TECHNOLOGICAL CHANGE IN THE CHINESE TEXTILE INDUSTRY, 1950–72

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DESPITE THE Communist development strategy of emphasizing heavy industries, economic planners in China have clearly recognized the importance of textiles. During the First Five-Year Plan, textiles accounted for 40 per cent of the output of light industries and 20 per cent of overall industrial output [31, p. 48]. The textile industry has had rapid growth since 1950. This can be seen from looking at annual output value during the 1949–70 period, as shown in Table I.

TABLE I

TEXTILE INDUSTRY PRODUCTION, 1949–70

(In billion of 1952 yuan)

Year	Output
1949	5.2[a]
1952	9.4[a]
1957	13.0[a]
1965	16.4[b]
1970	20.9[b]

Sources: *a*=[31, pp. 87, 92]; *b*=estimated by T. G. Rawski, "Chinese Industrial Production, 1952–1971," *Review of Economics and Statistics*, 1973, No. 2, pp. 169–77.

Such rapid growth in textiles can be attributed to (1) low capital-output ratio, (2) short gestation period, and (3) an extremely high rate of earnings [16, p. 2]. The payoff period is reported to be less than two years. Once a textile mill is producing normally, its earnings in one year are sufficient to construct two similar mills [16, p. 3]. During the first plan quinquennium, for instance, the earnings generated from the textile industry were six and a half times the original investment [16, p. 3]. No wonder the planners have aimed at a high rate of technological change in the textile industry. As Mao Tse-tung put it, "Even on the basis of developing heavy industries as our priority, a high rate of develop-

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ment in the textile industry will speed up our nation's industrialization" [23].

In addition to its low level of technology, the textile industry in pre-communist days depended heavily on imported materials.[1] To reverse this tendency, from the beginning the Communist regime adopted the policy of more fully using all kinds of natural fibers domestically produced. In addition to cotton, the use of jute, silk, and wool was encouraged. Subsequent new technology for synthetic fiber manufacturing was promoted. In the meantime, since the pre-communist pattern was to concentrate industry in coastal areas this was replaced by dispersing the locations over a greater area. New textile mills were established in Kwangsi, Fukien, Ningsia, Yunnan, and even in Sinkiang, Inner Mongolia, and Kweichow, where natural fibers are found. During the First Five-Year Plan, most new textile mills were modern large-scale production units established in urban areas. During the Great Leap, however, thousands of small and medium-sized mills were set up in the countryside and in the communes, using indigenous technology for small-scale production. Some seven hundred small production units like this were in operation in Kirin alone [6, 1958, No. 22, p. 6].

By promoting technological change in the textile industry, labor productivity increased considerably from 1949 to 1969. Available statistics on labor productivity in the spinning sector are given in Table II.

The table shows a remarkable rise in productivity in the spinning sector during the first plan quinquennium. There was some stagnation during the Great Leap as productivity did not increase in 1965 as compared to 1958. The high productivity estimates for 1969 suggest that technological change in the textile in-

TABLE II

LABOR PRODUCTIVITY IN COTTON YARN PRODUCTION

(Kg. per 1,000 spindle hrs.)

Year	Productivity
1949	18[a]
1957	25[b]
1958	30[c]
1965	30[d]
1969(I)	45[e]
1969(II)	50[f]

Sources: a=[6, 1959, No. 28, p. 10]; b=[6, 1959, No. 14, p. 1]; c=[6, 1959, No. 28, p. 10]; d=*Ajia tsūshin* (Tokyo), September 10, 1966, p. 2; e=[8, Oct. 13, 1969, p. 14]; f=*Kuangming Daily* (Shanghai), May 1, 1970, p. 2.

1 See *The Past and Present of China's Iron and Steel, Electric Power, Coal, Machine-Making, Textile and Paper Industries* (Peking, 1958), p. 151. Concentrating industry in coastal areas made it possible to depend heavily on imported materials. In 1924, for instance, 51.7 per cent of all looms in China were in Shanghai; in 1947 the corresponding figures were still 47.8 and 42.5 respectively.

dustry during 1966–69 was quite rapid. This is particularly revealing since technological change in the entire industrial sector (including textiles) was slow during the Cultural Revolution.

In the weaving sector, a somewhat different picture is given by Barry Richman, after visiting textile factories in China [26]. Based on estimates made by R. Field [11, pp. 269–95], K. Chao [4, pp. 88, 96], Liu and Yeh [21], and J. Emerson [9, pp. 403–69], Richman estimated labor productivity of cotton fabrics in 1957 at 5,600–6,650 square meters per man-year [26, p. 634]. A comparable estimate for the weaving sector in the aggregate cannot be derived for later years because of the lack of data on industrial production and employment. However, Richman was able to arrive at a labor productivity estimate for the weaving sector for 1965 on the basis of observations made during visits to three textile factories.[2] The average output per man-year for the three was 11,000 square meters in 1965. Compared to the 5,600–6,650 square meters per man-year in 1957, this estimate shows that labor productivity doubled. It could be argued that the three texile factories Richman visited were "model" factories. As such, their labor productivity should be much higher than that of the smaller factories. However, it should be noted that large and efficient factories also had greater weight in arriving at the average. With the small and medium-sized plants taken into consideration, the average labor productivity came to about 9,000 square meters per man-year, which still means a 50 per cent increase.

