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TECHNOLOGY AND LABOUR ABSORPTION IN THE INDIGENOUS SUGAR INDUSTRY OF INDIA: AN ANALYSIS OF APPROPRIATE TECHNOLOGY*

YUKIHIKO KIYOKAWA AND AKIHIKO OHNO

Abstract

A history of the Indian sugar industry occupies an unprecedented position in international terms in that the indigenous sugar industry survived even after the advent of the modern sugar industry. Even today the production of indigenous unrefined sugar outweighs that of modern refined sugar. This situation suggests us the indigenous sugar industry has possessed sufficient competitive edge against the modern industry. Our paper on the Indian sugar industry in the 1920s and '30s examines the reasons of the coexistence of the indigenous and modern sugar industries, based upon the facts that 1) the modern industry could only grow fragile competitiveness despite several protective measures, and that 2) the indigenous industry enhanced its competitive edge by adapting modern sugar technologies and improving indigenous ones.

Our investigation clarifies the necessary conditions for appropriate technology to satisfy, and also finds the great significance of the employment creation effect by appropriate technology.

I. *The Indigenous and Modern Sugar Industries in India*

The nineteenth century, in particular the latter half, saw a large increase in the production of sugar. This rise in production was largely the result of the growth in the production of beet sugar. The production of beet sugar became feasible, in a practical sense, at the beginning of the nineteenth century and then took off during the 1830s with the strong stimulus given by the Prussian and French governments. Its production accounted for one quarter of world sugar production by the 1860s and as early as the 1890s, its share exceeded 50%, surpassing the production of sugar from cane.

This rapid development in the production of beet sugar was brought about by 1) highly mechanised production methods and 2) production management techniques based on strict chemical control, which were made possible by Europe's advanced technology. In particular, it was the string of path-breaking technological innovations from the middle of the nineteenth

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century onwards that enabled such development. Typical innovations of those were the improvement and spread of the centrifuge, the development of the multiple-effect evaporator and vacuum [boiling] pan, which were decisive in determining the superiority of modern sugar manufacturing technology, and the diffusion process and carbonation method, which were crucial to the efficient production of beet sugar[1].

With the use of this new technology, the competitiveness of beet sugar grew and its production expanded rapidly, whilst the production of cane sugar was placed under increasing pressure. Towards the end of the nineteenth and the beginning of the twentieth century, this modern technology began to be introduced and adapted gradually to cane sugar production, so that the production of cane-sugar using modern methods saw a remarkable growth in all the world's sugar producing countries. It was the Indian modern sugar industry which was the only one to occupy a little unique position in this worldwide expansionary process. In countries such as Cuba and Java, the indigenous sugar industry was typically restructured in a comparatively short time to one using large factory production based on new technology. In contrast, the indigenous sugar industry in India managed to strengthen its competitiveness so that it was not easy for the modern sugar industry to become firmly established.

Various factors for the inability of the modern sugar industry to take a firm hold in India have been blamed, including 1) the difficulties in procuring raw material (sugarcane) and 2) the lack of managerial ability[2]. It is not our intention in this paper, however, to examine these problems in depth for the following reasons. Firstly, there is the fundamental problem relating to the form of control adopted by capital emanating from the colonial power. Secondly, we regard the second factor above as more important, but there are not sufficient micro data to be able to confirm the proposition.

It is certain, however, that the development of the modern sugar industry, hindered by the development of the indigenous sugar industry, was remarkably late. Furthermore, its international competitiveness was poor, since plantation white sugar continued to be imported from Java and Mauritius (the situation is illustrated in Figure 1). Consequently, we believe that it is more important to examine why the indigenous sugar industry in India was so competitive and moreover, to examine the implications. Therefore, our aims are 1) to investigate how indigenous technologies were improved by the indigenous sugar industry and how the improvements approximated appropriate technologies, and 2) to estimate the amount of labour absorption that occurred in the rural villages with large amounts of surplus labour, as the result of these improvements which realised the maintenance of competitiveness.

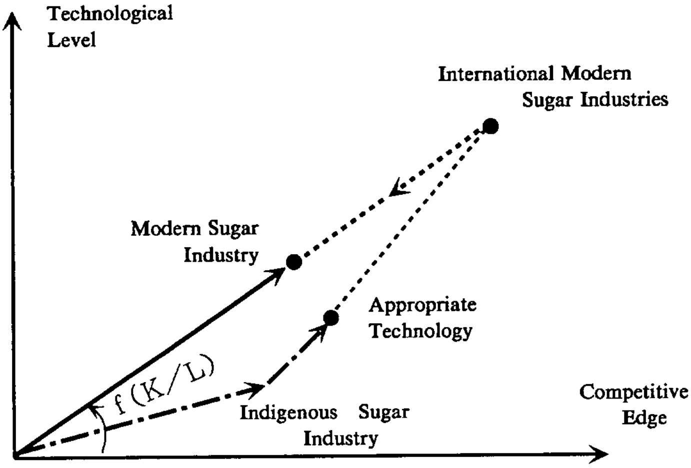
There are two kinds of indigenous sugars in India, *gur* and *khand*, which are produced in the cottage industry. The former is "unrefined" sugar, which contains molasses (approx. 10%) in addition to sucrose (approx. 70%). *Gur* is generally sweeter, but not suitable for long-term storage, since the molasses it contains tends to absorb moisture easily[3]. Hence, *gur* deteriorates rapidly, compared with *khand* and white sugar (defined as "refined sugars"), which are refined

[1] For a detailed description of the technology and for dates of patents please refer to N. Deer, *Cane Sugar*, 2nd ed., London: Norman Rodger, 1921.

[2] For example, see R. G. Padhye, *Sugar Industry in Western India and Methods of Sugar Manufacture*, Bulletin No. 116, Dep. of Agriculture, Bombay, 1924. We are of the same view as Padhye concerning the first cause, but differ with him on the other cause.

[3] In India, sugar in general and not just *gur*, is produced during the dry season between December and April. *Gur* comes on to the market soon after production and a substantial proportion is consumed before the onset of the rainy season.

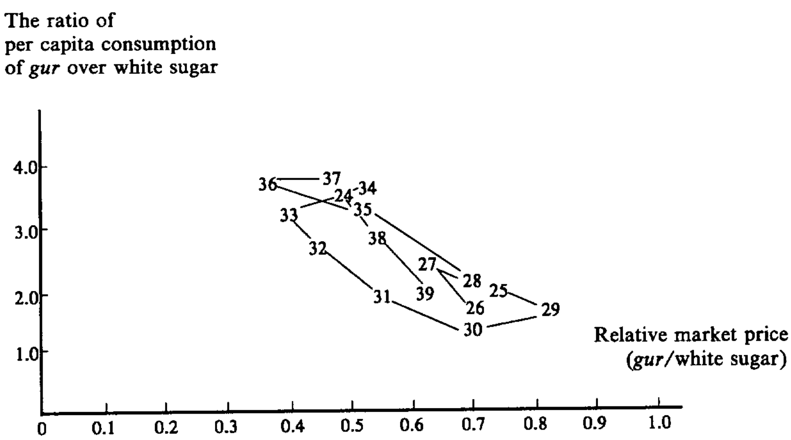
FIG. 1 STYLISED POSITIONS OF TWO SUGAR INDUSTRIES



with centrifuges and which both have had the molasses content almost totally removed[4]. There is a high degree of substitutability in consumption between *gur* and the refined sugars, however, because the price of *gur* is comparatively low by the low quality[5].

[4] White sugar produced in cane-cultivating countries is manufactured in almost the same way as raw sugar, except that more lime clarificant is used to decolorise it into white sugar for direct consumption. More specifically, the production of white sugar differs mainly from that of raw sugar in the use of the carbonation method and the sulphitation method for clarification. Also, in the process of concentration and crystallisation, more sophisticated treatments are adopted than in the case of raw sugar. Historically, such white sugar is known as plantation white sugar. Raw sugar is usually produced for foreign consumption. In the country with final demand, the raw sugar is carefully refined (washed, decolorised and crystallised) into quality white sugar in refineries.

[5] The substitutability between *gur* and white sugar.



Note: Figures are for the year $^{(t-1)}/_{t}$. The consumption figures for *gur* are estimated.

Source: Consumption: *The Indian Sugar Industry*, Bombay, 1934 and 1944. Price: *Marketing*, page 326.

Although *khand* is a refined sugar, its crystals are still coated with a little molasses. That is, the sucrose content of *khand* is about 97%, which is slightly lower than that of white sugar produced by modern sugar technology (For technological processes, see Appendix Diagram). It can safely be assumed, hence, that *khand* and factory-refined white sugar are close substitutes.

Below, we investigate the development of simplified or appropriate technology in the indigenous sugar industry, which produces *gur* and *khand* using indigenous processing techniques. The simple technology of the indigenous sugar industry was gradually improved through the influence of modern sugar manufacturing technology, which was introduced into India around the end of the nineteenth century. Thus, the ability to compete against the modern sugar industry was simultaneously and gradually enhanced.

We would like to emphasise that the competitiveness of appropriate technology is extremely important. This is because an intermediate technology which has a strong labour absorption effect, but no market competitiveness, has a negative impact on the development of the economy as a whole. In this sense, the indigenous sugar industry in India is a valuable object for analysis when examining the use of appropriate technology. It is a typical example of a rural industry that not only fulfilled the above condition, but was situated in the vast rural village sector and acquired its labour and raw materials from the agricultural sector.

