, Cotton Goods in Japan (Washington: U.S. Government Printing Office, 1914).

Variable input attributes in this analytical framework are exclusively different grades of raw cotton. Raw cotton is graded primarily but not exclusively by the length of its fiber, otherwise called its staple length. The longer the staple length, the less the fiber will break when it is being spun and woven. Because longer count yarn requires more spinning, the probability of breakage is higher and therefore higher count yarn generally requires longer staple raw cotton. Similarly, warp yarns must be stronger than weft yarns and in consequence also require longer staple raw cotton. Among raw cottons used in substantial quantities by the Japanese in the period under consideration here, Chinese raw cotton had the shortest staple. Next came Indian raw cotton, followed by raw cotton from the American South. Finally, the longest staple raw cotton used by the Japanese, as by the English, was from Egypt.

The X vector in (1) and (2) containing the fixed inputs includes as elements:

$X_1 \equiv$ spindle hours

$X_2 \equiv$ loom hours

$X_3 \equiv$ length of shift

$X_4 \equiv$ experience of the work force

$X_5 \equiv$ education of the work force

It is assumed that decisions as to the levels of each of these five inputs

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[1] W. Clark, Cotton Goods in Japan (Washington: U.S. Government Printing Office, 1914).

are exogenous to the decisions with respect to level and mix of output and level of the labor input. For much of the period under investigation here, capacity increases depended more or less intimately on imported capital goods. And the lag between order and delivery was sufficiently and unexpectedly varied such that a spinning mill manager's control over the time path of his mill's capacity could be quite limited.[1]

In other words, once the capacity is in place, the mill manager has only limited discretion with respect to capacity utilization and length of shift. The Japanese cotton spinning industry was, during the period under study, and remains today, an interesting blend of competition and oligopoly. Thus, while entry into the industry was always unrestricted and decisions regarding output per se were left to the individual firms, the trade association or cartel executive body, throughout virtually the entire period under study, determined the limits of capacity utilization and the length and number of working shifts.

Available evidence also suggests that individual firms had little control over the quality of their labor force or made decisions with a different longer horizon in mind. Throughout most of the pre-World War period, the spinning industry relied on young female recruits from the most underdeveloped regions of Japan. As late as 1893 very few of these recruits had been exposed to any kind of formal education. Due to an explicit change in government policy, by 1910 ninety-eight percent

[1] For further discussion, see Gary R. Saxonhouse, "Capital Accumulation, Labor Saving, and Labor Absorption Once More," Quarterly Journal of Economics, 89, (May, 1975), 322-330.

of the recruits from the very same poor families had attended primary school. Notwithstanding their increased education, the time path of departure of a entering cohort of recruits remained unchanged between the 1890's and the 1930's. The work experience of the average member of the spinning industry labor force rose from fourteen months in 1891 to over forty-four months in 1930, largely because a small constant proportion of each entering cohort became members of the permanent work force. Whatever policies the mills may have had to establish a permanent work force, they were unimportant by comparison with the simple maturation of the industry.[1]

The system of equations in (2) will be estimated using 903 firm observations over a twenty-nine-year period between 1906 and 1935. This is a subset of the sample of 2,138 observations over forty-five year which has been used in some of the previous work on the pre-war Japanese spinning industry. This subset is defined by the availability of brand price and attribute data. While the input data is taken from the records of Boren, the All Japan Cotton Spinners Association, the brand price is taken from the regular quotations made by the Osaka Cotton Merchants Union. For the entire period between 1906 and 1935, the Osaka Cotton Merchants Union quoted prices regularly on all the major brands and many of the minor brands of cotton yarn and cloth. Characterizations of these brands in terms of the seven attributes discussed above are also readily available.

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[1]These topics are treated in more detail in Saxonhouse, "Country Girls and Complementarity of Communications among Competitors," and Saxonhouse, "Productivity Change and Labor Absorption in Japanese Cotton Spinning, 1891-1935," op. cit.

D. The Implicit Prices of the Attributes of Japanese Cloth and Yarn

The prices of cloth and yarn attributes required for the estimation of (2) are not explicit market prices. Rather, following earlier work on hedonic price indices, cloth prices are first regressed on cloth characteristics to obtain a hedonic price function:

$$(3) \qquad P_c = \sum_i \sum_j d_{ij} u_i^{1/2} u_j^{1/2}$$

where u_i and u_j are cloth attributes, and P_c is the price of cloth.[1] By differentiating (3) after estimation, it is possible to obtain the implicit prices of the cloth characteristics:

$$(4) \qquad P_i = \frac{\partial P_c}{\partial u_i} = \frac{1}{2} \sum d_{ij} \left(\frac{u_j}{u_i}\right)^{1/2}$$

While one relationship is used to characterize the temporally pooled observations on firm brand prices, it is clear from the form of (4) that in general the implicit prices of attributes will vary from firm to firm and over time as the attribute composition characteristics of product varies.[2] This will occur even as these firms are at any one time operating in the same market and is at least theoretically possible because of the nature of

[1]The approach taken here follows S. Rosen, op. cit. and R. E. B. Lucas, "Hedonic Price Function," Economic Inquiry (June, 1975) among other papers. In (3) it is assumed that $d_{ij} = d_{ji}$ and $d_{ii} = 0$.

[2]Had the functional form of the hedonic price function in (3) been linear, the implicit prices of attributes would be constant even as the amount of a particular attribute embodied in a brand of cloth varied.

the demand for cloth and the technology associated with its production. The worldwide market for cotton cloth in which the Japanese participated between 1906 and 1935 consisted of a number of separate but highly interrelated markets. These markets for cloth were primarily differentiated according to taste and custom, climate, income levels, etc., a differentiation which occurred internally as well as internationally. In Japan, it was exemplified by the separate markets for traditional and modern cloth. Internationally, the light-weight, finely woven cloth which was climatically required in such Japanese export markets as India and South-East Asia, was not abundantly used in Japan. And again, the heavily-sized, sparsely-woven cloth which Japan sold in the 1930's to the poorer regions and lower income groups throughout the world would scarcely have been purchased by anyone with even moderate, not to mention substantial, means.

Were the attributes of the cloths all traded separately in explicit markets, the non-linear form of (3) would not make sense. Competition should make the price of an attribute everywhere the same.[1] Because clothing attributes satisfying a variety of different ultimate demands come packaged as cloth and cannot be trivially unraveled and recombined, because consumers in the world market differ in their tastes, needs and wealth, and because firms differ in their capabilities, and/or may choose to specialize in the satisfaction of particular markets by producing particular attribute packages, differences in the implicit prices of the same attribute could occur in competitive markets.[2]

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[1]Yarns of varying counts of course were traded in explicit markets.

[2]See the discussion in Rosen, op. cit. and J. Triplet, "Consumer Demand and Characteristics of Consumption Goods" in N. Terleckyi (ed.), Household Production and Consumption (New York: Columbia University Press, 1976).

TABLE 5

THE HEDONIC PRICE REGRESSION COEFFICIENTS

	d_{i1}	d_{i2}	d_{i3}	d_{i4}	d_{i5}	d_{i6}	d_{i7}	d_{i8}
i = 1 weight	0	893×10^{-5} (2.94)	$.851\times10^{-5}$ (2.56)	$.531\times10^{-6}$ (3.18)	$.941\times10^{-6}$ (1.96)	$.632\times10^{-8}$ ($.106\times10^{-6}$)	$.319\times10^{-7}$ ($.694\times10^{-5}$)	$.131\times10^{-4}$ (2.16)
i = 2 warp ya number			$.132\times10^{-2}$ (1.42)	$.623\times10^{-3}$ (1.04)	$.916\times10^{-3}$ (1.23)	$.511\times10^{-4}$ ($.522\times10^{-2}$)	$.238\times10^{-5}$ ($.114\times10^{-3}$)	$.273\times10^{-2}$ (1.66)
i = 3 weft yarn number				$.497\times10^{-3}$ (1.26)	$.724\times10^{-3}$ (3.43)	$.290\times10^{-4}$ (1.62)	$.321\times10^{-7}$ (1.03)	$.323\times10^{-3}$ (1.23)
i = 4 ends per inch				0	$.561\times10^{-2}$ (2.69)	$.438\times10^{-2}$ (3.20)	228×10^{-2} (2.35)	.113 ($.389\times10^{-1}$)
i = 5 picks per inch					0	$.517\times10^{-2}$ (1.58)	196×10^{-2} (1.78)	.263 ($.677\times10^{-1}$)
i = 6 plain weave						0	.000 (.000)	$.592\times10^{-2}$ (1.64)
i = 7 twill weave							0	$.681\times10^{-2}$ (1.94)
i = 8 width								

R^2 = .779. The figures in parentheses are t-statistics. The eight cloth attributes are indexed by i as above.

Equation (3) is estimated using generalized least squares methods which allow for unmeasured time-specific and firm-specific effects using dummy variables.[1] Some of the results of this estimation are presented in Table 5. These results should be interpreted with some care. The hedonic price regression is not a substitute for estimation of the decision making framework laid out in (1) and (2). The hedonic price function may be thought of as a relationship which traces out the transactions generated by the intersection of the attribute buyer's implicit compensated demand functions with the attribute seller's implicit compensated supply functions. Because buyers and sellers differ among themselves in the ways outlined above, the hedonic price function is generated by many different demand functions intersecting with many different supply functions. The hedonic price function duplicates econometrically the market information known to buyers and sellers. If, however, we wish to understand the determinants of the implicit transaction prices for each of the attributes rather than "simply" the implicit transaction price itself, demand and supply functions must be identified and estimated.

In Table 6 some attempt is made to summarize the market information obtained from estimating equation (3). The average implicit price for each characteristic, the coefficient of variation of this price among firms, and the average amount of this characteristic packaged in a piece of cloth are presented for five-year intervals

While great care must be exercised in interpreting Tables 5 and 6,

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[1] As with most such prices in pre-war Japan, changes in the price of cloth are dominated by fluctuations in the business cycle. In an effort to avoid imposing still greater complexity on the estimation of the hedonic price function, prices of cloth have been deflated by the price of raw cotton.

a number of observations should be made. First, dissimilar trends are found in the average implicit prices of the cloth attributes. The attributes of yarn fineness, sizing and width show increasing prices, while the cloth density variables show decreasing trends. At the same time, these differing trends can be loosely related to changes in attribute weight or quantities. Positive price trends are associated with increases in attribute quantities. Implicit price declines also do seem to be associated with small declines in attribute quantities. Since the hedonic price equation is not a structural equation, no real interpretation of these associations may be given. Only when the profit function has been estimated can such an interpretive linking of prices and quantities be made.

If the average price of Japanese-made cloth was getting wider and being more heavily sized, and came to use finer yarns which were less densely woven, it is also true that Japanese production was becoming more heterogeneous over time. This is certainly reflected in the coefficients of variation of the implicit prices of the attributes. For all the right attributes, there are non-trivial variations in the implicit attribute prices among firms. For all eight attributes this variation becomes more pronounced with World War I and continues to increase sharply through 1935.