The trend for productivity change was different for spinning and weaving sectors during 1957–65. While Table II shows that productivity increased only slightly from 1957 to 1965 in spinning, significant productivity increases took place in the weaving sector. Since spinning and weaving are very closely related, it is difficult to accept such diverse productivity trends in the two sectors. Information derived from both official and unofficial sources gives no indication that technological development was more rapid in weaving. The general picture of technological development in the industry as a whole shows that there were significant innovations in various branches during 1960–66 while technological development was only moderate during 1966–68. Thus, when we probe into the details of technological innovation in the textile industry during the 1950–72 period, the estimated output per 1,000 spindle hours in 1965 may be doubtful. The figure of 30 kg. seems to underestimate conditions. A more accurate estimate should be 40–45 kg. per 1,000 spindle hours.[3] If this estimate for 1965 is used in Table II, the trend of productivity change falls in line with that of the weaving sector, i.e., technological development was rapid from 1958 to 1966 especially for 1961–66, but slowed down during the Cultural Revolution. Although productivity increases can stem from numerous sources, technological

[2] These are the No. 3 Cotton Textile Mill in Peking, the No. 19 Cotton Textile Mill in Shanghai, and the No. 9 (Joint) Sung Sing Cotton Textile Mill in Shanghai.

[3] This estimate is supported by Li Wen-pin's statement that the productivity of cotton yarn manufacturing in 1964 was 34.7 per cent higher than 1959. See Li Wen-pin, "Technical Revolution in China's Textile Industry," *Economic Research,* 1965, No. 4, p. 7.

innovation is undoubtedly the most important. Technological development in the Chinese textile industry can be examined in its various phases.

I. THE FIRST FIVE-YEAR PLAN PHASE

Technological change in the textile industry may be generally classified into (a) material, and (b) operational technological change. The latter can be divided into (i) new working methods, (ii) modification of existing equipment, (iii) development of new equipment, and (iv) introduction of new production techniques.

During the first plan quinquennium, changes in material technology in the textile industry were almost entirely confined to dyeing and finishing. In spinning and weaving, the emphasis was more on fuller use of existing natural fibers, especially animal fibers such as goat, camel, and rabbit [6, 1958, No. 1, p. 7]. It was also reported that pure ramie textiles were successfully produced. This represented the first successful attempt in the world to isolate the plastic layer of ramie by chemical process. A mixed fiber composed of cotton and jute was, however, developed towards the end of the First Five-Year Plan [18, Mar. 30, 1957 and Dec. 25, 1957]. The development of synthetic fibers was also included in the First Five-Year Plan. It is estimated that 4.7 thousand metric tons of synthetic fibers) including both fibranne and rayon) were produced in 1957. This amount was slightly less than 2 per cent of all textiles processed by the industry.[4]

A great many changes in material technology were made in the dyeing sector. This was chiefly because most dyeing materials used in prevailing techniques had to be imported. The chemical industry was undeveloped in pre-communist China and did not develop at a very rapid rate in the early years of the Communist regime. In order to be less dependent on imported chemicals, a great deal of research was conducted to find possible substitutes [30, Oct. 9, 1955]. Soviet technology was borrowed as much as possible. Very often Soviet experts were invited to visit printing and dyeing factories.[5] Nevertheless the dyeing sector had only limited success in developing substitute chemicals for the process during the First Five-Year Plan period. A notable success was the use of sulphur compounds (which could be manufactured by chemical factories at that time) to replace imported chemicals for dyeing dark blue fabrics.[6] In most other cases, changes in material technology in the sector were innovations in the dyeing process leading to reduction in chemical consumption. Such innovations were mainly devices to reuse the unabsorbed dyeing materials, and the development of special starching materials. A notable example was the reabsorption of caustic potash. It was reported that 2,500 metric tons of caustic potash were saved in 1954 as a result of innovations in reabsorption techniques [30, Oct. 9, 1955].

In operational technology, during the first plan quinquennium, most tech-

[4] This estimate was made by R. Kojima [17].

[5] *Chungkuo chingnienpao* (Peking), November 25, 1954, reported a suggestion made by a Soviet expert that the ratio of two chemicals used in dyeing blue fabrics be lowered so as to lower cost and improve quality.

[6] The imported chemical was chrometrop blue AG10.

nological development consisted of new working methods. Very often, methods were the result of one-man innovation. The most frequently quoted and highly praised working methods are:

(1) The 1951 Weaving Working Method

This method resulted from the experience of textile workers in Tientsin, Tsingtao, and Shanghai. It has three characteristics. First, the working procedure with looms is orderly arranged. A major operation in weaving is the constant change of shuttles. The new working method emphasizes systematic change of shuttles in accord with a certain prescribed network. The looms in a factory are divided into groups and the compartments of each loom are divided into sections. Workers responsible for shuttle changing are required to follow a specified route in moving from one compartment to another. Second, workers perform different operations with different speed and strength. They are required to follow a prescribed routing, and reminded to be alert in order to cope with unforeseeable circumstances. For example, when shuttle changing and thread breaking happen simultaneously, workers should change shuttles first so that stoppage affects fewer compartments. Third, workers familiarize themselves with the performance of the machines and do a thorough check before production begins. A list of twelve points has been drawn up to guide the continuous checking of looms [15, Nov. 25, 1951].