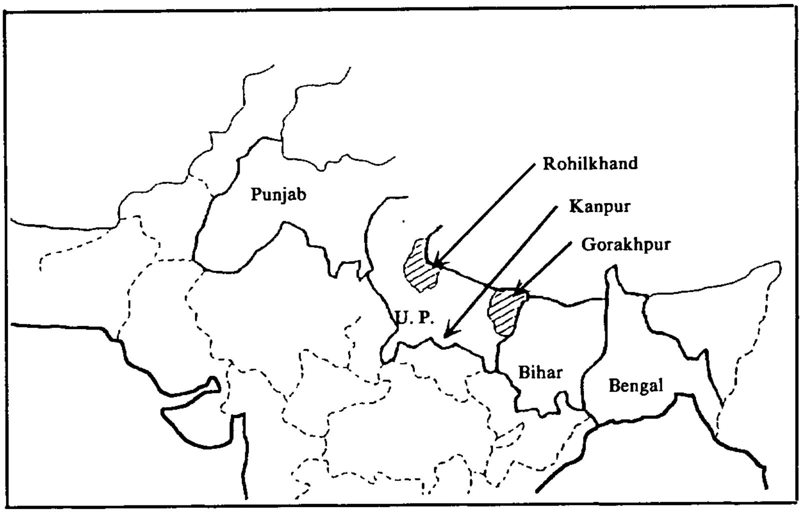
The competitiveness of the indigenous sugar industry is a precondition for our analysis and so we need to choose a period for study over which it can be considered that the survivorship principle was functioning. There were two important legislations relating to the Indian sugar industry. The first was the Sugar Industry Protection Act 1932, which aimed to protect the domestic sugar industry from imported sugar. The second is the U.P. and Bihar Sugar Factories Control Act 1938, passed in the wake of the sugar crisis of 1937. This act introduced a system of zoning arrangements, a minimum price support policy and licensing of sugar factories so as to protect the modern sugar industry. Therefore, it can safely be assumed that the period before 1932 was one of free competition, both internationally and domestically and the period up to 1938 one of free competition, at least domestically, for the sugar industry in India. Thus our period of analysis in this paper is confined to the period up to the latter half of the 1930s, in spite of the fact that the post-independent period does provide more typical examples of the use of appropriate technology[6].

The regions used in the study are the areas surrounding the River Ganges, as seen from Figure 2. The main sugar producing regions in the end of the 1930s were more or less limited to the northern states, such as U.P. (the United Provinces of Agra and Oudh), which accounted for the largest proportion of total production (a: area under cane=53%, b: production of *gur*=48% and c: production of *khand*=94%), followed by Punjab (a: 14%, b: 9% and c: negligible), Bihar(a: 11%, b: 14% and c: 3%) and Bengal (a: 8%, b:14% and c: 1%)[7]. Production of *khand* was mainly concentrated in the Rohilkhand Division of U.P. In

[6] For the development of appropriate technology in the contemporary indigenous sugar industry, refer to Institute of Applied Manpower Research, *Employment Study of the Khandsari and Gur Industry*, New Delhi, 1979 and United Nations Industrial Development Organisation, *Appropriate Industrial Technology for Sugar*, New York, 1980.

[7] Some cane was also produced in areas such as Madras Presidency (now known as Tamil Nadu) and Bombay Presidency (now, Maharashtra), but these regions are not the direct object of study here. Government of India, *Report on the Marketing of Sugar in India and Burma*, Delhi, 1943, pages 280–289.

FIGURE 2. NORTHERN INDIA



principle, the contents of our discussion in this paper refer to the regions listed above.

In Section II below, we support the proposition that the modern sugar industry suffered from poor market competitiveness and briefly indicate the causes. In Section III, we show that, in contrast, the indigenous sugar industry enhanced its competitiveness through gradually improving traditional sugar technology with the introduction of technological innovations. Section IV comprises an estimation and comparison of the labour absorption in the modern and indigenous sugar industries, using an estimate of their respective labour coefficient.

Finally, we mention here some of the representative sources used in this paper. Intensive surveys of the Indian sugar industry had not been conducted till the latter half of the 1910s. After that, several important survey reports were issued by the government, since the government intended to protect the sugar industry from imported sugar. For example, the first was the *Report of the Indian Sugar Committee 1920* (abbreviated to *Report 1920* below), issued by the Sugar Committee which was established in 1917[8]. Also important are the two reports of the Tariff Board, which examined the appropriateness for the Sugar Industry Protection Act. They are the *Report of the Indian Tariff Board on the Sugar Industry 1931* and *Report of the Indian Tariff Board on the Sugar Industry 1938* (abbreviated to *ITB Report 1931* and *ITB Report 1938* below)[9]. The Katiha survey[10] contains the most useful information relating to *khand* production. The *Report on the Marketing of Sugar in India and Burma* (abbreviated to *Marketing* below) is most informative as a comprehensive report on the Indian sugar industry as a whole.

[8] Government of India, *Report of the Indian Sugar Committee, 1920*, Simla, 1921.

[9] Government of India, *Report of the Indian Tariff Board on the Sugar Industry*, Calcutta, 1931 and Government of India, *Report of the Indian Tariff Board on the Sugar Industry*, Delhi, 1938.

[10] N. K. Katiha, *Sugar in the Fields, the Workshops and the Factories: A Survey of the Prospects of Sugar Industry in Rohilkhand*, Bulletin No. 5, Allahabad, Bureau of Statistics and Economic Research, 1938.

II. *The Market Competitiveness of the Modern Sugar Industry.*

1. The Formation and Decline of the Modern Sugar Industry

A modern sugar factory is defined in this paper as a sugar factory equipped with multiple-effect evaporators and vacuum [boiling] pans, which were technologies imported from Europe. Vacuum pan technology was not used in the indigenous sugar industry due to the technological indivisibility and the constraint imposed by low cane crushing capacities of this industry. The indigenous sugar industry used open pan technology. This difference in pan technologies was the main technological distinction between the indigenous and modern sugar industries.

The modern sugar industry started in India with the establishment of the Kanpur Sugar Factory in U.P. in 1884[11]. It is frequently claimed that first factory-style sugar manufacturer was the Roza Sugar Factory, which being established with the participation of British capital in Shahjahanpur (the Rohilkhand Division) of U.P. in 1805[12]. The Roza Factory, however, used the rather similar technology as the traditional *gur* refinery, so it cannot really be described as a modern sugar factory according to our definitions in this paper. On the other hand, the Kanpur Sugar Factory adopted multiple-effect evaporators and vacuum pans[13], and therefore, is distinguishable as a modern sugar factory.

Nevertheless, the Kanpur Sugar Factory, which was converted from an indigo factory when the indigo business went into decline, was a type known as not a usual sugar manufacturing factory but a modern *gur* refinery, which produced white sugar by refining *gur* produced by farmers[14]. In the Kanpur district, there existed 7 similar modern *gur* refineries in 1916 and a further 11 in 1924[15]. This was mainly because there was little cultivation of sugarcane in Kanpur. In other words, the refining of *gur* was the only possibility for these factories, due to the problems of transporting cane.

Thus a part of the modern sugar industry in India first took the form of refining *gur* produced by farmers, rather than of producing directly from sugarcane, for two reasons. Firstly, the sucrose in sugarcane starts to acidify immediately after cutting and microorganisms also cause fermentation, leading to rapid decomposition. Secondly, the transportation of sugarcane over long distances is costly and the time taken results in decomposition. Therefore the sugar manufacturer needed to be situated near the site of the raw material.

The refining of *gur* is a relatively inefficient process. The recovery ratio (the proportion of sugar derived from sugarcane, weight for weight) for *gur* refining amounted to no more than 5.5%. This figure was noticeably low compared to 9% recovery ratio achieved by the modern

[11] Government of India, Indian Tariff Board, *Written Evidence Record during Enquiry on the Sugar Industry*, Volume I, Calcutta, 1932, page 161.

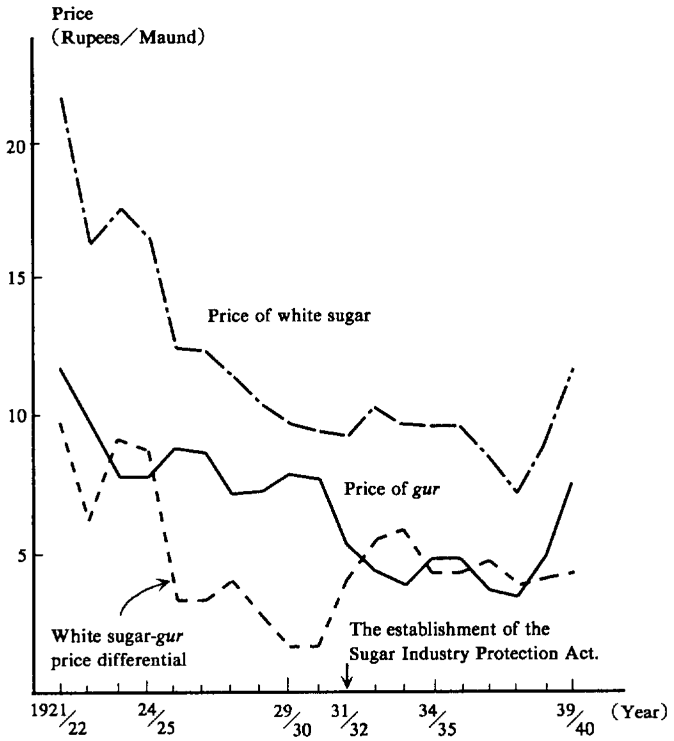
[12] Government of India, op.cit., page 98.