E. The Estimation of Derived Product Attribute Functions and Derived Input Demand Functions

Implicit prices calculated using the coefficient estimates in Table 5 are used in the estimation of the equations in (2). Note that these implicit prices are not predetermined variables. While textile firms being modeled did not have market power, brand choice and implicit prices were determined simultaneously. It is also plausible to assume that elements of

TABLE 6

THE IMPLICIT PRICE OF CLOTH CHARACTERISTICS

	1906	1911	1916	1921	1926	1931	1935
WEIGHT (lbs per square yard)							
Real implicit price (index)*	100.0	108.2	105.7	112.1	115.8	124.3	124.6
Coefficient of variation of price	.043	.041	.038	.069	.052	.097	.103
Quantity (index)	100.0	100.7	100.4	108.9	106.4	109.5	108.7
WARP YARN NUMBER (hanks)							
Real implicit price (index)	100.0	109.5	107.3	110.1	115.4	120.2	133.4
Coefficient of variation of price	.85	.83	1.36	3.22	2.67	4.13	3.63
Quantity (index)	100.0	103.6	104.1	104.9	110.6	114.6	119.2
WEFT YARN NUMBER (hanks)							
Real implicit price (index)	100.0	109.9	107.9	108.8	109.1	124.3	128.0
Coefficient of variation of price	.81	.79	1.28	2.93	2.58	4.01	3.43
Quantity (index)	100.0	103.1	103.4	104.2	108.5	111.2	115.9
ENDS PER INCH							
Real implicit price (index)	100.0	106.9	105.5	89.4	92.7	89.8	83.4
Coefficient of variation of price	2.01	1.89	2.99	4.28	3.50	5.25	4.63
Quantity (index)	100.0	104.2	105.1	100.0	101.2	99.8	100.3

*As with most such prices in pre-war Japan, changes in the price of cloth are dominated by fluctuations in the business cycle. In an effort to avoid imposing still greater complexity on the estimation of the hedonic price function, prices of cloth have been deflated by the price of raw cotton.

TABLE 6 continued

	1906	1911	1916	1921	1926	1931	1935
PICKS PER INCH							
Real implicit price (index)	100.0	105.8	104.1	86.0	90.7	96.3	89.1
Coefficient of variation of price	.962	.884	1.31	1.73	1.55	1.94	1.83
Quantity (index)	100.0	103.4	103.9	98.4	99.1	99.0	99.6
PLAIN WEAVE							
Real implicit price (index)	100.0	100.2	97.9	103.3	102.2	98.1	97.3
Coefficient of variation of price	.18	.22	.25	.33	.36	.29	.32
Quantity (index)	100.0		2.5	97.4	89.6	98.5	97.0
TWILL WEAVE							
Real implicit price (index)	100.0	101.3	103.6	107.2	105.3	106.3	110.7
Coefficient of variation of price	.13	.14	.17	.38	.32	.35	.39
Quantity (index)	100.0	104.6	108.3	110.4	107.5	109.3	109.4
WIDTH (inches)							
Real implicit price (index)	100.0	107.8	105.0	109.2	115.8	138.3	147.7
Coefficient of variation of price	4.47	5.49	5.43	8.87	7.35	7.91	8.16
Quantity (index)	100.0	132.1	147.3	163.5	176.9	195.0	231.8

the stochastic terms in different derived supply and derived input demand will have non-zero covariance.[1] These two factors together suggest that a variant of Three-Stage Least Squares should be used in estimating (2).[2]

Once these demand and supply functions have been estimated, it is possible to fully describe the technical relationships between the differin attributes of and inputs into the production of cloth in Japan. Tables and present partial elasticities of transformation between attributes, partial elasticities of substitution between inputs and partial elasticities of transformation between attributes and inputs.[3]

The results in Tables 7A and 7B confirm that the technical relationships in Japanese cloth production were such that Japanese textile firms could make significant adjustments in the attributes of the cloth they produced in response to changing conditions in both product and factor markets. Of the thirty-five elasticities of transformation including non-elasticity for attributes in Tables 7A and 7B seventeen are significantly different statistically from zero. Tradeoffs clearly existed among cloth attributes.

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[1]Given that the sample being used here is a time series of cross-sections, it is easy enough to imagine firm and time effects providing non-zero covariances.

[2]The instrumental variables actually used in estimating (2) include a) money borrowed on promissory notes, b) formally educated technicians per plant, c) managerial experience, d) price of coal, e) cotton yarn inventory, f) exports, g) rate of dividends, h) paid-in capital, and i) horsepower.

[3]These elasticities are defined in terms of the profit function in W. Diewert, "Application of Duality Theory" in M. Intriligator and D. Kendrick (eds.), Frontiers of Quantitative Economics, Vol. II (Amsterdam: North Holland Publishing Co., 1974).

TABLE 7A

PARTIAL ELASTICITIES OF TRANSFORMATION

	1	2	3	4	5	6	7
1. weight	-.509	1.73	.394	1.43	1.65	.170	.708
	(.183)	(.186)	(.819)	(2.72)	(2.80)	($.526 \times 10^{-2}$)	($.593 \times 10^{-2}$)
2. warp yarn number		-14.3	-1.72	-5.50	-1.10	3.05	1.96
		(2.76)	(3.37)	(3.86)	(2.95)	(.930)	(.351)
3. weft yarn number			-9.26	-1.91	-5.41	4.78	.639
			(2.49)	(2.12)	(6.16)	(1.41)	(.887)
4. ends per inch				-1.64	-6.35	5.45	4.52
				(2.04)	(2.81)	(1.08)	(1.24)
5. picks per inch					-3.15	2.65	1.99
					(6.08)	(.533)	(1.37)
6. plain weave						-18.0	8.16
						(1.69)	(6.61)
7. twill							-13.4
							(2.43)

TABLE 7B

PARTIAL ELASTICITIES OF TRANSFORMATION AND SUBSTITUTION

	8	9	10	11	12	13	14
1. Weight	.928	-.401	-.777	-1.91	$.993 \times 10^{-1}$	-.602	.389
	(.597)	(.883)	($.611 \times 10^{-3}$)	($.681 \times 10^{-1}$)	(521×10^{-4})	(.328)	(.237)
2. Warp yarn number	-4.79	1.85	-6.84	-4.61	3.78	2.46	-1.93
	(.226)	(4.03)	(2.75)	(3.58)	(6.45)	(1.00)	($.611 \times 10^{-3}$)
3. Weft yarn number	-.536	2.74	-7.60	-4.33	7.02	1.39	.000
	(1.52)	(1.99)	(2.14)	(8.89)	(1.63)	(.810)	(.000)
4. Ends per inch	$.758 \times 10^{-1}$	.686	-2.25	-3.19	9.90	.534	3.82
	($.630 \times 10^{-6}$)	(1.77)	(4.11)	(2.67)	(1.62)	($.116 \times 10^{-8}$)	($.704 \times 10^{-3}$)
5. Picks per inch	.104	1.20	-4.00	-3.52	11.0	.657	5.25
	($.373 \times 10^{-5}$)	(2.67)	(1.72)	(2.15)	(1.58)	($.398 \times 10^{-5}$)	(.677)
6. Plain weave	.821	.555	$-.348 \times 10^{-2}$	$-.402 \times 10^{-1}$	$-.153 \times 10^{-4}$	.146	-3.90
	(1.74)	($.194 \times 10^{-3}$)	($.516 \times 10^{-5}$)	($.371 \times 10^{-3}$)	(.000)	(.389)	(1.03)
7. Twill	-.244	.819	$-.655 \times 10^{-4}$	$-.947 \times 10^{-2}$	$.180 \times 10^{-5}$	$.595 \times 10^{-5}$	-2.58
	(1.63)	($.742 \times 10^{-1}$)	(.000)	($.666 \times 10^{-1}$	($.781 \times 10^{-5}$)	(.602)	(1.26)

TABLE 7B continued

	8	9	10	11	12	13	14
8. Width	-1.13 (3.84)	1.04 (1.53)	$.318 \times 10^{-1}$ $(.503 \times 10^{-2})$	$.898 \times 10^{-2}$ $(.100 \times 10^{-1})$	$.651 \times 10^{-4}$ $(.883 \times 10^{-3})$	$-.441 \times 10^{-1}$ $(.912 \times 10^{-2})$	-.144 $(.349 \times 10^{-1})$
9. Labor		-1.82 (1.94)	-14.6 (1.61)	-9.09 (2.00)	1.56 (2.41)	3.88 (1.43)	.915 (.882)
10. Chinese cotton			-15.2 (1.49)	.397 (1.91)	16.23 (2.12)	7.82 (1.74)	8.51 (.994)
11. East Indian cotton				-13.5 (1.81)	.868 (1.60)	5.34 (2.50)	.960 (3.00)
12. American cotton					-10.9 (2.34)	1.25 (1.72)	4.98 (.631)
13. Egyptian cotton						6.31 (1.02)	12.41 $(.107 \times 10^{-2})$
14. Other cotton							-.555 $(.140 \times 10^{-3})$

The numbers in parentheses are t-statistics.

Variations were possible in response to changing demand conditions.

Substitution was also possible among the different kinds of raw cotton input. Of the fifteen partial substitution elasticities (including own elasticities) among the five different grades of raw cotton, nine are statistically significant from zero, and only one has a sign which is *a priori* implausible. Given that each of these partial elasticities is calculated on the assumption that all other attributes and inputs are being held constant, these results are a potent demonstration of the character of Japanese cotton mixing or blending techniques. The following quote from a former president of the Toyo spinning Company is instructive:

> . . . when we say 'cotton blending' we refer to the technical skill and ability to choose most cheaply and economically those varieties among the world's cotton embodied with the necessary and sufficient use values to spin yarns of a given quality. Normally speaking, however, since there is no single variety of raw cotton that will simultaneously meet their qualifications, men contrive to fulfill their conditions by blending and mixing various varieties of raw cotton . . . cotton blending consists of skill in choosing and purchasing cheaper cotton as well as the mechanical skills needed to put this cotton to use in the mills.
>
> In America where cotton of a uniform quality is plentiful and readily available, there is no economic need to resort to blending, so these skills have not developed there. England, however, is in a geographical position similar to Japan which should encourage consideration of adopting blending procedures. They have not, however, developed these either partly perhaps [sic] because trade unions have a voice in the usage of raw cotton. Cotton blending has therefore, come to be known world-wide as a technique unique to the Japanese.[1]

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[1] K. Seki, The Cotton Industry of Japan (Tokyo: Japan Society for the Promotion of Science, 1956).

Of special interest to this study are the elasticities of transformation in Table 7 between variable inputs and output attributes. For example, as observations on actual practice confirm, the finer the yarn in the Japanese cloth, the greater the input of high-quality (American and Egyptian) raw cotton. Similarly, the more densely the yarn has been laid in the cloth, the greater the input of raw cotton.

In view of the continuing interest in the process of labor absorption in LDC's, special attention centers on the elasticities of transformation and substitution associated with the labor variable. Of the fifteen elasticities presented in Table 7B, eight are statistically significant with plausible signs. These estimated elasticities clearly suggest that the more slack there was in the labor market, the more appropriate it was to produce coarser yarn. Specifically, as Table 7B indicates, a 1% decline in the price of labor relative to the price of yarn was associated with a 1.8% decline in the count of warp yarn and a 2.7% decline in the count of weft yarn produced. In other words, the lower quality cotton is significantly associated with larger labor absorption. This makes sense since coarser yarn, by being twisted less, makes relatively less use of the most capital intensive processes of the textile mill while more labor can be used to repair the largernumber of broken ends in the spinning process.

The elasticities also show that the more slack there was in the labor market, everything else being equal, the easier it was to use lower quality raw cotton. Raw cotton mixing and blending is a relatively labor intensive process. With cheap labor available, short-stapled Chinese and East Indian cotton could be substituted for American and Egyptian cotton. Table 7B shows that a 1% decline in the price of labor relative to the price of

Chinese raw cotton is associated with a 14.6% average in the amount of Chinese raw cotton being used by each laborer. By contrast, a 1% decline in the price of labor relative to the price of American raw cotton is associated with a 1.6% decline in its use.