[13] Both are essentially the same technology, which is called the *vacuum pan technology*. Conversely, the technology used in the indigenous sugar industry is the *open pan system*. It is the difference in the two technologies which separates the modern and indigenous sugar industries.

[14] To distinguish this from the indigenous *gur* refining industry, we shall call it the modern *gur* refining industry.

[15] S. Amin, *Sugarcane and Sugar in Gorakhpur*, Delhi, Oxford University Press, 1984, page 96.

FIGURE 3. TRENDS IN THE FINAL CONSUMPTION PRICE (Rupee/Maund) OF WHITE SUGAR AND *GUR*



Source: *Marketing*, p. 326.
Note: There are no time series data for the price of *khand*, but it can be safely assumed that it was nearly the same as the price for white sugar.

sugar factories that were established later, which refined directly from sugarcane[16]. On average, cane grown in India usually contains a sucrose content of 12%, which implies that the total wastage rate exceeded 50%. As is also mentioned in the next section, the low juice extraction ratio and the poor crystallisation of sucrose achieved by farmers in the production of *gur* resulted in such a low recovery ratio of the modern *gur* refineries[17]. As a consequence, the modern *gur* refining industry failed to be sufficiently competitive and even at its zenith there were only 26 refineries which were called pure refineries and distinguished from sugar factories equipped with auxiliary refining plants. The modern *gur* refining industry relied on the price differential between *gur* and white sugar. As the differential narrowed during the latter half of the 1920s (see Figure 3), the industry as a form of the earlier modern factory gradually went into decline.

Some early modern factories to produce sugar directly from sugarcane, using vacuum pan

[16] *ITB Report 1931*, page 28.
[17] The recovery ratio for *gur* is approximately 9%. Ten percent of *gur*, however, is relatively heavy molasses and *gur* has a sucrose content that is nearly 30% lower than white sugar. For the rest of the paper we shall only use simple comparisons of weight, but it is as well to bear the above point in mind.

TABLE 1. PERCENTAGE OF CANE USED IN THE PRODUCTION OF THE DIFFERENT TYPES OF SUGAR

(%)

	White sugar	*Khand*	*Gur*
1921–25	1.2	19.6	66.6
1926–30	2.4	15.9	67.6
1930/31	3.9	14.6	66.4
1931/32	4.2	12.4	67.8
1932/33	6.8	11.2	65.9
1933/34	9.4	7.3	66.7
1934/35	12.1	5.5	65.3
1935/36	16.0	4.0	62.8
1936/37	17.4	4.6	61.7
1937/38	17.7	4.8	61.2
1938/39	19.2	4.6	57.3

Note: Just under 20% of total sugarcane production was used for ratoon and for direct consumption other than sugar production.
Source: *Marketing*, p. 69.

technology (abbreviated to modern sugar factory below), were established in east U.P. and Bihar in the first decade of this century. The usual recovery ratio in the modern sugar industry was about 9%[18] and such a ratio certainly compared not very unfavourably with the ratios in other cane sugarproducing countries. Despite its reasonable efficiency of modern technology, however, the modern sugar industry did not enjoy a favourable development in India. There were only 29 modern sugar factories in 1930/31 and the modern sugar industry had failed to totally eliminate the modern *gur* refineries, in spite of the latter's low recovery ratio[19]. In the 1920s for example, out of all sugarcane used in the production of sugar, only 5% was used by the modern sugar factories (Table 1). These facts would appear to show the weak competitiveness of the modern sugar industry.

The stagnation of the modern sugar industry was reflected in its weak international competitiveness. At the beginning of the twentieth century India turned from being a net sugar-exporting to a net sugar-importing country. Java was the main country of origin for imported sugar (mostly plantation sugar). Java had lost its market in America because of the American sugar industry protection policy and had started to look for new outlets in Asian countries. In 1910/11 sugar imported into India amounted 750,000 tones (out of which 60% was Javan), causing a sugar crisis in the early months of 1911. Although the increase in sugar imports (especially beet sugar from European countries) was brought to a halt due to the impact of the First World War, imports once again increased rapidly during the 1920s. In spite of frequent upward revisions of the import tariff (Table 2), imports amounted to nearly one million tones in 1929/30. The white sugar market in India had become completely dominated by imported sugar. At that time, domestic production of white sugar amounted to not more than 100,000 tones (see Figure 4). The growth in imports of foreign sugar led to a fall in the

[18] Even today the recovery ratio in the Indian modern sugar industry is 9 to 10%. Thus, we can say that the refining technology of the modern sugar industry was efficient in those days too.

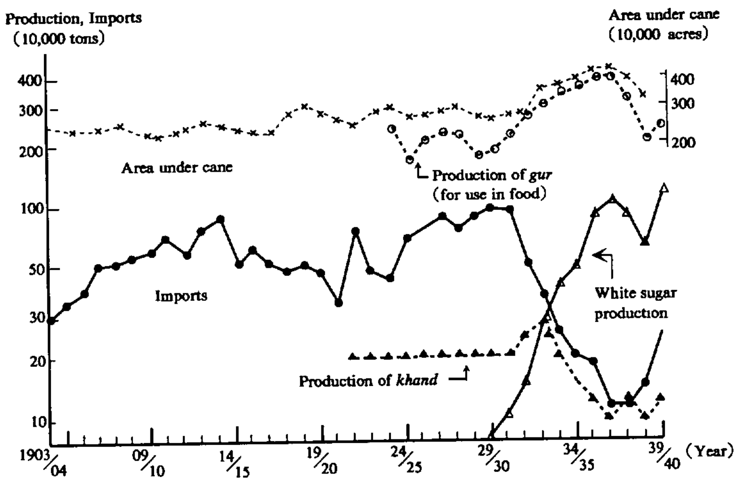
[19] The decline of the *gur* refining industry in the late 1920s was not brought about by competition from the domestic modern sugar industry. Rather, it was caused by the import of foreign-produced white sugar, as is mentioned later in the paper.

TABLE 2. THE TREND IN IMPORT TARIFFS ON SUGAR

Period	Type of Duty	Rate of Duty
–1916	Ad valorem	5%
1916–1921	〃	10%
1921–1922	〃	15%
1922–1925	〃	25%
1925–1930	Specific duty	4Rs.8A.
1930–1931	(per cwt)	6Rs.
1931 (revised)	〃	7Rs.4A.
1931–1937	〃	9Rs.1A.
1937–1939	〃	9Rs.4A.
1939–1940	〃	9Rs.12A.

Note: 1cwt (one hundred weight) is 50.8kg.
Source: Same as for Table 1, p. 311.

FIGURE 4. AREA UNDER THE CULTIVATION OF SUGARCANE (acres) AND AMOUNTS OF SUGAR PRODUCTION AND SUGAR IMPORTS



Note: The production of white sugar produced by refining *gur* and the production of white sugar by the modern sugar industry in the years preceding 1929/30 amounted to less than 100,000 tonnes. The production figures for *gur* and *khand* are estimated.

Source: Area under sugarcane: For the period up to 1911/12: H.C.P. Geering, *The World's Sugar Cane Industry Past and Present*; Manchester, Norman Rodger, 1912, p. 47. For the period between 1912/13 to 1928/29: Indian Tariff Board, *Written Evidence Recorded during Enquiry on the Sugar Industry*, Volume 6, Calcutta, 1932, p. 37. For the period between 1928/29 and 1933/34: M.P. Ghandi, *The Indian Sugar Industry, Its Past, Present and Future*, Calcutta, 1934, p. 50. For the period after 1933/34: *Marketing*, p. 293.

Production of *gur*: up to 1932/33, Ghandi, *ibid*., p. 30 and after 1932/33, *Indian Sugar Industry 1944*, Bombay, p. 12.

Production of *khand*: up to 1931/32, Ghandi, *ibid*., p. 57 and after 1931/32, *Indian Sugar Industry 1944*, p. 1.

Production of white sugar: up to 1929/30, *ITB Report 1931*, p. 20 and after 1929/30, *Indian Sugar Industry 1931*, p. 20 and after 1929/30, *Indian Sugar Industry 1944*, p. 12.

Import: *Marketing*, p. 310.

domestic prices of all types of sugar, including those of the indigenous sugars (see Figure 3). Needless to say, it was the price for white sugar which experienced the largest fall, since imported white sugar and domestically-produced white sugar were perfect substitutes. The price differential between *gur* and white sugar was also reduced as a result. Had this differential reduction continued, it is possible that the *gur* manufacturing industry would have withered, since the quality of *gur* was lower.

2. The 1932 Sugar Industry Protection Act and its Effects

Throughout the 1920s, the price of sugar continued to fall, leading to a fall in the price of sugarcane, which in turn depressed the farmers' income. This trend jeopardised the attempts of the colonial government to maintain sufficient land revenues by stimulating the cultivation of sugarcane, the archetypal cash crop. A comprehensive inquiry into the protection of the sugar industry was the direct result.