Finally, it is also clear from Table 7 that the number of warp and weft threads in a square inch of cloth were adjusted to the character of the labor market. For a given count (or yarn number), weft yarn, because it is filling, can use lower quality, shorter staple raw cotton. Warp yarns to survive breakages in weaving requires higher quality raw cotton. For this reason, an increased use of weft yarn may be viewed as a relatively labor-using innovation. This is consistent with our findings which show that the more slack in the labor market the number of picks per inch (weft) rose relative to the number of ends (warp).

Estimation of the equation system in (2) also makes it possible to obtain estimates of the elasticity of transformation (in this context sometimes called the elasticity of intensity) and each of the variable output attributes and inputs. These elasticities are presented in Table 8. The results support earlier work by Saxonhouse on the relationship between labor quality and labor absorption.[1] The earlier observations on this subject by Hirschman and Gerschenkron and the contrasting more recent empirical work seem rather too simple. The two quality dimensions of labor have rather different implications for labor absorption. The more experienced the labor force becomes, the more productive it becomes, but also the greater the demand for labor. Worker experience within the Japanese textile industry, in other words was labor absorbing. By contrast, while more exposure to formal primary education also meant a more productive textile worker, this way of showing

[1] G. Saxonhouse, "Productivity Change and Labor Absorption in Japanese Cotton Spinning, 1891-1935", op. cit.

labor production has diminished the demand for labor. The quality dimension in Japanese cotton textile labor markets will be explored further in section IV.

TABLE 8

ELASTICITIES OF TRANSFORMATION BETWEEN FIXED INPUTS AND VARIABLE QUANTITIES

i =	Spindle hours	Loom hours	Length of Shift	Experience	Education
1. Weight	.723	.440	$-.849 \times 10^{-3}$	2.77	1.59
	(10.6)	(8.63)	(.151)	(1.96)	(1.82)
2. Warp yarn number	$.238 \times 10^{-3}$	$.745 \times 10^{-4}$		$-.243 \times 10^{-1}$	$.682 \times 10^{-1}$
	(7.64)	(1.61)	(1.07)	(1.56)	(1.78)
3. Weft yarn number	$.241 \times 10^{-3}$	$.529 \times 10^{-4}$	$-.828 \times 10^{-2}$	$-.992 \times 10^{-2}$	$.319 \times 10^{-1}$
	(6.85)	(1.70)	(.681)	(1.78)	(2.42)
4. Ends per inch	$.514 \times 10^{-5}$	$.381 \times 10^{-1}$	$.562 \times 10^{-2}$	.197	$.736 \times 10^{-2}$
	($.338 \times 10^{-5}$)	(2.68)	(.786)	(2.10)	(.981)
5. Picks per inch	.881	$.334 \times 10^{-1}$	$-.264 \times 10^{-2}$	.212	$.681 \times 10^{-2}$
	($.162 \times 10^{-2}$)	(4.02)	(1.35)	(3.02)	(1.41)
6. Plain weave	$.621 \times 10^{-4}$	$-.139 \times 10^{-4}$	$.158 \times 10^{-3}$		.132
	$.546 \times 10^{-3}$	(1.09)	(.673)	(1.55)	(1.00)

TABLE 8 continued

i =	Spindle hours	Loom hours	Length of Shift	Experience	Education
7. Twill weave	$.735 \times 10^{-4}$ $(.442 \times 10^{-3})$	$.167 \times 10^{-2}$ (.742)	$.710 \times 10^{-4}$ $(.285 \times 10^{-3})$	$.593 \times 10^{-2}$ (1.09)	$.101 \times 10^{-1}$ (1.16)
8. Width	$.320 \times 10^{-3}$ (1.91×10^{-2})	$.726 \times 10^{-1}$ (2.15)	.000 (.000)	$-.112 \times 10^{-4}$ $(.626 \times 10^{-2})$	$.532 \times 10^{-3}$ (.501)
9. Labor	.861 (5.23)	.391 (1.78)	.561 (4.01)	1.80 (3.21)	-.657 (4.98)
10. Chinese cotton	.505 (4.61)	-1.34 (1.51)	.231 (.984)	1.07 (4.61)	$-.219 \times 10^{-}$ (.846)
11. East Indian cotton	.892 (6.13)	$.361 \times 10^{-2}$ (1.856)	.149 (.611)	1.25 (3.89)	$.571 \times 10^{-1}$ (.298)
12. American cotton	.715 (4.48)	.517 (3.29)	.474 (.251)	.223 (.681)	1.03 (1.96)

TABLE 8 continued

i =	Spindle hours	Loom hours	Length of Shift	Experience	Education
13. Egyptian cotton	1.01	1.21	$.840 \times 10^{-2}$	$-.991 \times 10^{-1}$	1.14
	(3.36)	(.936)	(1.31)	(1.41)	(1.48)
14. Other cotton	.529	$.141 \times 10^{-1}$	$.437 \times 10^{-2}$	$-.182 \times 10^{-1}$	$-.849 \times 10^{-2}$
	(.976)	(.394)	($.219 \times 10^{-1}$)	(.945)	(.622)

The numbers in parentheses are t-statistics. The elasticities calculated in both Tables 3 and 4 are for mean variables of the variable quantities and fixed inputs only.

IV: The Quality Dimension in the Supply and Demand for Workers

A: Statement of the Problem

In the West, historical treatments of the rise of the factory system have always stressed the attitudes, pressures, and discontents of workers. Despite this historical interest most economic analysis of early European and American industrialization has stressed changes not in the supply but in the demand for labor, particularly technological developments, capital accumulation and the opening of markets. This has been even more true for developing economies.

Not surprisingly, the few systematic international historical comparisons of labor supply which have been made have come up with widely diverse conclusions. Morris, writing in the 1960's, concludes explicitly that labor supply was a "slack variable," and extends this assertion not only to India (1855-1914) but to Great Britain (1770-1840 "In no case did the shortage of skilled labor...inhibit the pace at which the industry would otherwise have expanded...I think it is safe to say that the supply of raw unskilled labor was never an inhibiting factor in economic growth."[1] By contrast Gerschenkron has made the inelasticity of the supply of such labor in the early stages of development, regardless of differences in endowment and demographic pressures, a foundation stone in his understanding of the industrial

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[1]Morris D. Morris, "The Recruitment of an Industrial Labor Force in India; with British and American Comparisons" Comparative Studies in Society and History 2 (April, 1960).

development of the various continental European countries. Lacking the traits of stability, reliability and discipline, it is argued that the underemployed peasants and urban poor of nineteenth century Central and Eastern Europe did not necessarily translate into a ready supply of labor for the newly borrowed Western European factory system.[1]

For Japan, quite unlike the experience of Europe and the United States, historically inclined economists and economic historians have not neglected the description and economic analysis of the supply of labor in early industrialization. Two-sector Marxist school derived models of Japanese economic development were developed in the 20's and 30's which among other contributions analyzed how changes in agricultural conditions might affect the terms of labor supply to the industrial sector. In the postwar period, Kazushi Ohkawa, building on some of these earlier insights, developed a highly influential model which rationalized the coexistence of Japanese unemployment with equilibrium conditions by assuming average productivity pricing of labor in agriculture and marginal productivity pricing in industrial employment.[2]

Ohkawa's view that Japan's industrial sector fed on elastic supplies of labor from the traditional sector (a view compatible with Morris' work cited earlier) is explicitly contrasted with Gershenkron's

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[1] Alexander Gerschenkron, Economic Backwardness in Historical Perspective (Cambridge, Mass., 1962).

[2] This analysis is presented in Kazushi Ohkawa, Nogyo no keizai bunseki (Tokyo, 1955), among other places. Ohkawa's model is closely related to models in the West in the W. Arthur Lewis tradition [see "Economic Development with Unlimited Supplies of Labour", Manchester School 22 (May 1954)] and Fei and Ranis, Development of the Labor Surplus Economy: Theory and Policy, Richard D. Irwin, 1964.

historical finding that, for continental Europe, underemployment of labor is not synonymous with elastic supplies of labor to a nascent industrial sector. Rosovsky,[1] supporting Ohkawa, finds that Japan, unlike Germany and Russia, could quickly convert its underemployed agricultural populati into a disciplined and reliable industrial labor force:

> There is both direct and indirect evidence that was capable of forming a disciplined and reliable labor force, suitable for factory work, more easily than many backward countries of continental Europe. The historical record, suc as it is, contains few complaints on this score. Population growth spewed forth labor from the countryside, creating competition for industrial jobs; and even though it took a long time to cut the cord reaching to the rural areas, after a while the cord became stretched beyond recognition.

Rosovsky explains Japan's success in this area by noting the survival of traditional institutions in the early factory system:

> Sociologists tell us that Japanese society is very "integrated" and therefore may present lesser disciplinary problems. Others have emphasized innovating enterprising leadership, combined with teamwork and solidarity in group organization, "sufficient" to give order and momentum to the process of change. Contemplating factory employment, or more specifically servicing a machine,

[1] Henry Rosovsky, Capital Formation in Japan (Glencoe, Ill. 1961) p. 103.

> probably filled the early Japanese worker with a certain amount of horror. But the transition was made softer and smoother by the concessions which the factory was willing to make to him: he was still treated as a typical Japanese...Japanese economic development has taken place with much less change from the kinds of social organizatio and social relations of pre-industrial or non-industrial Japan than would be expected from the Western model of the growth of industrial society.[1]

Rosovsky's writing on Japan's labor force in early industrialization remains an extreme statement of the view that 1) Japan had relatively elastic supplies of labor suitable for factory work and 2) the ease with which early Japanese industry obtained such labor may be attributed to culturally distinctive circumstances. Subsequent Western writers have emphasized the important Japanese scholarship and primary evidence whicl Rosovsky overlooked in drawing his conclusions. Indeed the pendulum has swung far in the other direction, with Saxonhouse now finding that the early Japanese factory textile labor force was more unstable and undisciplined than their historical counterparts elsewhere in Asia, in the Northern and Southern United States and in continental Europe,[2] certainly an encouraging finding as far as todays LDC's are concerned.

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[1] Ibid

[2] In Gary R. Saxonhouse "Country Girls and Communication Among Competitors in the Japanese Cotton Spinning Industry" in Hugh Patric (ed.), Japanese Industrialization and Its Social Consequence (Berkeley, California, 1976) instability is indexed primarily by turnover experience. Similar conclusions, however, can be drawn from examination of the rate of absenteeism.

Moreover, this finding is not based on the culturally inherent unsuitability of Japanese men and women for long-term textile factory work. Rather, Japan's early industrialists got the kind of labor force they wanted. Resources do not appear to have been spent in unsuccessful efforts to do what could not be done. What is most interesting for our purposes here is that profit maximization by textile industry entrepreneurs and utility maximization by unskilled workers led to an equilibrium which did not resemble a stable, permanent labor force. Gerschenkron argued that underemployed labor notwithstanding, the absence of the traits of reliability, stability and discipline in workers recently emerged from peasant society would force newly developing economies to adopt large-scale, capital intensive modes of production. Quite to the contrary, Japan accommodated a large volume of labor along labor intensive productive functions, with the quality of the early industrial labor force apparently as much a decision variable as scale and factor proportions.