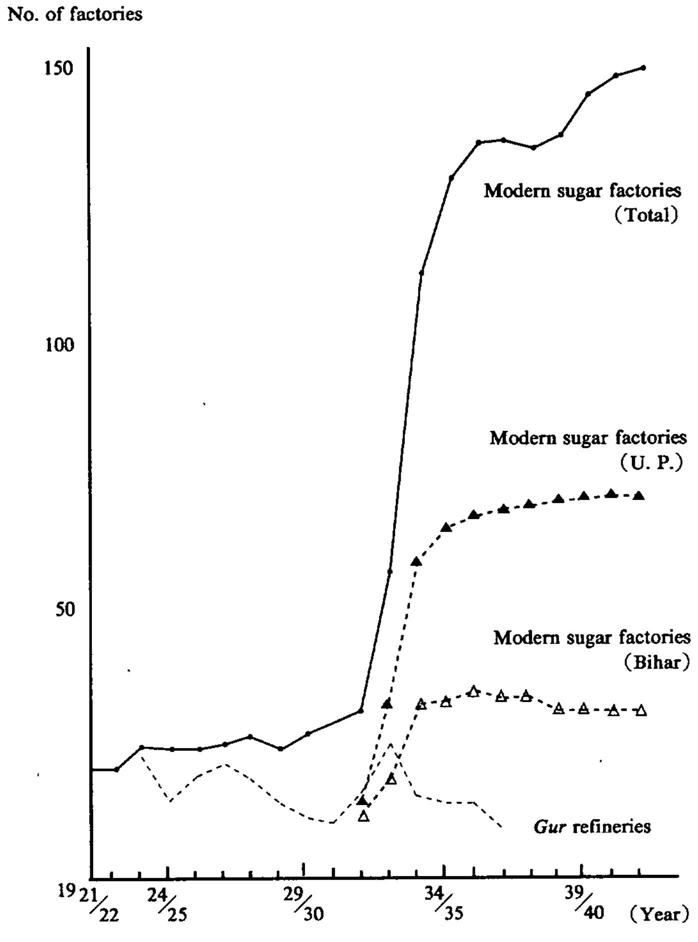
First, in June 1929, the Imperial Council of Agricultural Research was set up to examine the tariffs problem. This body of inquiry commissioned the Indian Tariff Board (ITB) to study the appropriateness for protectionist tariffs and in 1931, the ITB produced a comprehensive report (*ITB Report 1931*). In the report, the costs of production of domestically-produced sugar and Javan sugar were compared and it was recommended to the government that a protectionist tariff (specific duty) should be introduced in order to equalise the prices of the two types of sugar. The Sugar Industry Protection Act was passed in 1932. The imposed tariff, when calculated on an *ad valorem* basis, was as high as 185%. As a result, sugar imports decreased drastically so that by 1940, imports had all but ceased. Well protected, the whole of the Indian sugar industry experienced growth, including the indigenous sugar industry. For example, modern sugar factories were established one after another in the cane growing regions of U.P. and Bihar (Figure 5). It certainly did not mean, however, that the modern sugar industry was back on track for favourable development and growth.

It is clear that, since the sugar industry protection policy was one of adopting a uniform tariff, rather than discretionary subsidies, the indigenous sugar industry received protection as well as the modern sugar industry. Thus, both the modern and indigenous sugar industries were placed in a situation for free competition, at least domestically, after 1932. The expansion of the whole domestic sugar industry increased the demand for sugarcane, which enabled sufficient land revenue to be maintained. The aim of the colonial government had been achieved[20]. Although imported sugar, which had been a strong competitor of the modern sugar industry, had been removed by the Sugar Industry Protection Act, the indigenous sugar industry still remained an able competitor. A study of the trends in the markets for each type of sugar after 1932 shows that, in contrast to an expanding market for *gur*, the growth in the market for domestic white sugar stopped at merely replacing the imported white sugar. The production of white sugar reached a stagnant stage as early as the latter years of the 1930s (see Figure 4). These trends imply that the *gur* manufacturing industry had enough competitiveness against the modern sugar industry in the domestic sugar market.

Khand production experienced growth immediately after the passing of the Sugar

[20] To protect the cultivation of cane was one of the most important targets of the Sugar Industry Protection Act. *ITB Report 1931*, page 39.

FIGURE 5. NO. OF THE MODERN SUGAR FACTORIES



Source: Ghandi, *ibid*, page 40 and 42 for 1930/31.
The Indian Sugar Industry 1944, p. 1. for other years.

Industry Protection Act in 1932, but after 1935, production declined. The decline was caused by the imposition of an excise tax in 1934 on both white sugar and *khand*. The tax amounted to between 10 to 15% when calculated on a specific tax basis. In view of the sugar production after 1934, Figure 4 appears to imply that *khand* was less competitive than white sugar. Nevertheless, the production of *khand* did undergo a recovery to some extent with the lowering of the tax rate in 1937 and after independence, production was further increased with large improvements in technology.

Hence, the competitive weakness of the modern sugar industry needs to be emphasised. The modern sugar industry failed to displace with ease both the *khand* and modern *gur* refining industry, which produced sugar that was almost a perfect substitute for white sugar and moreover, which had inferior sugar recovery ratios. These are the main factors that allowed the coexistence of the modern and the indigenous sugar industries over a long period of time.

An investigation and analysis of the main relevant factors is beyond the immediate scope of this paper, so we will no more than list briefly a few of the factors below.

One explanation that is generally used for the stagnation of the modern sugar industry in India is that sugarcane was grown by small-scale farmers. The successful management of a large modern factory with huge cane crushing capacities, compared with indigenous manufacturers, required that plant should lie idle for as short a time as possible, so that the productivity of capital could be increased, if only by a little. To achieve this requirement, it was necessary that a constant supply of sugarcane could be ensured over a long period of time, in order to meet the processing capabilities of the factory. In India, however, many of the farmers grew cane only on one part of their holdings (on average, less than half an acre)[21]. A modern factory in the early 1930s could crush up to 500 tones of cane per day on average and therefore, sugarcane needed to be procured from more than 10,000 farmers. In addition, difficulties could arise when direct procurement of large amounts of cane was attempted in a market where there was insufficient information. The difficulties were exacerbated by the rapid decomposition of sucrose shortly after harvesting the cane. In India, middlemen (contractors or agents) entered to fill the missing link between a factory and a large number of sugarcane cultivators. Consequently, the modern sugar factories had to procure sugarcane at a higher price than the indigenous manufacturers.

In many sugar-producing countries, efforts were directed towards vertical integration of the raw material suppliers, an example of which is the creation of the plantation system. In Java, it took the form of planning the supply of cane from estates over which the factory had complete control (known as "Cultuurs telsel")[22]. In India, however, the colonial government gave priority to the collection of land revenues and its policies hindered vertical integration. In India at that time, land revenue accounted for one third of total government revenue. The forced purchase of cane growing land was the last measure the government wanted to take, since such a measure would mean the loss of a source of revenue. Certainly, the tiny average size of land under sugarcane cultivation worked against the modern sugar industry, but it did work in favor of the very adaptable indigenous sugar industry.

The stagnation of the modern sugar industry probably cannot be explained by the above factors alone. It is well known that the modern sugar industry in India used a managing agent system, which made long-term management of industrial capital difficult. The Begg and Sutherland company is a case in point. In the modern sugar industry, the introduction of technological innovations was not pursued positively, since most managing agents had risk-averting behavior with a myopic view. Usually modern sugar factories held redundant labour, but were not keen on cutting costs by reducing the number of workers. Therefore, they could not even begin to envisage the strengthening of direct control over cane supply as a means to increase competitiveness, since controlling cane supply was a much more difficult problem to solve than that of overmanning in an Indian context. In the light of other countries' experiences, the problems were not all related to the Indian land holding structure or the behavior of the colonial government. A serious problem was also consisted in insufficient efforts from the management or a lack of entrepreneurial spirit in the modern sugar factories

[21] G. Watt, *A Dictionary of the Economic Products of India*, Volume 6, Part 2, Calcutta, Central Printing Office, 1883, page 256.

[22] For more detail refer to *Report 1920*.

themselves. There were other problems which made the development of the modern sugar industry in India more difficult, such as the lack of a road network and means of transport or insufficient irrigation facilities. The low sucrose content of Indian sugarcane (or the backwardness in improving strains) compared with other countries was also critical.

As a result of a combination of several factors, the stagnation of the modern sugar industry allowed the indigenous sugar industry, a typical rural industry, to grow in a gradually expanding domestic sugar market. The earlier establishment of competitiveness of the indigenous sugar industry also made the development of the modern sugar industry more difficult. Whenever the prices of *gur* rose, sugarcane cultivators produced *gur* themselves. As a result, the modern sugar industry found itself short of sugarcane and the scale of operations inevitably shrunk. In contrast, so long as enough price differentials between *gur* and white sugar remained to exist, the modern *gur* refining industry could survive without serious shortages of raw material (*gur*)[23]. This allowed the modern *gur* refining industry to exist at the side of the modern sugar industry, in spite of the former's low recovery ratio. Also of interest is the fact that in 1919/20, 9 out of 22 and, in 1930/31, 20 out of 29 modern sugar factories possessed *gur* refining equipment[24], as a measure for dealing with sugarcane shortages. *Gur* refining was a manifestation of the peculiarity of the Indian modern sugar industry and furthermore, it was a symbol of its weak competitiveness.