B. The Supply of Quality Workers and the Demand for Quality in Jobs

How did the labor market operate in the textile industry, given the fact that wages were only marginally above agricultural opportunity cost and that mill owners were reluctant to finance on the job quality improvement programs because of the unusual degree of technological homogeneity plus virtually free entry of the Japanese textile industry? An investment in the work force could not be easily recouped. Textile workers for their part were typically in no position to make such an

investment. With opportunities thus constricted, low wages and high turnover persisted for decades as the industry norm

This discussion of the transience and instability of the Japanese textile industry labor force ignores the paternalistic practices emphasized by Rosovsky in his account of the Meiji labor force. Over the long-term,instability and indiscipline make strange bedfellows with paternalism. Yet this apparently was the case for at least fifty years in Japan--persisting even beyond the 1929 Factory Act. How do these paternalistic practices fit into the picture drawn here of a labor force whose indiscipline and instability was the accepted outcome of industry policies? It is easy to suggest that paternalism was adopted to mask the use of very young workers in what were, by Japanese and Western standards, very mean circumstances. But this is too simple. Japanese cotton spinning mills did have all the accoutrements of paternalism. There was the mill dormitory and the dining hall, the mill health personnel and dispensary and/or hospital, the mill school with teacher and classrooms, as well as the other side of paternalism--the often severe restrictions on mill worker activity during non-working hours. What were the Japanese mill managers trying to accomplish with this panoply of ameliorative institutions and how did these nonpecuniary dimensions of quality affect labor supply and job choice?

In what follows, the Japanese cotton spinning mill will be viewe as supplying a bundle of job characteristics relating to wages, pace of work, hazards and health care and the availability and quality of dormitory life. Workers will be viewed as having preferences wit

respect to varying bundles of job characteristics. Such preferences will be assumed to vary with the traits of these workers, e.g. age, experience and education.[1] The market equilibrium in early industrialization resulting from the interaction of firm desires and capabilities with workers' preferences and opportunities needs to be studied more systematically.

C. The Data Base

The early development of the Japanese textile industry presents an unusual opportunity for conducting an investigation into worker preferences and worker quality. In 1897, as discussions in the Ministry of Agriculture and Commerce caused heightened concern among cotton spinning firms that strict factory legislation might be enacted, the All Japan Cotton Spinners Association, hereafter Boren, established a working group of the representatives of fourteen firms for the purpose of collecting information on the working conditions in the industry. In an industry whose constituent firms had been reporting to Boren for more than eight years a remarkably detailed account of their outputs, inputs and costs,[2] it is perhaps not surprising that this committee was exceedingly successful in meeting its charge. Seventy-one thousand workers in seventy-five mills were examined. A detailed report was obtained from each mill 1) on recruitment practices and payments;

[1]Elsewhere [in Gary R. Saxonhouse "Productivity Change and Labor Absorption in Japanese Cotton Spinning 1891-1935" Quarterly Journal of Economics XCI (May 1977), pp. 195-221] it has been established that increasing education and experience were major determinants of productivity change.

[2]See data utilized in Section II, above.

2) on mill workers classified by age, work experience and literacy; 3) on number and length of rest periods during a working day and on length of shifts and number of days between shift rotation; 4) on the mill wage payment system; 5) on mill expenditures on health care, the incidence of sickness, injury, and death attributable to particular diseases and other causes; 6) on the existence of mill dormitories, their rules and provision of services restriction; and 7) on the rate of worker absenteeism and turnover.

The summary of this investigation paints an interesting picture of mill life in the late 1890's. A significant percentage of the total labor force was recruited hundreds of miles from where the spinning mills were located. Already in the 1890's, the familiar pattern of Kansai (Osaka, Kobe and Kyoto) mills recruiting girls from Southern Kyushu and Shikoku, and Kanto (Tokyo area) mills recruiting girls from northern Honshu had become established. Upon successful recruitment the usually teen-aged girl's family received a bonus which, on the average, was equivalent to approximately twenty days' beginning wages. For the female labor force as a whole the average age was nineteen years, with almost thirty percent of the labor force aged fourteen years or less.

The young girls faced a working day which, on the average, was almost twelve hours long, with something in excess of three rest periods, cumulating to one hour, interspersed throughout the day. Half the mill labor force worked a day shift, typically beginning at six o'clock in the morning, and half worked an evening shift

beginning at six o'clock in the evening. Shifts were normally rotated at weekly intervals.

A large majority of the female workers lived in company-run dormitories. These dormitories, to some extent inspired by glowing reports of the early 19th century Lowell, Massachusetts experience, offered the workers many services and placed many restrictions on the workers' off the job activities.[1] Permission to leave the mill compound was restricted. Mill regulations varied--some mills allowing one or two hours outside the mill each day, others none. In practice, these regulations were more of a mill ideal than a practice. Infractions of mill discipline, a less than excellent attendance record and an otherwise poor work record could lead to a suspension of the privilege.

Included among the benefits offered were subsidized food in company dormitories and health and educational facilities. The implicit food subsidy per month was on the average equivalent to a week's wage for an inexperienced female recruit. Also, sixty-three of the sixty-five mills reporting on their provision of health care had dispensaries, staffed by at least one full-time nurse, while thirty-seven of the mills surveyed offered general educational instruction to its workers.

Having dispensaries in the mills certainly made sense since one time or another during the course of the year at each mill an average of seventy-five percent of the labor force would become ill. And while

[1]On the role of foreign models in the development of the spinning industry's dormitory system see Gary R. Saxonhouse "A Tale of Japanese Technological Diffusion in the Meiji Period" Journal of Economic History XXXIV (March 1974).

it is difficult to ascertain the quality of the health care, the survival rate of mill workers from sickness and accident was excellent. The mills surveyed experienced no more than 4.3 deaths per 1000 workers during 1897, a lower mortality rate than the average of the age cohorts from which they were drawn.[1]

It is equally difficult to ascertain the quality of the primary education offered. It should be noted that among the thirty-seven mills offering primary education there were, on the average, four instructors for each 1000 female workers. Since thirty percent of the work force was fourteen or under, individual exposure was probably quite limited. Moreover, receptivity was undoubtedly reduced by having the two-hour long classes typically scheduled for workers coming off an eleven hour working day.

The high labor turnover characteristic of the cotton spinning labor force during the entire period was demonstrated in this 1897 survey. Over forty percent of the newly recruited workers left the mills within the first six months of their initial employment, i.e., the average work experience of the spinning industry labor force in 1897 was about eighteen months. In addition, temporary absences ran high, i.e. the rate of absenteeism among dormitory workers during the survey month was 8.3 percent.

[1]There was, of course, some auto-selectivity at work here, in terms of the more fit more likely to be recruited.

D. The Conceptual Framework for the Analysis of Job and Worker Attributes

The traditional theoretical treatment of job choice which goes back as far as Adam Smith has stressed wage differentials as compensating for differences in job attributes. Similarly, the historical treatment of job choice in early industrialization has highlighted the importance of working conditions and living environments in addition to wages in the decision to accept and maintain a factory job. For all the theoretical insights and historical descriptions, there has been little systematic econometric analysis of the market for job characteristics, whether with contemporary or historical data. In part, the lack of sufficiently rich data sets has been responsible. In part, there has also been the presumption that the forces producing observed wage variation are so varied and so complex as to preclude isolating the impact of individual effects. It is not clear, however, why price determination in labor markets should be more complex than in any other market where tied sales occur. Indeed, the hedonic reconstruction of demand theory suggests that tied sales and package deals of product characteristics are the rule and not the exception in virtually all market exchange. With this in mind and given the availability of our unusually rich data set we endeavor , in what follows, to investigate workers' preferences with respect to the place of employment.

The market which is being investigated here consists of firms on the one side that, in the context of profit maximization, were seeking workers of varying quality and were offering wages and the opportunity to live and work in a mill compound offering many amenities, and some disamenities. On the other side, workers of varying traits, in the course of attempting

to maximize utility, were seeking higher wages, and better working conditions and living environments. It is further assumed that firm decisions on the quality mix of workers hired and the mix of amenities and disamenities were separable from other firm decisions. Similarly, it is assumed that worker decisions regarding the mix among wages and other amenities were separable from other consumption decisions.

Ignoring random terms the model to be estimated can be written as

(1) $W_i(Z) = F^i(W_c, W_f, Z_i, \ldots, Z_n, T_1, \ldots, T_k) \qquad i = 1, \ldots,$

$\equiv$ demand for labor job characteristics;

(2) $W_i(Z) = G^i(W_c, Z_i, \ldots, Z_n, T_1, \ldots, T_k, M_1, \ldots, M_m) \qquad i = 1, \ldots$

$\equiv$ supply of labor job characteristics;

where $W_i(Z)$ is the price of the job characteristic Z_i

W_c is money wages available for off the job consumption

W_f is money fees available for off the job consumption

T_j is the jth worker's attribute

M_k is the kth nonjob firm characteristic

The W's, Z's, and T's in the system of demand and supply equations (1) and (2) are assumed to be endogenous. The M's are assumed predetermined. Thus, if $M > k + n + 1$ the demand equations will be identified.

While data on the Z_i, W_c, W_f, T_j and M_i are potentially available the absence of explicit markets for individual job characteristics as opposed to jobs or bundles of job characteristics means the W_i would not normally be available. It has been widely suggested that the W_i might be computed indirectly from the derivative of the regression which

explains wages. Thus, we let wages be explained by

(3) $W_c = H(Z_1, \ldots, Z_n, T_1, \ldots, T_k)$

with $\frac{\partial W_c(Z)}{\partial Z_i} = \hat{W}_i(Z)$

It should be emphasized that estimation of (3) without following through with the estimation of the system of supply and demand equations will not give us the information being sought here. $\hat{W}_i(Z)$ may be thought of as a function which traces out the transactions generated by the intersection of buyers of Z_i's compensated demand functions and sellers of Z_i's compensated supply functions, i.e. suppressing all other changes. In the markets for job characteristics being studied here workers clearly differ according to their traits and qualities, and firms clearly differ according to their cost conditions, if for no other reason than that factor prices did differ regionally in Japan. Thus, $\hat{W}_i(Z)$ is generated by many different demand functions intersecting with many different supply functions as determined by the distribution of buyers and sellers in the 1897 cross-section sample. The slope of $\hat{W}_i(Z)$ in the $\hat{W}_i$, Z_i space is not the slope of a demand curve nor the slope of a supply curve. If we wish to understand the determinants of the transactions prices for each of the job characteristics rather than "simply" the implicit transaction price itself, demand and supply functions must be identified and

estimated.[1]

E. The Estimation of the Implicit or Shadow Prices of Job Characteristics

In the estimation which follows it will be assumed that (3) is semi-logarithmic.

$$\ln W_{cf} = \Sigma a_i Z_i + \Sigma b_j T_j + \Sigma c_k R_k + W_o$$

Where $W_{cf} \equiv$ female wage rate

$Z_1 \equiv$ payment to recruitee

$Z_2 \equiv$ length of working shift

$Z_3 \equiv$ length of rest periods during shift

$Z_4 \equiv$ incidence of sickness and injury at place of work

$Z_5 \equiv$ mortality at place of work

$Z_6 \equiv$ living in dormitory

$Z_7 \equiv$ if dormitory occupant, number of free hours per day

$Z_8 \equiv$ food subsidy per dormitory worker

$Z_9 \equiv$ company primary school instructional personnel per worker

[1] Even if labor were perfectly mobile $\hat{W}_i$ should differ from mill to mill provided the functional form of (3) is nonlinear. This is an issue which may be resolved empirically, but that a nonlinear form for (3) might be hypothesized at all requires some discussion. First, it must be assumed that workers cannot repackage jobs. In the present context this is quite easy to assume. Part-time work was really not feasible at all for mill girls. Also all renumerative work was done within the set mill environment. If mill workers slept in the dormitories and if their access to the world outside was limited they could hardly fail to use company dining halls or company health facilities. Second, it is also assumed that firm technology for designing or producing jobs is not linear. This is a common but, of course, not universally made assumption for production functions. For further discussion of these issues see Rosen op. cit. and Lucas op. cit.