III. *The Indigenous Sugar Industry —Technological Progress and Market Competitiveness—*

1. The Advances in Cane Crushing Technology

In the previous section, we described the conditions in which the indigenous and modern sugar industries existed together and showed the weak competitiveness of the modern sugar industry. It should not be overlooked, however, that the indigenous sugar industry enhanced its competitiveness through technological innovation. In this section, we throw light on the actual technological innovations that are believed to have contributed to the strengthened competitiveness of the indigenous sugar industry.

The manufacture of sugar from cane consists of three operations: 1) crushing cane for the extraction of juice, 2) clarifying and boiling [concentrating] the juice and 3) refining to remove molasses and other unwanted substances from the crystallised sucrose[25]. Needless to say, the last process is not required for the production of *gur*. The technological innovations or improvements can be classified by these three processes. In the crushing process for the manufacture of both *gur* and *khand* a crusher or mill of the same technological sophistication was used. The equality of technological sophistication arose because the choice of crushing techniques was limited by the use of bullocks as the power source. Let us start by examining

[23] The average working days per season were 150 for modern refineries and 300 days for *gur* refineries. *Marketing*, page 96.

[24] *ITB Report 1931*, Appendix I, page 256.

[25] The paper can only be of limited length, so detailed descriptions of sugar manufacturing techniques are not possible. For more detailed descriptions refer to *Marketing* and Katiha, *ibid*.

the advances in crushing technology.

The efficiency of a crusher is evaluated by its extraction ratio (weight of juice per weight of cane) and its crushing capacity per unit of time. The oldest type of crushing technology is the mortar and pestle. A stone or wooden cane crusher was worked by a pair of bullocks. With this method, however, the cane had to be cut into small pieces and impurities became mixed in with the juice. Hence, the operational efficiency of this technology was so low that we are told that "working day and night a *kolhu* (crusher) will not press more than 1.5 acres of cane a month"[26]. The limited source of usable power, that is, the limited number of bullocks available, created a bottleneck. It was impossible to expand the area under the cultivation of cane and consequently, the growth of the indigenous sugar industry was limited. Wooden two-roller mills were devised, but they were so heavy that they needed to be worked by two or three pairs of bullocks. In addition, cane had to be passed through the rollers 3 or 4 times, whilst the juice extraction ratio remained at the level of 40%[27]. The greatest advance in crushing technology came with the introduction of the iron-made two-roller mill in 1874. Messrs Thomson and Mylne started the manufacture of the iron-made two-roller mills after being invited to India by the government, with the aim of developing the sugar industry. The mills that were common in the islands of western India were used as a model[28] and it is said that between 1874 and 1891, some 250,000 mills were produced[29]. In 1880, the production began of iron-made three-roller mills. The juice extraction ratio of the three-roller mills ranged between 50 to 60% and the cane only needed to be passed through the rollers once. Thus, 2 to 3 maunds (75 to 112 kilos) of cane could be crushed in one hour[30], which meant that the three-roller mill could crush 5 to 6 times the amount crushed by the old mortar and pestle crusher. Moreover, it could be worked by one pair of bullocks.

Since the construction of the iron mills was similar to that of the wooden mills, they could be manufactured using indigenous technology. Along with the increase in demand for sugar from the mid-nineteenth century onwards, factories were established for making iron-made mills in every area of India. By the turn of the century, the old-fashioned and inferior crushers had been almost totally replaced by the new, improved mills[31]. Diffusion of the more efficient cane crushers increased total crushing capacity, leading to a rapid increase in the area of land under cane[32].

In the 1920s, the power mill began to be introduced into the indigenous sugar industry, but the use of power mills was mainly confined to *bels* (a boiling plant for making *rab*, ie massecuite, from which *khand* is made), where large amounts of cane were crushed[33]. In U.P. in 1935, for example, power mills only accounted for 0.24% of all crushers and even in Rohilkhand, the centre for the production of *khand*, only 0.45% (205 mills) were power

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[26] I. Stone, *Canal Irrigation in British India*, Cambridge, Cambridge University Press, 1984, pages 295–296. This corresponds to a cane crushing capacity of 12 to 13 kilos per hour.

[27] M. S. Randhawa, *History of Agriculture in India*, Volume 2, New Delhi, Indian Council of Agricultural Research, 1984, page 253. In this connection, the juice extraction ratio in the modern sugar industry exceeded 80%.

[28] Watt, *ibid.*, pages 84–114.

[29] Amin, *ibid.*, pages 124–125.

[30] One *maund* is equal to 37.3 kilos.

[31] Stone, *ibid.*, page 296.

[32] Watt, *ibid.*, page 257.

[33] The word *bel* also signifies both the boiling pan and the place of *gur* and *rab* manufacturer. To avoid confusion, the word *bel* in this paper refers only to the combination of a furnace and a boiling pan.

mills[34]. The introduction of power mills was probably hindered because the boiling capacity of a *gur* plant was lower than the crushing capacity of a power mill. Furthermore, the extraction ratio of bullock-driven improved types of crusher was as high as that of the power mills, although the crushing capacity of the latter was much greater[35].

2. Technological Progress in the Manufacture of *Gur*

In short, the main technological advances in the manufacture of *gur* were in the crushing technologies described above. As is mentioned in the next section, it is believed that the diffusion of these technological innovations was almost completed by 1920. The iron-made three-roller mill could process 6 to 7 times the amount of the old mills and had an extraction ratio 10–20% higher. Its diffusion contributed greatly to the competitiveness of the *gur* manufacturing industry by raising the sugar recovery ratio.

Advances in boiling technology were slow, however. The usual boiling pan was placed on a simple furnace, which was made by digging a pit in the ground. With this type of *bel*, irregular heat and wide fluctuations in temperature could cause inversion, caramelisation and charring. As a result, the quality of *gur* deteriorated and the sugar recovery ratio for *gur* was lowered. It was recommended that the *bel* could be improved by constructing the furnace with a chimney and grate and by the use of a flat-bottomed pan, so that the heat was equalised over its surface[36]. These recommendations were hardly adopted, however. It was also possible to avoid charring and inversion by boiling the cane juice in two or three pans on top of each other and moving the juice. This multiple-pan technique failed to become popular and during the 1930s the single-pan technique remained dominant[37].

It was inevitable that technological innovation should be capital-saving, since the manufacture of *gur* was in the hands of small-scale farmers. One plausible method that the *gur* industry could use to increase its competitiveness was to use a combination of a power mill and multiple-pan furnace that has a larger boiling capacity than a single-pan furnace under a co-operative or special contract arrangement. In fact, this is nowadays a common form of production in Punjab, Haryana and western U.P.

3. Technological Progress in the Manufacture of *Khand*

The *khand* refinery is divided into two stages: a) the *bel*, used for making *rab* and, b) the *khandsari*, where *rab* is refined into *khand*. From the middle of the nineteenth century, when the demand for sugar started to increase, there were technological advances in both parts of the *khand* refinery given above. There were also large changes in the organisational form of the operations and management.

a) Technological Advances at the *Bel* Stage

Until the mid-nineteenth century, cane growers supplied *rab* they had produced them-

[34] Government of U.P., *The Livestock Census Report for the U.P*, Allahabad, 1935.
[35] *Marketing*, page 51.
[36] For diagrams of the *bel*, refer to S. C. Roy, *Monograph on the Gur Industry in India*, Kanpur, Indian Institute of Sugar Technology, 1951.
[37] Roy, *ibid*., page 161.

selves to the *khandsari* under a contractual arrangement with advances in cash[38]. The process used by farmers to prepare *rab* was more or less the same as that for *gur*. In the production of *gur* it is chiefly the colour that is important, whilst in the case of *khand*, it is the size of the sucrose crystals that is important, since the size determines the *khand* recovery ratio. Consequently, in the production of *khand*, it is necessary to make the utmost effort to prevent sugar inversion, caramelisation and charring in order to improve the *khand* recovery ratio. Hence, more attention had to be paid in the production of *rab* than in the case of *gur*. For example, two pans were usually used in the manufacture of *rab*, in contrast to the single-pan technique used for *gur*, for this very reason. The regional *khandsals* (the owners of *khandsari*) even needed to send their servants to guarantee a good quality *rab* and they had to ensure that all the contracted cane was used in the manufacture of *rab*[39].

The problems encountered in the manufacturing of rab were largely solved with the appearance of the Rohilkhand *bel*, which had been introduced widely in the Rohilkhand Division during the latter half of the nineteenth century[40]. The Rohilkhand *bel* was large and had five iron-made open pans. These *bels* were generally constructed and operated by the *khandsals* themselves. Thus, the production of *rab* was transferred from the farmers to the *khandsals* and at the same time the supply of high quality *rab* for use in the *khandsaris* was secured. Only the crushing process remained in the hands of the farmers, because bullocks owned by the farmers were required as the power source[41]. As power mills began to be introduced, however, even the crushing process was taken out of the hands of the farmers and the sole role of the farmers was to supply sugarcane.

It is reasonable to claim that the Rohilkhand *bel* was the greatest technological advance in the manufacturing of *rab*. The diffusion of the power mill also had an impact and the *khand* industry managed to increase its competitiveness as it gradually internalised the *rab* manufacturing stage.

b) Technological Advances at the *Khandsari*

The competitive power of the *khand* industry was also strengthened by technological advance at the *khandsari*. The technological advance was the transition from the *kanchi* technique to the centrifuge technique.

The *kanchi* technique was an indigenous process and references to it can be found in writings dating back to before the birth of Christ. *Rab* produced by the farmers were placed in small hempen bags which were stacked and trodden on by a labourer so that the molasses was squeesed out of the *rab*. The resulting contents were then removed from the bags and placed in a room made with bricks (called a *kanchi*)[42] and then covered with a layer of aquatic weed. The water from the weed gradually washed away the remaining molasses to produce *khand*. The washing process took two or three months and furthermore, the sugar recovery ratio in the production of first *khand* was only 3.3%. Even the second *khand* only gave an

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[38] Amin, *ibid.*, pages 57–64.

[39] Watt, *ibid.*, page 285.

[40] For a detailed description of the Rohilkhand *bel*, refer to R. C. Srivastava, *The Open Pan System of White Sugar Manufacturing*, Calcutta, Central Publications Branch, 1932. The diagrams are particularly useful.

[41] Ten to twelve crushers were installed around the *bel* and hired by the farmers. *Marketing*, page 62.

[42] The word *kanchi* refers to both the brick rooms used for refining at the *khandsaris* and the refining technique itself.

overall sugar recovery ratio of 4.4%[43].

The greatest technological advance in the *khandsari* was the introduction of the centrifuge from the modern industry. The centrifuge was created in Europe in 1837 and, like the iron-made roller mill, was first introduced into India in the 1870s. As improvements and simplifications were made[44], the simplified centrifuge became widespread in the main *khand*-producing region, Rohilkhand. Using the centrifuge, the recovery ratio in the production of *khand* was 5.5%, including the second *khand* (4.4% excluding the second *khand*), which was high compared with the recovery ratio of 4.4% achieved with the *kanchi* technique[45]. As a result, the *kanchi* method had almost died out by the end of the 1930s.

We have just examined the technological advances in the production of *khand*. It is also possible to prove that these innovations strengthened the competitiveness of the *khand* industry, by examining the cost performance of production when each of the methods are used. The three forms of organisation for producing *rab* were the following: A) the cane growers make the *rab*, B) the *rab* is made at the *khandsal's bel* from cane juice extracted by the cane growers and C) *rab* is made directly from sugarcane at the *khandsal's bel*. The unit cost of *khand* when *rab* was produced under these three forms can be compared. Let the unit cost of *khand* using the type–A form of *rab* production be equal to 100. The unit cost using type–B was equal to 81.9 and using type–C was 76.6%[46]. The impact of technological innovation is clearly shown by these figures. Furthermore, we can compare the unit cost of producing *khand* using either the *khanchi* technique of the centrifuge technique. If the unit cost of under the *kanchi* technique is set at 100, the unit cost of the centrifugal technique was 81.2[47].

As was demonstrated above, the technology of the indigenous sugar industry was not static. Rather, various technological advances were adopted by the industry. It is of interest that the *khand* industry in particular absorbed the imported technology. The series of developments in the *khand* industry was possible because the modern sugar industry in India could not wield an overwhelming competitiveness over the indigenous sugar industry giving the latter enough time to import and develop its own technology. Furthermore, the indigenous sugars (especially *gur*) had enough competitiveness, in spite of their poor quality, since they were cheap and the proportion of the low income groups in India was high. Thus, the very competitiveness that had been fostered in the indigenous sugar industry came to hinder the development of the modern sugar industry.

[43] Government of India, Indian Tariff Board, *Written Evidence Recorded during Enquiry on the Sugar Industry*, Volume 1, Calcutta, 1932, page 92.

[44] Concerning the simplification of the centrifuge, refer to S. M. Hadi, *The Indian Sugar Industry*, Bophal, no pub., 1929, Chapter 4.

[45] *Marketing*, page 64.

[46] *ITB Report 1938*, page 98, calculated from Table XLI.

[47] *ITB Report 1932*, calculated from pages 225–226.

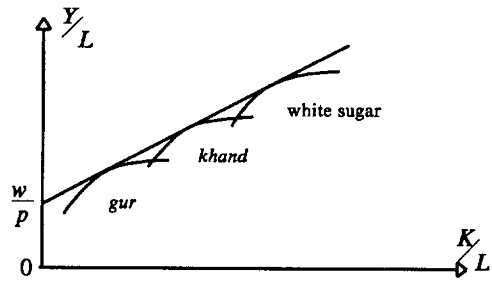
IV. *Labour Absorption in the Indigenous Sugar Industry*

1. The Labour Coefficient in the *Gur* Manufacturing Industry

Above we showed that in India, the indigenous sugar industry possessed sufficient competitiveness to cope with competition from the modern sugar industry. In this section we will attempt to evaluate the importance of the indigenous sugar industry, specifically from the point of view of labour absorption, since unemployment was a serious problem in Indian villages. We intend to measure labour absorption using a labour coefficient. The labour coefficient is generally defined as the units of labour input per unit of output. In this study, however, we are comparing the labour absorption in different types of sugar production that use different technologies. Therefore, it is not possible to use output as a denominator, since efficiency and quality of output will naturally be affected by the type of technology or equipment in use. Here, we define the labour coefficient as the units of labour per unit of raw material, (L/R). R represents an amount of sugarcane and L represents the amount of labour required to produce sugar from R. In using this definition, it is assumed that the indigenous sugar industry was sufficiently competitive against the modern sugar industry[48], which has already been shown. Under this assumption the high labour (to raw materials) coefficient is offset by the low capital to raw material coefficient. The unit of measurement for cane is tones and one labour day is eleven hours[49]. The labour coefficient is calculated by specifying the sugar manufacturing technology that was most common in the 1930s and by identifying the amount of cane that could be processed by that technology and the number of labourers employed.

We start with estimating the labour coefficient in the manufacture of *gur*. By the 1920s, "iron-made three-roller bullock-driven mills were used widely in all the important *gur* producing areas of India"[50]. In addition, it is said that at the end of the 1930s, about 90% of

[48] Here we are concerned with the following point. Although there are differences in the juice extraction ratio and the use of molasses, there are far outweighed by the differences in the capital-raw material ratios and labour-raw material ratios. This point is shown in the diagram below.



Y: product, r: profit rate,
K: capital, w: wage rate

[49] This figure is based on the fact that the work period was half a day (11 actual working hours) in the indigenous sugar industry and that there were two shifts of 11 hours each in the modern sugar industry.

[50] *Report 1920*, page 213.

TABLE 3. THE CANE CRUSHING CAPACITIES OF THE MAIN BRANDS OF IRON-MADE, BULLOCK-DRIVEN THREE-ROLLER MILLS

	Name of crusher	Crushing capacity per hour (mds)	Juice extraction rate (%)
1	Sultan	2–3	66–70
2	Kumar	2–2.5	58–62
3	Karamat	1.75–2.25	65–68
4	Hathee	4–4.5	60–65
5	Delhi Type	1.75–2.25	62–65
6	Collectory	2–3	50–60
7	Renwick	3–3.5	50–55
8	Batala	2.4–3.6	53–60
9	Charkhari	2.4–3.6	53–60
10	Sataria	2.5	60–65
11	Attaria	2.5	60–65
12	Vakil	3.4	60–62
13	Ban	3–4	60–62

Source: S.C. Roy, *Monograph on the Gur Industry of India*, Kanpur, 1951, p. 251.

cane used in the manufacture of *gur* was crushed by iron-made three-roller bullock-driven mills[51]. Thus, during the 1930s, the period of study in this chapter, it can be considered that the iron-made three-roller bullock-driven mill was the most typical type of crushing technology. The efficiency of this technology depended on the brand of mill (see Table 3), but on average, these mills crushed 2.5 to 3.5 maunds (93.3 to 130.6 kilos) per hour and had a juice extraction ratio of between 60 and 65%. These are test results, however. In fact, the farmers loosened the rollers to reduce the strain on their cattle so that the average crushing capacity was reduced to 2.5 *maunds* (93.3 kilos) and the actual extraction ratio was reduced to 55%[52]. It is these actual figures that are used in our estimation. In the average *gur* factory 1.0 ton of cane (93.3 kilos multiplied by 11 hours) was crushed daily to yield 550 kilos of juice. The single-pan type of boiling pan was the most common type used in the production of *gur*. With the main 25 brands of single-pan boilers, it was possible to boil up to 17.6 *maunds* (656.5 kilos) of juice a day[53]. Such an amount of cane juice can be obtained from 1.2 tones of cane when it is assumed that the juice extraction capacity of the mill is 55%. Hence, the cane processing capacities of the mill and boiling pans were approximately the same. In this paper we will use the lower limit of the cane crushing capacity, which is 1.0 ton of cane per day.

It was said that "generally, 5 men are required to work at a *bel*"[54]. According to the Roy survey[55], a *gur* factory which crushed 25 *maunds* (932.5 kilos) of cane a day using bullock-driven crushers employed 4 labourers in addition to one *halwai* (sugar boiler). It is assumed in this paper, that 5 workers were required by a *gur* manufacturer of average size. Two people were involved in crushing operations one drove the bullocks used for turning the crusher and the other fed cane between the rollers. One of these workers was also required to remove the bagasse (remains after crushing) and spread it out to dry in the sun.