T_1 ≡ risk of recruit leaving within six months

T_2 ≡ age of worker

T_3 ≡ relevant experience of worker

T_4 ≡ rate of absenteeism

T_5 ≡ worker literacy

R_1 ≡ agricultural wage rate in area in which plant is located

W_o ≡ constant term

The results of estimating the wage explaining relationship are presented in Table 9. By the usual standards of semi-logarthmic regressions to explain the wage, the results in Table 9 are most interesting. For a one-tailed test of significance with a .05 critical region five explanatory variables and the constant term are significant with the expected sign. When the critical region is expanded to 10 percent another 6 explanatory variables become significant.

1) Agricultural Opportunities and Bonuses

In examining some of the explanatory variables it will first be noticed that for all the long-distance recruiting, opportunities in the vicinity in which the mill was located R_1 have a significant relationship with mill wages. Evaluated at the mean point the elasticity of female mill wages to female agricultural wages is .83 .

The analysis here does not directly tell us the character of the impact of the recruitment bonus on the decision to enter the spinning mill. The sign of the coefficient on Z_2 does suggest, however, that the recruitment bonus was taken out of future wage payments. A spinning mill recruit receiving the industry-wide average wage and the industry-wide recruitment bonus paid a total of three yen out of future wages for each hundred yen she initially received.

Table 9

THE ESTIMATION OF $\ln W = W_o + \Sigma a_i Z_i + \Sigma b_j T_j + \Sigma c_k R_k$

VARIABLE	COEFFICIENT
W_o	$.763 \times 10$ [a]
Z_1	$-.350 \times 10^{-4}$ [c]
Z_2	$.362 \times 10^{-1}$ [c]
Z_3	$-.438 \times 10^{-1}$ [b]
Z_4	$-.289 \times 10^{-2}$
Z_5	$.259 \times 10$ [b]
Z_6	$-.190$ [b]
Z_7	$-.403 \times 10^{-3}$ [c]
Z_8	$-.149 \times 10^{-4}$ [c]
Z_9	$-.133 \times 10^{2}$ [b]
T_1	$.348 \times 10^{-4}$
T_2	$.303 \times 10^{-1}$ [c]
T_3	$.166 \times 10^{-1}$ [c]
T_4	$-.179 \times 10^{-2}$ [b]
T_5	$-.385 \times 10^{-1}$
R_1	$.694 \times 10^{-3}$ [a]

$R^2 = .93$

a ≡ significant at 1% level
b ≡ significant at 5% level
c ≡ signifitant at 10% level

2) Shifts and Rest Periods

A longer daily shift for a mill force was compensated in higher wages in the same way that longer rest periods during a shift of any given length meant lower wages. That the absolute signs of two coefficients are also statistically insignificant from one another even as they are both significantly different from zero is reassuring. The size of the coefficient suggests that typically the marginal compensation for additional work by mill hands was less than average compensation. How the derived demand for labor and worker preferences between leisure and work might yield this result is left for future analysis and the fuller statistical identification of the appropriate functions.

3) Health and Safety

In assessing the impact of health and safety conditions in the m: the analysis here is hampered, as elsewhere, by difficult problems of multicollinearity. The coefficient on sickness and injury is insignificantly different from zero with the wrong sign. On the other hand, the coefficient on mortality is statistically different from zero with the proper sign. The magnitude of the coefficient on mortality suggests that the typical female worker receiving the average industry wage would pay somewhat more than ¥ 2 over her period of employment in order to reduce the risk of mortality by .001. A thousand workers in the same situation would collectively pay ¥ 2000 in order to save one life.

4) Dormitory Conditions and Free Time

The remaining job characteristics in the wage explaining regression are all statistically different from zero. Workers implicitly paid for their dormitory accommodations and food. Firms in 1897 implicitly compensated workers for the restrictions placed on their activities during their leisure. At the same time workers implicitly paid tuition for the existence and quality of schools within the dormitory compound. While restrictions on leisure demanded compensation the worker apparently was not indifferent as to what she did while confined within the mill compound.

Inserting sample values for wages and firms with one-hundred female workers the estimated coefficient on dormitory living implies that an additional worker living in the dormitory would pay an implicit rent equivalent to eight and one-half percent of actual wages. Such a share for rent in total expenditures is not out of line with the budget data which are independently available for almost the same year.

The coefficient on the hours of free time for mill workers living in dormitories, while significantly different from zero, is exceedingly small. The price of an extra hour of free time outside the mill compound is less than 1 percent of a day's wages for most mills. This somewhat surprising result may be explained in a number of ways. First, in this one instance the data might be suspect. Sample information on number of daily hours allowed outside the mill compound was taken by Boren investigators from firm regulations and not, as in the case of

most of the information, collected from actual firm practice. Alternatively, assuming the data is correct, it does follow that the typical worker already allowed two hours outside did not value additional freedom very highly. That the mill for its part should take this attitude is still something of a puzzle. Elsewhere it has been shown that the runaway rate of mill recruits was so high for so long that mills almost certainly could have cut this rate had they been so inclined.[1] The mills chose not to do so because they viewed workers' running away from the mill as an acceptable means of separation. Notice in Table 9 that even the mills with relatively high rates of retention of newly recruited workers paid such cohorts of recruitees no special premium. The mills, in other words, were not interested in investing even the small resources necessary to build a work force composed primarily of longer-term workers. The low implicit price for lessening mill workers' opportunities to run away is certainly consistent with this view.

The coefficient on food subsidies for workers in the wage explaining regression implies that typical workers implicitly "returned" approximatel twenty-eight percent of this subsidy in the form of lower wages. This is puzzling, since, if we assume the possibility of arbitrage among job opportunities of varying characteristics there should have been a yen for yen substitution between wages and food subsidies. Given, however, the fact that packages of job characteristics could not really be untied the

[1] See Saxonhouse, "Country Girls and Communication Among Competitors in the Japanese Cotton Spinning Industry" op. cit.

results here are plausible.[1] Workers lived in a mill dormitory compound with restricted access to the outside and firms had to provide meals The inability to cater to individual tastes and to problems inherent in the mass preparation of food may have caused workers to place a low value on what the firm was providing no matter how efficiently the firm might have been performing this function.

It will be noticed that the coefficient on literacy in the wage explaining regression is insignificantly different from zero. Notwithstanding that firms do not pay literate workers a premium, workers did implicitly pay firms for the quantity and quality of education offered. For example, when the mills doubled the number of instructors per students or halved the class size, workers implicitly paid five and one-half percent of the money wages they would have otherwise received in return for this opportunity. Such implicit payments are all the more surprising since, as was pointed out, these classes were attended after the conclusion of a twelve-hour day or night shift. The importance of the achievement of literacy as a consumption good seems to be underlined.

5. Worker Traits

While the Japanese cotton spinning mills of 1897 apparently paid no premium to workers for their literacy or for their initial disinclination to run away, the other traits in the wage explaining equation are statistically different from zero. The coefficient on the rate of absenteeism is, however,

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[1]Also, perhaps, because the mill was buying in bulk, conceivably the worker might have implicitly paid out more than it was costing the firm to provide the subsidized food.

sufficiently small that it appears the typical mill provided little extra compensation for workers with good attendance. This is interesting since already in 1897 quite a few mills were reporting programs of bonuses for workers with perfect attendance records. Since there is evidence that such programs did not have a time series impact[1] it should not be too surprising to find that their cross-sectional impact was also quite limited.

If workers did not receive a substantial special premium for good attendance, age and increased experience appear to have brought significant rewards. While multicollinearity dogs any effort at precisely distinguishing the separate impact of increased age from increased experience in this sample, they are each significantly different from zero within a 10 percent critical region. Taken jointly a small critical region will suffice to reject the null hypothesis. A twenty year old worker with a year and one-half's experience in a firm of some two hundred workers might expect a 5 percent increase in wages should she work one additional year.[2]

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[1] See Saxonhouse, "Country Girls and Communication Among Competitors in the Japanese Cotton Spinning Industry" op. cit.

[2] In Saxonhouse, "Country Girls and Communication Among Competitors in the Japanese Cotton Spinning Industry" op. cit., using a more comprehensive data set for the 1891-1935 period, relationships between productivity and experience and wages and experience were found in a general setting to be significant. The coexistence between these relationships and high turnover and firm disinterest in cutting turnover can be understood if it is recognized that 1) technologically speaking most Japanese mills were almost identical and 2) most firms were reluctant to invest in improving the quality of their workers. In this paper it was argued that the improvement in worker skills was mainly worker financed.

F. The Estimation of the Utility Function of Workers With Varying Traits

Having briefly summarized what the estimation of (3) can tell us about the implicit market prices for job characteristics and the institutions of mill paternalism, an effort will now be made to look at the determinants of these market prices. Market price is determined by the interaction of supply and demand. It should be the intention here to estimate both these functions. Unfortunately, as can be seen from equations (1) and (2), while it is possible to identify the demand for job characteristics, using nonjob firm characteristics which do not appear in (1), there are no variables in (1) available for use as exclusion restrictions in order to identify (2). Workers traits are assumed to affect both supply and demand functions. Thus, in what follows only individual worker demand functions for job characteristics will be estimated.

With only one side of the market firmly identified, a full explanation of the determination of the price of job characteristics cannot be given. Nonetheless, estimation of the worker demand function alone will still provide an invaluable source of information regarding what workers valued in the early period of Japan's industrialization.

With ten job characteristics and five worker traits, the estimation of a system of demand functions which will serve the purposes of the analysis here is more complex. It is desirable to allow interaction among the demands for job characteristics. At the same time, with so many variables, unless considerable structure is imposed on the problem

there is little hope of feasible estimation. Thus, on the one hand, i will be assumed that workers had transcendental logarithmic utility functions, a functional form which offers very rich possibilities for interaction between various job characteristics,[1] and from which a system of demand equations can be derived. On the other hand, it will be assumed that the utility function here is a utility tree with four branches.[2] The worker, it is hypothesized, makes a decision on how to allocate her Beckerian income among four large categories of off- and on-the-job expenditures.[3] After the decision to allocate among these four categories, a decision is made on within category expenditures. The four categories include

W = Off the Job Consumption[4]

W_c = off the job consumption equal to money wages

W_f = consumption out of bonuses paid at time of recruitment

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[1]A description of a transcendental logarithmic utility function is given in W. E. Diewert, "Applications of Quality Theory" in Frontiers of Quantitative Economics Vol. II, ed. by Michael D. Intriligator and David Kendrick (Amsterdam: North-Holland, 1974).

[2]The utility tree approach is described in R. A. Strotz. "The Empirical Implications of a Utility Tree," Econometrica XXV (April 1957) and R. H. Strotz, "The Utility Tree--A Correction and Further Appraisal," Econometrica XXVII (July, 1959)

[3]Beckerian income is defined as the sum of money wages plus the maximum wages which might be received by the worker. On this concept see Gary Becker, "A Theory of the Allocation of Time" Economic Journal LXXV (September, 1965).

[4]These categories are arguably arbitrary, but given the functional form being used here some such choice is necessary. A priori it is clear that it makes no sense to estimate the health care branch. In a two attribute world Z_{2a} and Z_{2b} can only be substitutes. This is beyond the realm of plausibility. In any event, since it is not possible to get statistically significant estimates of $W_{Z_{2a}}$, it will be assumed that $Z_2(Z_{2a}, Z_{2b}) = Z_{2b}$.

$Z_1 \equiv$ Pace of Work

$Z_{1a} \equiv$ length of rest periods

$Z_{1b} \equiv$ length of working shifts

$Z_2 \equiv$ Health Care

$Z_{2a} \equiv$ incidence of sickness and injury

$Z_{2b} \equiv$ incidence of mortality

$Z_3 \equiv$ Availability and Quality of Dormitory Experience

$Z_{3a} \equiv$ % of workers living in dormitories

$Z_{3b} \equiv$ numbers of hours of time outside mill compound per day

$Z_{3c} \equiv$ food subsidy per dormitory worker x % of workers living in dormitories

$Z_{3d} \equiv$ instructional personnel for company school per worker

Formally the above system can be expressed as follows:

$$(4) \quad \ln U = \ln U(W_c, W_f, Z_{1a}, Z_{1b}, Z_{2a}, Z_{2b}, Z_{3a}, Z_{3b}, Z_{3c}, Z_{3d}; T)$$

$$= \ln U[W(W_c, W_f), Z_1(Z_{1a}, Z_{1b}), Z_2(Z_{2a}, Z_{2b}), Z_3(Z_{3a}, Z_{3b}, Z_{3c}, Z_{3d}; T)]$$

where, as before, T is the traits vector.

Assume now that the worker is maximizing her instantaneous utility subject to the constraint that

$$(5) \quad W - \sum_{i=1}^{3} w_i Z_i = 0$$

within the large budget allocation.[1] The first order conditions for the

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[1]The analytics of utility maximization and the derivation of the system of demand equations will be done for the tree and its four branches The analytics of the within branch utility maximization, of course, are identical.

maximization of utility can be written as follows:

(6) $\frac{\partial \ln U}{\partial \ln W} = \mu \frac{W}{U}$

$$\frac{\partial \ln U}{\partial \ln Z_i} = \mu \frac{W_i Z_i}{U} \quad (i = 1, 2, 3)$$

where μ is the marginal utility of income. From the budget constraint

(7) $\frac{\mu}{U} = \left(\frac{1}{W + \sum_{i=1}^{3} w_i Z_i}\right) \left(\frac{\partial \ln U}{\partial \ln W} + \sum_{i=1}^{3} \frac{\partial \ln U}{\partial \ln Z_i}\right)$ so that

(8) $$\frac{\partial \ln U}{\partial \ln W} = \frac{W}{W + \sum_{i=1}^{3} w_i Z_i} \left(\frac{\partial \ln U}{\partial \ln W} + \sum_{i=1}^{3} \frac{\partial \ln U}{\partial \ln Z_i}\right)$$

The form of the relationship used to approximate the negative logarithm of the utility function is given by

(9) $$-\ln U = \alpha_o + \alpha_W \ln W + \sum_{i=1}^{3} \alpha_{Zi} \ln Z_i + \sum_{i=1}^{3} \beta_W \beta_{Zi} \ln W \ln . Z_i$$

$$+ \sum_{i=1}^{3} \sum_{j=1}^{3} \beta_{Z_i Z_j} \ln Z_i \ln Z_i$$

$$+ \sum_{i=1}^{5} \beta_{WT_i} \ln W \ln T_j + \sum_{i=1}^{3} \sum_{j=1}^{5} \beta_{Z_i T_j} \ln Z_i \ln T_j$$

Using this form with (8) the following can be obtained

(10) $$\alpha_W + \beta_{WZ_i} \ln Z_i + \Sigma\beta_{WT_j} \ln T_j = \frac{W}{W + \Sigma W_i Z_i} [\alpha_W + \Sigma\beta_{WZ_i} + \Sigma\beta_{WT_k} \ln T_k +$$

$$\Sigma(\alpha_{Z_i} + \beta_{WZ_i} \ln W \beta_{Z_i Z_j} \ln Z_j + \Sigma\beta_{Z_i T_j} \ln T_k)$$

$$\alpha_{Z_i} + \beta_{WZ_i} \ln W_j + \Sigma\beta_{Z_i Z_j} \ln Z_j + \Sigma\beta_{Z_i T_k} \ln T_k$$

$$= \frac{W_i Z_i}{W + \Sigma W_j Z_j} [\alpha_W + \Sigma\beta_{WZ_j} \ln Z_j + \Sigma\beta_{WT_k} \ln T_k$$

$$+ \Sigma (\alpha_{Z_j} + \beta_{WZ_j} \ln W + \Sigma\beta_{Z_j Z_m} \ln Z_j + \Sigma\beta_{Z_m T_k} \ln T_k)$$

$$(i = 1, 2, 3)$$

Rearranging

$$(11)\quad \frac{W}{W + \Sigma W_i Z_i} = \frac{\alpha_W + \Sigma\beta_{WZ_i} \ln Z_i + \Sigma\beta_{WT_j} \ln T_j}{[\alpha_W + \Sigma\beta_{WZ_i} \ln Z_i + \Sigma\beta_{WT_k} \ln T_k + \Sigma(\alpha_{Z_i} + \beta_{WZ_i} \ln W + \Sigma\beta_{Z_iZ_j} \ln Z_j + \Sigma\beta_{Z_iT_k} \ln T_k)]}$$

$$\frac{W_i Z_i}{W + \Sigma W_i Z_i} = \frac{\alpha_{Z_i} + \beta_{WZ_i} \ln W + \Sigma\beta_{Z_iZ_j} \ln Z_j + \Sigma\beta_{Z_iT_k} \ln T_k}{[\alpha_W + \Sigma\beta_{WZ_j} \ln Z_i + \Sigma\beta_{WT_k} \ln T_k + \Sigma(\alpha_{Z_j} + \beta_{WZ_j} \ln W + \Sigma\beta_{Z_jZ_m} \ln Z_j + \Sigma\beta_{Z_mT_k} \ln T_k)]}$$

$$(i = 1, 2, 3)$$

The budget share equations in (11) constitute the first level of the system of demand which will be estimated. Of the four equations, because of the budget constraint, only three are independent. In the empirical work to be reported it is assumed that the budget share equations have additive disturbances with a joint normal distribution. Given the disturbances of any n - 1 of the budget share equations, the disturbance of the remaining equation can be determined from the budget constraint.[1]

The estimation of the within branch share equations will proceed analogously with the first level of estimation. $W(W_c, W_f)$, $Z_1(Z_{1a}, Z_{1b})$, $Z_2(Z_{2a}, Z_{2b})$, and $Z_3(Z_{3a}, Z_{3b}, Z_{3c}, Z_{3d})$ will be separately approximated by a transcendental logarithmic form analogous to (7) and separate blocks of budget share equations analogous to (10) will be derived.

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[1] The budget share equations (11) are homogeneous of degree zero in the parameters; hence a normalization of the parameters is required for estimation. The following normalization is adopted $\Sigma\alpha_i = -1$.

1. Estimation of Off-the-Job Consumption Branch[1]

The results in Table 10 provide the demand part of the system which generates the market data on the relationship between recruitment bonuses and wages reviewed earlier. Female workers viewed recruitment bonuses and wages as substitutes. A higher recruitment bonus today was a substitute for higher wages throughout the worker's period of employment.

Using the parameters of the demand subsystem a number of elasticities have also been calculated. The "expenditure" elasticities (really receipt elasticities) suggest that as workers receive more in wages and recruitment bonuses, the latter become relatively less preferred. This is entirely consistent with the expected relation between resources and time preference.

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[1]To estimate the unknown parameters of the branch budget share equations and the grand budget share equations the iterative Zellner estimated procedure is used. This procedure is described in A. Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias" Journal of the American Statistical Association LVII (June 1962) and A. Zellner, "Estimators for Seemingly Unrelated Regression Equations: Some Exact Finite Sample Results" Journal of the American Statistical Association LVIII (December, 1963). The nonlinear estimation routine used in these procedures employs a combination of Gauss-Newton and the method of + steepest ascent.

Table 10

Parameter	Estimate
α_{W_c}	-.8221 (.0964)
α_{W_f}	-.1779 (.0000)
$\beta_{W_c W_c}$	.8209 (.3348)
$\beta_{W_c W_f}$	.5514 (.1459)
$\beta_{W_f W_f}$	.0048 (.0013)
$R^2 = .772$	
Estimated Expenditure Elasticities	
$\eta_{W_e E}$	1.02
$\eta_{W_F W}$	.89
Estimated Allen Elasticity of Substitution	
$\sigma_{W_c W_f}$	4.78
Estimated Price Elasticiti	
$\eta_{W_c W_c}$	.012
$\eta_{W_f W_f}$	-.236
$\eta_{W_c W_f}$	1.021
$\eta_{W_c W_c}$	4.66

2. Estimation of the Pace of Work Branch

The results of Table 11make clear that the hypothesis that mid-Meiji textile workers viewed rest periods during a shift and length of the shift itself as substitutes provides a plausible framework for estimation. A one percent increase in the implicit price of either a change in the total length of the rest period or a change in the length of a shift led to a better than two percent increase in implicit "expenditures" on the other job characteristic. Also, as a female worker had more resources to allocate to the improvement of the quality of her job, the estimated expenditure elasticities taken from th fitted utility function indicate that shortening the work shift was given priority over increased rest periods. This accords well with the historical experience of other spinning companies after 1897 though it would be hard to argue that the shortening which did occur was largely a result of changing market phenomena.[1]

[1]Rather, the step-wide reduction of shifts from eleven to eight and one-half hours resulted at least in large part from the persistent pressure of the International Labor Organization.

Table 11

Parameter	Estimate
$\alpha_{z_{1a}}$	-.438 (.052)
$\alpha_{z_{1b}}$	.562 (.000)
$\beta_{z_{1a}z_{1a}}$	.640 (.284)
$\beta_{z_{1b}z_{1b}}$	.043 (.025)
$\beta_{z_{1a}z_{1b}}$	.119 (.056)
$R^2 = .58$	
Estimated Expenditure Elasticities	
$\eta_{z_{1a}(\Sigma W_{z_{1i}z_{1i}})}$	.87
$\eta_{z_{1b}(\Sigma W_{z_{1i}z_{1i}})}$	1.24
Estimated Allen Elasticity of Substitution	
$\alpha_{z_{1a}z_{1b}}$	4.3
Estimated Price Elasticities of Demand	
$\eta_{z_{1a}z_{1a}}$	-2.03
$\eta_{z_{1b}z_{1b}}$	-3.35
$\eta_{z_{1a}z_{1b}}$	2.42
$\eta_{z_{1b}z_{1a}}$	2.90

3. Availability and Quality of Off-the-Job Compound Experience

It is instructive to review the estimates for off-the-job but within the mill compound attributes of jobs presented in Table 12 in light of the earlier discussion of typical implicit prices for these attributes. Despite the low implicit price for free time outside the mill compound, the expenditure elasticity of demand for unchaperoned hours outside the mill is very high. If increasing resources for improving her off-the-job environment became available unsupervised leisure time outside the mill was the preferred attribute. These findings, together with the price inelastic demand for free time, suggests that a highly elastic supply of free time from the firm's side may be responsible for the observed low implicit price of unsupervised time. Firms apparently just did not care that much about security. That unsupervised free time and worker education should have relatively high elasticities of expenditure and that shelter and food should have low elasticities of expenditure is entirely consistent with most demand and budget studies.[1] Stereotypes of the susceptibility of young Japanese female workers to paternalistic blandishments aside, the same independence which resulted in high runaway rates also resulted in a high preference for free time outside the mill compound over organized "leisure time" activities provided by management.