[51] *Marketing*, page 51.
[52] *Marketing*, page 51.
[53] Roy, *ibid*., page 71.
[54] *Marketing*, page 58.
[55] Roy, *ibid*., page 71.

From these facts, we estimated a labour coefficient of 5 (5/1.0) for the typical *gur* manufacturing process of the 1930s.

2. The Labour Coefficient in the *Khand* Industry

As pointed out previously, the manufacture of *khand* is composed of two stages: a) the rab making process at the *bel* and b) the refining process undertaken at the *khandsari*.

a) The Labour Coefficient in the Manufacture of *Rab*

As has already been explained, *rab* could be manufactured under three organisational forms. They are A) the cane growers make the *rab*, B) the rab is made at the *Khandsal's bel* from cane juice extracted by the cane growers and C) the *rab* is made directly from sugarcane at the *khandsal's bel*. Taking an average for the four periods between 1935/36 and 1939/40, each of the above forms accounted for 33.8%, 55.4% and 10.8% repectively of the *rab* manufacture for the production of *khand*[56]. Hence, we take type B to be the typical form of manufacture.

The cane processing capacity of the *bel* is now estimated as follows. An average Rohilkhand *bel* consumed 100 *kardas* (242 tones) of juice in a season extending over 100 days, which gives a consumption rate of one *karda* per day[57]. We are told that "the crushing work commences at about 4 am.... By the sunset, the crushing work is stopped.... The hours of work (for *rab* extend from midday till midnight"[58]. This quote implies that the operation period for a *bel* was almost half a day (11 hours). Thus, taking the extraction ratio of the mills as 55%, the processing capacity of a *bel* that consumed one *karda* per day amounted to 4.4 tones of sugarcane per day[59].

The labour coefficient for the crushing stage at a Rohilkhand *bel* was equal to that in *gur* manufacture. Since crushing capacity was one ton per day using two people to operate the crusher, 8.8 labour days were required to crush 4.4 tones of sugarcane. The labour coefficient in the crushing stage is estimated to be 2 (8.8/4.4).

An average *bel* employed 11 to 12 paid workers[60], excluding those employed in the crushing stage. The job composition of these workers was as follows. The *munshi* (one person) was the accountant who weighed and recorded the sugarcane and the *darga* (one person) undertook general supervision of the *bel*. Both these workers were generally Hindus, since their job required honesty and reliability and most of the *khandsaris* were owned by Hindus. Juice extracted by the farmers was transported to the *bel* by a *bhisti* (one person). The boiling was undertaken by a *halwai* or a *karigar* (juice boiler) and two assistants. These workers were generally Mohammedans with experience in the job and were seasonal migrants from the environs of Agra. In addition, 6 or 7 people to feed the furnaces (*jhonkias*) were required, who also laid out the wet bagasse to dry. These workers were generally of the Chamar caste

[56] *Marketing*, page 100.

[57] The weight of one *karda* differs in each district of the Rohilkhand Division. One *karda* is equivalent to 62.5 *maunds* in Bareilly, 65.62 *maunds* in Philibhit and 66.66 *maunds* in Shahjahanpur. Katiha, *ibid.*, page 36. In this paper we take one *karda* to be equal to 65 *maunds* (2.42 tons).

[58] Khatiha, *ibid.*, page 48.

[59] Since the *rab*-cane juice ratio is 20%, the daily *rab* production of a Rohilkhand *bel* is 13 *maund* (484.9 kilos). The average yearly quantity of *rab* prepared in one *bel* is 1300 *maunds*.

[60] Katiha, *ibid.*, page 46 and *Marketing*, page 294.

(untouchables) who came from near-by villages. In this paper, the number of people employed is taken to be 12.

The labour coefficient in the manufacture of *rab*, undertaken at the *bel* and excluding the crushing stage, is therefore 2.7 (12/4.4). When the crushing stage is included, the labour coefficient becomes 4.7. The labour coefficient for the manufacture of *rab* is slightly lower than that for *gur* manufacture, showing the economies of scale that resulted from using the Rohilkhand *bel*.

2) The Labour Coefficient in the *Khandsari* Stage

The use of centrifuges had become common by the end of the 1930s. Approximately 85% of all *rab* used in the manufacture of *khand* was cured in centrifuges[61]. The early centrifuges were turned by hand, but even and uniform spinning could not be ensured. Thus, the electric power centrifuge became widespread.

In 1937 in Shahjahanpur district of Rohilkhand Division, the centre of *khand* production, 60 out of 70 centrifuges were turned by electricity[62]. Centrifuges powered by diesel engine were also used. In this paper, the typical technology is taken to be the power centrifuge. In relation to the processing of *rab*, Katiha states that "on average, electric centrifuges take 10 to 12 minutes in warm months and 12 to 16 minutes in the cold season for machining a charge of 30 to 35 *seers* (30.0 to 32.6 kilos) of *rab*"[63]. In one refining operation of 17 minutes, 32.5 seers (30.3 kilos) of *rab* were processed, giving a processing capacity of 106.8 kilos per hour. The ratio of *rab* to cane was 11%, so that 106.8 kilos of *rab* was equivalent to 970.9 kilos of sugarcane[64]. These are also test results and we are told that the actual processing capacity was 80% of the test results[65]. In this paper, the actual processing capacity of the centrifuge is taken to be 776.7 kilos of sugarcane per hour, or 8.5 tones per day. Finally it is assumed an average *khandsari* with three sets of *bels* treated 4,500 *maunds* (167.9 tons) of *rab* each season[66].

An average *khandsari* using electric centrifuges employed one sugarman experienced in the operation of centrifuges, one centrifuge assistant and one supervisor (*munshi*). Four unskilled labourers were hired to smash the earthenware pots containing *rab*, remove the *rab* and fill the centrifuge. Generally 7 people were employed in total[67]. Thus, the labour coefficient of the centrifuge stage is calculated to be 0.8 (7/8.5).

The sugar produced by the centrifuge (called *pachani*) was then dried by spreading it over gunny mats (*patta*), where it was trodden on by labourers known as *pataha* with their bare feet. One drying process took 7 hours and 3 *patahas* to dry 16 *maunds* (596.8 kilos)[68]. Since the recovery ratio in the production of first *khand* was 4.4%, 16 *maunds* of *pachani* was equivalent to 13.6 tones of sugarcane. When these figures are converted to amounts used in 11 hours of operation, a labour coefficient of 0.1 is obtained. From the above calculations, the labour

[61] *Marketing*, page 100.
[62] *ITB Report 1938*, page 92.
[63] One *seer* is equivalent to 923.5 grammes. Forty seer=one *maund*. Katiha *ibid*., pages 61–62.
[64] Katiha, *ibid*., page 274.
[65] Srivastava, *ibid*., page 48.
[66] The average *khandsari* had three sets of *bels*. The average yearly *rab* production in one *bel* was 1300 *maunds*. The remaining 600 *maunds* of *rab* was purchased from farmers who had produced it themselves. Hence a *khandsal* who had an average size *khandsari* purchased the remaining 600 *maunds* in the local markets.
[67] Katiha, *ibid*., page 63.
[68] Katiha, *ibid*., page 63.

coefficient for the first *khand* is estimated at 5.6 (2.0+2.7+0.8+0.1).

The second *khand* is made from molasses that still contains some sucrose. There are no data available for estimating the labour coefficient in the centrifuge stage of second *khand* production. By regarding the molasses as cane juice, we assume that the second *khand* is manufactured with the same labour coefficient as the first *khand*. Sixty kilos of molasses can be obtained from one ton of cane, since the recovery of first molasses in the first centrifuge process averages about 60%[69]. Thus the labour coefficient of second *khand* is estimated at 0.4[70]. Therefore a labour coefficient of 6.0 is obtained for the complete manufacture of second *khand*.

3. The Estimation of Labour Absorption

According to the *ITB Report 1931*, the cane crushing capacity of the average modern sugar factory around 1930 was 500 tones using a two-shift system, each shift lasting for 11 hours. The total number of employees was 675, consisting of 500 seasonal workers, 70 unskilled annual labourers, 75 technicians and 30 management staff[71]. Hence the labour coefficient for the modern sugar industry is 1.4 (675/500).

The highest labour coefficient in the Indian sugar industry is for the *khand* industry, with a coefficient of 6.0, followed by 5.0 for the *gur* manufacturing industry. The modern sugar industry has the lowest coefficient of 1.4. Now, we will attempt to calculate the number of employees in each type of sugar industry for the mid–1930s (taking an average for the figures for the five years between 1933/34 and 1937/38), during which period, the modern sugar industry experienced some growth. In this period, the average yearly amount of sugarcane consumed in the production of sugar was 48,840,000 tones, out of which 76.2% was used for *gur*, 6.2% for *khand* and 17.6% for the production of white sugar. The calculation of the labour absorption for each type of sugar industry is given below. It should be noted here, that the annual number of working days in the modern sugar industry is taken to be 120 days, which is equal to the number of days the modern sugar refinery operated over the year. This sugar manufacturing period also nearly coincides with agricultural slack season in Northern India.