[1]Of course, the categories used here are rougher or at least quite different from what is normally found in demand and budget studies. The expenditure elasticity of demand for food subsidies is not the same as expenditure elasticity for food. This does not, however, alter the conclusion drawn.

Table 12

Parameter	Estimate
$\alpha_{z_{3a}}$	-.3727 (.0159)
$\alpha_{z_{3b}}$	-.0814 (.0622)
$\alpha_{z_{3c}}$	-.4294 (.2602)
$\alpha_{z_{3d}}$	-.1165 (.0000)
$\beta_{z_{3a}z_{3}}$	.8210 (.4325)
$\beta_{z_{3a}3b}$	.0892 (.0649)
$\beta_{z_{3a}z_{3c}}$	.7801 (.3920)
$\beta_{z_{3a}3d}$	.0399 (.0161)
$\beta_{z_{3b}z_{3b}}$	-.0689 (.0408)
$\beta_{z_{3b}z_{3c}}$	-.0724 (.0137)
$\beta_{z_{3b}z_{3d}}$	.0083 (.0126)
$\beta_{z_{3c}z_{3c}}$	-.7992 (.1414)
$\beta_{z_{3c}z_{3d}}$	-.1191 (.0082
$\beta_{z_{3d}z_{3d}}$	-.0546 (.0200)

Table 12 - continued

Parameter	Estimate
$\bar{R}^2$	
$z_{2a} \equiv .82$	
$z_{3b} \equiv .68$	
$z_{3c} \equiv .90$	
$z_{3d} \equiv .41$	
Estimated Expenditure Elasticities of Demand	
$\eta_{z_{2a}(\Sigma W_{z_{3i}} z_{3i})}$	.56
$\eta_{z_{3b}(\Sigma W_{z_{3i}} z_{3i})}$	2.10
$\eta_{z_{3c}(\Sigma W_{z_{3i}} z_{3i})}$	.88
$\eta_{z_{3d}(\Sigma W_{z_{3i}} z_{3i})}$	1.09
Estimated Allen Elasticities of Substitution	
$\alpha_{z_{3a} z_{3b}}$	-.264
$\alpha_{z_{3a} z_{3c}}$	-.381
$\alpha_{z_{3a} z_{3d}}$	4.209
$\alpha_{z_{3b} z_{3c}}$	.818
$\alpha_{z_{3b} z_{3d}}$	1.93
$\alpha_{z_{3c} z_{3d}}$	.975

Table 12 - continued

Parameter	Estimate
Estimated Price Elasticities of Demand	
$\eta_{z_{3a} z_{3a}}$	.0717
$\eta_{z_{3a} z_{3b}}$	.0240
$\eta_{z_{3a} z_{3c}}$	0768
$\eta_{z_{3a} z_{3d}}$	5556
$\eta_{z_{3b} z_{3b}}$	0221
$\eta_{z_{3b} z_{3a}}$	6843
$\eta_{z_{3b} z_{3c}}$	1.253
$\eta_{z_{3b} z_{3d}}$	4694
$\eta_{z_{3c} z_{3c}}$	-.7518
$\eta_{z_{3c} z_{3a}}$	.1859
$\eta_{z_{3c} z_{3b}}$	.1382
$\eta_{z_{3c} z_{3d}}$	.2406
$\eta_{z_{3d} z_{3d}}$	-18.40
$\eta_{z_{3d} z_{3a}}$	1.975
$\eta_{z_{3d} z_{3b}}$	2451
$\eta_{z_{3d} z_{3c}}$	8867

It is also most reasonable that dormitory services should be complementary with free time outside the mill and food subsidies. A substantial number of female workers bought no dormitory services and hence had little desire to implicitly purchase unsupervised leisure time and diminished if not negligible desire to gain company subsidized food.

While it is difficult to rationalize market prices explicit, implicit or otherwise in the absence of information about the character of suppl the results on worker preferences for education do remain puzzling. Recall the implicit price of other available education within the mill was estimated as being very large. Now if the quality of available education is measurable by the teacher-pupil ratio it would seem the supply of more and better quality primary and department education would be highly price elastic. Given that the expenditure elasticity of demand for education is near unity and that education's own price elasticity of demand is evidently very high it is hard to understand why the implicit price of education was so high for many workers.

G. The Choice Among Off-the-Job Goods, Pace of Work, Health and Dormitory Life.

The estimates of each of the branches or demand subsystems allows for the condensing of nine attributes into four off-the-job goods, pace of work, health and dormitory life. The estimation of the demand system given in (10) describing the allocation of female worker Beckerian income on these four attributes conditioned on five workers' traits is given in Table 13.

Table 13

Parameter	Estimate
α_W	-.7242 (.0510)
α_{z_1}	-.0921 (.0357)
α_{z_2}	-.0448 (.0109)
α_{z_3}	-.1389 (.0000)
β_{WW}	.9007 (.2879)
β_{Wz_1}	.0343 (.0209)
β_{Wz_2}	.0108 (.0022)
β_{Wz_3}	.2343 (.1641)
β_{WT_1}	-.2167 (.9834)
β_{WT_2}	.0828 (.0169)
β_{WT_3}	.0633 (.0391)
β_{WT_4}	-.1368 (.0452)
β_{WT_5}	.0034 (.0145)
$\beta_{z_1z_1}$	-.0284 (.0001)
$\beta_{z_1z_2}$	-.0479 (.0683)

Table 13- continued

Parameter	Estimate
$\beta_{Z_1Z_3}$	.1423 (.1046)
$\beta_{Z_1T_1}$	+.0527 (.0040)
$\beta_{Z_1T_2}$	-.0096 (.0044)
$\beta_{Z_1T_3}$	.0041 (.0158)
$\beta_{Z_1T_4}$	.0114 (.0059)
$\beta_{Z_1T_5}$	-.0186 (.0047)
$\beta_{Z_2Z_2}$	-.0304 (.0121)
$\beta_{Z_2Z_3}$	.0174 (.0063)
$\beta_{Z_2T_1}$	.0088 (.0150)
$\beta_{Z_2T_2}$	.0694 (.0199)
$\beta_{Z_2T_3}$	.0332 (.0146)
$\beta_{Z_2T_4}$	-.0241 (.0202)
$\beta_{Z_2T_5}$	.0081 (.0069)
$\beta_{Z_3Z_3}$	-.0910 (.0229)
$\beta_{Z_3T_1}$	.0728 (.0304)
$\beta_{Z_3T_2}$	-.0380 (1.0492)

Table 13- continued

Parameter	Estimate
$\beta_{Z_3T_3}$	-.0198 (.0146)
$\beta_{Z_3T_4}$	.0776 (.0749)
$\beta_{Z_3T_5}$	-.0093 (.0057)

R^2's

$W = .93$

$Z_1 = .52$

$Z_2 = .59$

$Z_3 = .69$

Estimated Expanditure Elasticity of Demand

$\eta_{W(W+\Sigma W_i Z_i)}$	.84
$\eta_{Z_1(W+\Sigma W_i Z_i)}$	1.38
$\eta_{Z_2(W+\Sigma W_i Z_i)}$	1.47
$\eta_{Z_3(W+\Sigma W_i Z_i)}$	1.12

Estimated Allen Elasticities of Substitution

σ_{WZ_1}	1.899
σ_{WZ_2}	3.302
σ_{WZ_3}	2.851
$\sigma_{Z_1Z_2}$	1.919
$\sigma_{Z_1Z_3}$	1.670
$\sigma_{Z_2Z_3}$	1.141

Table 13 - continued

Parameter	Estimate
Estimated Price Elasticity of Demand	
η_{WW}	-.1828
η_{z_1W}	2.374
η_{z_2W}	3.455
η_{z_3W}	2.875
η_{Wz_1}	.2523
$\eta_{z_1z_1}$	-1.565
$\eta_{z_2z_1}$	.3121
$\eta_{z_3z_1}$	.2569
η_{Wz_2}	.1856
$\eta_{z_1z_2}$	.1477
$\eta_{z_2z_2}$	-2.658
$\eta_{z_3z_2}$	.1012
η_{Wz_3}	.5129
$\eta_{z_1z_3}$	.4236
$\eta_{z_2z_3}$	.3627
$\eta_{z_3z_3}$	2.222

The expenditure elasticities of demand calculated from the estimated demand system suggest that at very low Beckerian incomes workers cared most about wages. As incomes increased higher priority was placed on reducing the risk of mortality, and improving on-the-job conditions, and to a lesser extent on improving dormitory life. Evidence from this cross-section also does well as an indicator of secular trends. Real wages have risen since 1897 and while the prices paid are not known workers have implicitly purchased more safety and improved on-the-job conditions. And while improvement in the quality of dormitory life did occur before World War II the great changes comparable to what happened in safety and shifts were only to come in the late 1950s.

Too much should not be made of the poor workers' strong preference for money wages. The results in Table 13on elasticities of substitution and price elasticities of demand are such that even at a low level of Beckerian income workers will be most sensitive to new opportunities to inexpensively reduce the risk of mortality, slow the pace of work and improve dormitory life.

H. Traits and Preferences

In order to understand how preferences may vary among workers with different traits the sign of the partial derivative of each of the elasticities presented in Table 13 with respect to each of the five worker traits are presented in Table 14.

Table 14

	T_1	T_2	T_3	T_4	T_5
$\eta_{W(W + W_i z_i)}$	-	+	+	-	-
$\eta_{z_1(W + W_i z_i)}$	+	-	-	+	-
$\eta_{z_2(W + W_i z_i)}$	+	+	+	-	+
$\eta_{z_3(W + W_i z_i)}$	+	-	-	+	+
σ_{Wz_1}	-	+	+	-	-
σ_{Wz_2}	-	+	+	-	+
σ_{Wz_3}	-	+	+	-	-
$\sigma_{z_1 z_2}$	+	+	+	-	-
$\sigma_{z_1 z_3}$	+	-	-	+	-
$\sigma_{z_2 z_3}$	+	+	+	+	+
η_{WW}	-	+	+	-	-
$\eta_{z_1 W}$	-	+	+	-	-
$\eta_{z_2 W}$	-	+	+	-	-
$\eta_{z_3 W}$	-	+	+	-	+
η_{Wz_1}	-	+	+	-	-
$\eta_{z_1 z_1}$	+	-	+	+	+
$\eta_{z_2 z_1}$	+	+	+	-	-
$\eta_{z_3 z_1}$	+	-	-	+	-
η_{Wz_2}	-	+	+	-	+

Table 14 continued

	T_1	T_2	T_3	T_4	T_5
$\eta_{z_1 z_2}$	+	+	+	−	−
$\eta_{z_2 z_2}$	+	+	+	−	+
$\eta_{z_3 z_2}$	+	+	+	+	+
$\eta_{W z_3}$	−	+	+	−	+
$\eta_{z_1 z_3}$	+	−	−	+	−
$\eta_{z_2 z_3}$	−	+	+	−	−
$\eta_{z_3 z_3}$	+	−	−	+	+

The impact of traits on preferences is understandably most complex. Workers with relatively low Beckerian income and a high propensity to run away exhibit a greater preference for money wages than their more stable counterparts. The same result carries over to workers exhibiting a high rate of absenteeism. The unstable poor worker cared relatively little for the mill environment. By contrast, older, more experienced workers, even when poor, showed relatively more interest in shortening the workday and improving the dormitory environment. Interesting enough, this concern with the nonwage aspects of the job does not extend to lowering the risk of mortality. Older more experienced workers when poor seemed less inclined to pay for safety than other workers. Presumably the more experienced workers placed more reliance on themselves and less on the mill environment in trying to avoid risk. Similarly, older workers, closer to retirement or natural death, might be viewed as having less to lose in human capital than their younger counterparts

The findings on the substitution and price elasticities are consistent with the above interpretation of the expenditure elasticities. Workers with high absentee rates and a high propensity to run away found nonpecuniary benefits relatively poorer substitutes for wages than other workers. For such workers the share of wages in the total Beckerian income will be relatively insensitive to changes in implicit prices.