We estimate the *gur* manufacturing industry absorbed 1,549,000 people (86.0% of the total employed in the sugar industry) for 185,930,000 working days, the *khand* industry, 152,000 people (8.4%) for 18,220,00 working days and the modern sugar industry, 100,000 people for 12,060,000 working days, out of a total of 1,801,000 people employed in the sugar industry. If we imagine that all the sugarcane went for the production of white sugar in the modern sugar industry, employment would have been reduced by 1,232,000 people (or 68.4%) to 570,000 people (our estimated figure). If all refined sugar made by centrifuging were *khand*, the number of workers employed in the *khand* manufacturing industry would have been 583,000, which is more than double the actual figure of 252,000.

From the above study, we can say that labour absorption in the indigenous sugar industry

[69] *Marketing*, page 64.

[70] 3.6 days of labour were needed to produce first *khand* from the 550 kilos of cane juice that was obtained from one ton of cane. If the 66 kilos of molasses is assumed to be equivalent to 66 kilos of cane juice, (3.6 x 6.6)/550=0.4 days of labour required to produce the second *khand*.

[71] *ITB Report 1938*, pages 192–195.

was 3 to 4 times the absorption in the modern sugar industry. While the indigenous sugar industry maintained its competitiveness, it played an extremely important role in the Indian economy, an economy with abundant surplus labour. It was a labour absorptive industry based on appropriate technology. It can still be said to play that role nowadays.

V. *Conclusion and the Some Remarks*

It is sufficiently clear from our research so far that the indigenous sugar industry had a great significance for the Indian economy. Firstly, from the point of view of the survivorship principle, the fact that the indigenous sugar industry managed to exist alongside the modern sugar industry for so long is a testament to the sufficient competitiveness of the former. For example, the 1932 Sugar Industry Protection Act lent a hand to the modern sugar industry by excluding imported white sugar from the home market. The Act had only a small effect on the modern sugar industry, however, since the modern white sugar substituted only for the imported sugar and not more than that (Section II). Moreover, the competitiveness of the indigenous sugar industry continues to this day. More than half of present sugar production is accounted for by indigenous sugars, which is an unprecedented situation even in international terms.

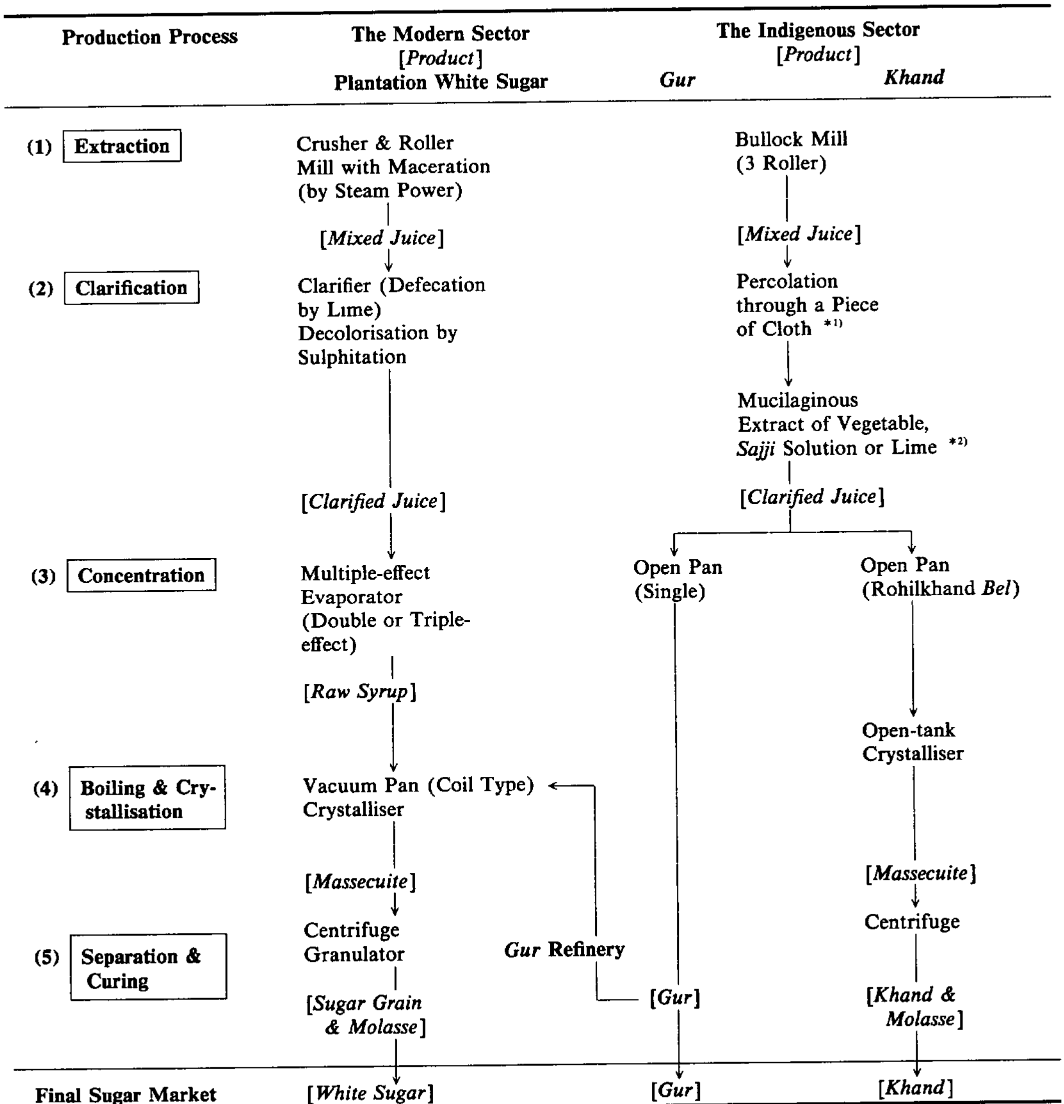
The situation in India should properly be described as both the result of the modern sugar industry's stagnation or as the result of its lack of competitiveness, and as a result of the competitive strength of the indigenous sugar industry. The weakness of the modern sugar industry should probably be explained by reference to its weak entrepreneurial spirit, the peculiarities of Indian agriculture or the fetters placed on the colonial economy. This paper focused on the capacity of the indigenous sugar industry for using technological adaptations as means of enhancing its competitiveness. More specifically, this paper focused on the technological advances that were induced by the establishment of the modern sugar industry and on the use of appropriate technology (Section III). We concentrated on these aspects because the technological innovations of the indigenous sugar industry contain several good examples of appropriate technology that fulfil the necessary condition of being competitive. Thirdly, the significance of the advances in the appropriate adaptation of technology achieved by the indigenous sugar industry should be seen in the industry's role of absorbing labour. In this paper we estimated the labour absorption by estimating the labour coefficients for each sugar industry. The most important aim of the paper was to try and demonstrate the importance of appropriate technology in the pre-independence indigenous sugar industry, in spite of the lack of sufficient production statistics. The indigenous sugar industry was the industry situated in Indian rural villages, where there was abundant surplus labour. We concluded that the indigenous sugar industry created at least 1,600,000 employment opportunities by managing to compete with the modern sugar industry (this can be compared with the domination of the market by the modern sugar industry that occurred in other countries).

Even today, the indigenous sugar industry has become no less important. The problem of surplus labour in the rural sector has worsened and great expectations are placed on the prosperity of rural industry to provide linkages in India's industrialisation. The amount of labour required to process a unit of raw material is falling in both the modern and indigenous sugar industries, but there is still a large differrential between the labour-raw material ratio in each industry. Moreover, this differential exists because the indigenous sugar industry continues to be sufficiently competitive. Thus, the indigenous sugar industry should continue to attract our attentions, since it is a typical example of a rural industry situated in villages (and rural towns), that absorbs both agricultural products as its raw material and, moreover, labour from the rural sector.

Our study suffered from limitations in the availability of data. Hence, we were only able to ratify the competitiveness of the indigenous sugar industry using the *ex post* perspective of the survivorship principle. It would be desirable in the future to conduct a more rigorous study using detailed production cost data. Although such a study is difficult for the period of the 1920s or 1930s, it should be possible to conduct one for the contemporary sugar industry. We were only able to indicate possible factors leading to the stagnation of the modern sugar industry by referring to circumstantial evidence. We were not able to give a rigorous proof. In future we would like to undertake a broader in-depth study of the reasons for this situation peculiar to the Indian sugar industry. It may be possible to derive more meaningful insights by comparing India's experience with the experience of other sugar-producing countries. Due to limited space, we were unable to discuss the sugar industry research institutes which, in spite of a certain lack of activity, were nonetheless responsible for several technological innovations. A more comprehensive discussion on this point and on the lack of organisations established for technical education and for the diffusion of technology is required. Finally, in taking the indigenous sugar industry as a typical example of rural industry, it is probably necessary to undertake an analysis of 1) the complementary linkages with other agricultural activities and 2) the flows of labour and capital between agriculture and industry. These are all topics for future research.

HITOTSUBASHI UNIVERSITY
OSAKA CITY UNIVERSITY

Appendix Diagram: Stylised Technological Processes of Sugar Manufacturing



* In the case of raw sugar production, there is no decolorisation step in Process (2), and Process (4) produces bigger grain with less sophistication than the case of white sugar.

** To produce refind sugar from raw sugar in a refinery, Process (4) and (5) are repeated with decolorisation by bone charcoal.

*1 This process is often left out.

*2 *Sajji* solution is a mixture of crude sodium carbonate and sodium sulphate to produce *khand*. The clarifying agents are added when juice is heated and reaches the boiling point.