Again, for older and more experienced and stable workers the opposite is generally true. For these workers most job characteristics are relatively good substitutes for each other and expenditure shares are relatively sensitive to price changes.

I. The Market for Workers: Summary and Conclusions

Changes in the quality, morale and organization of the labor force in Japan's early textile industry appear to be responsible for the bulk of the improvement in total factor productivity during this period.[1] A better educated, more experienced labor force, working shorter hours, transformed an industry which could not compete with even Indian yarns in its home market into the major force in world textile markets. Most of these changes in the quality, morale and organization of the labor force were exogenously determined. The incidence of exposure to government-sponsored primary education changed dramatically during the latter half of the Meiji period. Shifts were shortened mainly in response to international pressures, and worker experience increased not because new recruits on average stayed longer but because the industry matured and the one or two workers from each entering cohort who stayed permanently became part of the corps of supervisory workers. That the Japanese textile industry continued for fifty years to have a transient labor force does not, therefore, imply that the industry's elaborate paternalistic practices were a failure. In all likelihood the industry did attract the kind of labor force it wanted. Other developing nations have organized their labor forces differently and have had textile industries using many more men and much more experienced labor. If this is so, what is the meaning of the Japanese industry's paternalistic practices? The answer to this question is really two-fold, i.e. in terms

[1] Saxonhouse, "Productivity Change and Labor Absorption in Japanese Cotton Spinning 1891-1935," Quarterly Journal of Economics, op. cit.

first, of what paternalism meant to labor recruitment, and second, in terms of how the practice of paternalism related to the choice of technique by the industry. We have begun here to address the first of these two issues. The attempt is made within the broader setting of trying to understand the overall structure of worker preferences and job choice.

The econometric analysis performed finds that workers in Japan's early industrialization chose their jobs on the basis of both pecuniary and nonpecuniary considerations. In their transactions with their employers, workers exhibited a willingness to implicitly pay for the dormitory space they might occupy, for food subsidies, for more time outside the mill compound and for within the mill educational opportunities. Workers also exhibited a willingness to pay for on-the-job improvements such as more safety, longer rest periods and shorter working shifts. They were clearly not indifferent to compound and job conditions. This does not mean, however, that a bundle of job characteristics weighted with nonpecuniary benefits was necessarily an "efficient" means of attracting workers. For example, the econometric analysis presented here suggests workers would have considered themselves better off if the resources their employers devoted to food subsidies had been given to them directly. Moreover, reactions to job and compound amenities varied from worker to worker. The less the Beckerian income the worker received from the mill the stronger his preference for pecuniary benefits. Also, the less a worker's attachment to his job the stronger his preference for pecuniary benefits. Such workers viewed nonpecuniary amenity as relatively poor substitutes for money. By contrast, older and more experienced worker

seemed to place a relatively higher priority on nonpecuniary benefits and were more sensitive to relative prices in deciding between pecuniary and nonpecuniary benefits.

The association between the traits of stability and positive reaction to the mill and the job environment suggest further manipulation of these variables might be one way to obtain the more stable work force which was absent from the Japanese textile industry in this period. Given the package of job characteristics offered, the industry acquired a work force which cared primarily for money wages and had little attachment to the job they were performing. More significant is the fact that the recruitment of such workers was apparently in the firms' interest, i.e. consistent with profit maximization along labor intensive production functions.

V. Summary and Conclusions

This paper tackles the question of technology choice in the Japanese cotton textile industry historically from two rather unconventional points of view. One, it is unconventional in going beyond the customary factor price distortion story in trying to explain the choices made over time in the 19th century Japanese cotton textile industry, with the help of the contrasting experience of its Indian counterpart. It is unconventional, moreover, in another sense, i.e. in pursuing the appropriate goods or quality variation avenue initiated by Lancaster but via the use of a basically conventional, i.e. profit maximization cum production function derived, methodology

Both approaches yield cumulative and mutually reinforcing conclusions helpful for our understanding of the technology choice and technology change process at the private entrepreneurial level, and to the evolution of a more appropriate public policy framework to affect the social returns emanating from such private choices.

Our effort to understand the relationship among the common source of spinning technology, Platt's of London, and the individual Japanese entrepreneur, in contrast to his Indian counterpart, illuminated the importance of overall rules of the game within which industries are operating. The two sequential waves of labor-using innovation processes adopted in Japanese spinning, for example, were not duplicated in India mainly because of differences in organizational features within the two industries. These differences had less to do with the extent of overal

protection and relative factor price distortion than they did with the relative strength of domestic animal spirits, enhanced by a cartel-like Japanese Cotton Spinners' Association structure, and diminished by the Indian Managing Agency system.

Part of the explanation of why Japan enhanced the labor absorption capacity of a given technology set, whether mules (earlier) or rings (later), has to do with such relatively "conventional" responses as the resort to more double shifting and fuller physical use of the capital stock generally by reducing "down-time" and maintaining machines more intensively in general. Part also has to do with the less conventional notion of exploring the trade-offs among various attributes of the product in terms of the response of changes in labor absorption rates on the primary factor input side and of market demand changes on the output side. A second important dimension of the latter is the additional flexibility which may be achieved via changes in the quality of the intermediate input, in this case raw cotton, with or without associated changes in product quality. The two applications of the appropriate goods concept first explored by Lancaster and pushed further by Frances Stewart in the LDC context gives one hope that, if relative commodity prices can be made to reflect more accurately the attribute bundle contained, not only can consumer choice decisionsbe rendered more efficient, in terms of the avoidance of irrelevant or even undesirable dimensions, but the more efficient use of the economy's primary factor endowment promoted. In short, we found convincing evidence that the so-called Eckaus straitjacket with respect to factor proportions in a labor surplus context, which

had been losing its credibility in recent years, from the strict existence of alternative technologies for a strictly defined given product point of view, is further weakened in at least two respects: one, in terms of the additional evidence presented on the important role of technological substitutability among production technologies in both the important cotton spinning and weaving industries; and second, in terms of the wide range of additional technological choices which become relevant once the implausible veil over the perfectly standardized intermediate input and output quality mix is lifted

With respect to the closely related dimension of technology change our results indicate the important linked nature of such dynamic innovations as the judicious mixing of various cotton staples on widening the static technology choices available with respect to the use of alternative average qualities of raw cotton to be worked up to a given quality cotton yarn. Secondly, our findings underline the importance of the introduction and rapid diffusion of the major innovation represented by the shift from mule to ring technology and a variety of less dramatic but nevertheless important technological changes in cotton weaving. In both instances the importance of domestic adaptations of new imported technology variants, e.g. in speeding up the rings and using more female labor and in the Batten and Jacquard-related improvements of traditional hand-loom technology, was demonstrated.

Finally, this study tries to shed some new light on LDC labor markets by examining the paternalistic structure of nineteenth century Japanese experience from the point of view of individual worker characteristics and preferences as well as its effects on firm

recruitment techniques and technology choices. Surprisingly, in terms of commonly held beliefs, the cotton textile labor force was mainly concerned with the levels of direct remuneration and showed little job attachment in response to the paternalistic features offered by employers. Perhaps even more surprising, this high-turnover unskilled labor force proved highly efficient and satisfactory from the profit-maximizing perspective of firm management.

There are a considerable number of policy conclusions to be drawn from this foray into economic history combined with econometric analysis. For one, the attention of LDC policy-makers should be turned increasingly to the potential of hitherto neglected appropriate goods--not only as a way of satisfying internal markets demands more efficiently in terms of the avoidance of attribute overspecification but also in terms of the additional mopping up of surplus labor made possible in this fashion. Part of the challenge lies in information gathering and dissemination with respect to both output and technology options, even within a given industry. In Japan this task was performed by the trade association which, combined with relatively non-restrictive credit markets and free entry, led to remarkable rates of diffusion. The historical case of India is, of course, much closer to the contemporary LDC situation highly imperfect credit markets restricting entry, and a management system under a veil of institutional constraints restricting entrepreneurial incentives. In addition to important, if not altogether novel actions indicated in the direction of credit market liberalization i.e. the demand side, the evidence points to an important direct role for the public sector on the supply side, namely that of making producers

as well as consumers aware of existing appropriate good options. While some commodity attributes come in fixed bundles, many others are substitutable for each other; just the information on what is feasible in terms of alternative counts, weft-warp-weight combinations and their relation to the warmth or strength dimensions of the final product may be of great value. We are not speaking of the dissemination of a simple-minded catalogue of all the technological and attribute alternatives on some sort of theoretical "world shelf." Much more modestly, information on the variability in relative prices accompanying variability in commodity characteristics in existence even within different regions of the same country, and certainly within the rural sector of countries in the same region, could be very valuable. Ideally such information should be combined with a flexible and mobile rural appropriate goods technical assistance capacity to help entrepreneurs break a particular informational or input bottleneck. Workshop and repairshop capacities are required along with the information adjustment and dissemination capacity. A system's ability to shift to a more participatory development path by fully deploying it human resources to satisfy basic consumption requirements could be substantially enhanced by such actions.

Most developing countries have some beginnings at least of a science and technology research network. As is well known, however, most such institutions are generally only beginning to interest themselves in the area of appropriateness of goods and/or technologies, especially in the rural areas. Establishing a new autonomous institution here and there oriented to this purpose, while leaving the bulk of meager

public sector R & D funds to be expended on the usual array of "big" science and "breakthrough" technology projects is not enough. A decision has to be made that the capacity to spread information and assist in identifying opportunities in this area must be just as decentralized as the system's decisions on conventional public overhead allocation and on its willingness to deploy the market mechanism to ensure more equitable access to credit and the other critical inputs. Relative goods prices can reflect the existence of trade-offs among the competitive atttributes facing consumers only when producers can respond to the underlying alternative cost reducing factor combinations.

Our findings also tend to support the importance of domestic adaptations relative to the technology imports. Foreign suppliers' advice on major technology choices has relatively little impact; what matters more is the extent of competitiveness in the recipients industrial environment which affects not only their borrowing choice but also their adaptive technological capacity. Placing too much emphasis on machinery salesmen and multi-national corporations' inappropriateness of technology choice is probably a matter of secondary importance in contrast with creating and maintaining conditions of workable competition in the organized industrial sector.

Moreover, our work on Japanese cotton textile labor markets leads us to the conclusion that turnover rates have been much exaggerated as an explanation of efficiency levels along labor intensive production functions. What is clearly more important than individual unskilled labor productivity is the ability to organize large numbers of relatively unskilled workers along production

functions which ensure high capital productivity by maintaining emphasis on simple repetitive tasks requiring a manual dexterity which can be learned in a very short while. The maintenance of low wages and the rapid accrual of learning by doing clearly more than outweighed the possible advantages of formal within-plant education and lower turnover rates. Moreover, the evidence indicates that, especially younger workers, respond better to pecuniary rather than the equivalent non-pecuniary or paternalistic benefits. As long as labor surplus persists, if labor markets are subject to less interference, firms will be in a better position to select the precise quantity and quality of labor desired.