(2) The Ho Chien-hsui Work Method

Basically, the principles underlying the Ho Chien-hsui work method[7] are the same as those of the 1951 weaving working method, although it applies to the cotton spinning process. This method is considered scientific in the sense that it represents a systematic and logical arrangement of the work procedures to achieve specific objectives. The basic principles [15, Nov. 20, 1959] include (i) jobs are planned, (ii) work-flow is regulated, (iii) different operations are co-ordinated, and (iv) a precautionary attitude is promoted and developed.

(3) The 1953 Working Method of Textile Machinery Maintenance

Part of this working method was based on the Soviet experience. This method calls for a shift system of machine parts. Whenever the major parts of a textile machine are sent for check or repair, they are immediately replaced by a set of like parts so that the production process is not interrupted. Second, a detailed procedure is laid down governing the composition of a machine, and checking, repair, and testing. Third, there are detailed procedures governing day-to-day maintenance of textile machines. For example, workers are required to carry out lubrication and cleaning according to prescribed rules.

Many new work methods have been introduced in winding, lap doffing, and sizing.[8] Generally speaking, these are innovations to enhance labor efficiency without installing new machines. Innovations in work methods, therefore, con-

[7] Ho Chien-hsui was a member of the labor force in the textile industry.

[8] [32, July 22, 1952]; *Chiehfang jihpao* (Shanghai), May 10, and May 30, 1952; *Chunchung jihpao* (Si-an), June 3, 1952. The new working method was called the light sizing method. The essence was to reduce the fats and starch constituents in the sizing material.

stitute an important source of productivity increases in the textile industry from 1950 to 1957. Labor productivity in the textiles during 1953, for instance, increased 117.3 per cent over 1949 [30, May 15, 1954].

Modifications of existing equipment and machinery and development of new equipment and machinery often have more important technological change than new working methods. Such modifications and develpment are aimed at (i) reducing the number of production processes, (ii) mechanizing essential operations, and (iii) eliminating sources of inefficiency in existing machinery. These are also the objectives Chinese planners have been trying to achieve in bringing about technological change in the textile industry. The relatively slow rate of building up modern equipment and machinery in the textile industry during the first plan quinquennium is understandable. At that point, China was in no position to design and build modern textile machinery. At the same time, Soviet Russia, the chief source of China's technology imports, was relatively underdeveloped in textile technology. In addition, under the development strategy of the First Five-Year Plan, consumer goods industries received low priority in capital investment. As a result, innovations in textile technology have mostly taken the form of modifying and improving existing equipment and machinery. Such modifications and improvements can be quite effective in increasing equipment efficiency. No. 2 Textile Factory in Hengyang, for example, after successfully modifying a certain type of manual weaving machine, raised the number of shuttles per minute from 120 to 180 [13]. Also, in Wuhan, the improvement of an existing model of blowing machine brought lowered impurities on lap doffing equipment from 1.8 to 1.4 per cent [3].

Sometimes, improvement of old equipment is made by adding accessories. For instance, in 1951 a triangular stretching rod was invented and installed in existing ginning machines. This device reduced the level of waste in the ginning process [15, Dec. 4, 1951]. In some cases, substantial increase in the efficiency of existing epuipment can be brought about by simple innovations such as replacing a wooden by a steel wheel or by changing the upward position of a gear lever to a downward position [28] [27].

Although modifications of existing equipment was the predominant practice during the 1950–57 period, a few models of textile machinery were designed and constructed in China with Soviet aid.[9] They include (i) a machine combining the processes of bale breaking, mixing, opening, and scutching cotton fibers [14, p. 10]; (ii) a new carding machine with high production capacity [14, p. 10]; (iii) a new super-high draft capable of stretching cotton thread more than a hundred times in length in a single process using the old-type spinning machine [14, p. 10]; (iv) a new machine to separate impurities in textile fibers at lower production costs and turn out higher quality yarns [30, Dec. 3, 1953]; and (v) a new knitting machine capable of producing a large variety of controllable patterns and color [19].

[9] Unlike heavy industries, there was no import of complete textile plants from Soviet Russia. Even textile machinery imports from the USSR were limited. This was attributable to the stagnation of textile technology in the Soviet Union, as pointed out above.

In addition, a shuttle-less weaving machine modelled on the jute weaving machine was reportedly constructed as early as 1952 [32, Sept. 22, 1952]. However, no further development or installation of this type of shuttle-less weaving machine is reported. Probable technical drawbacks and operational difficulties in the modified machine prevented it from further development and widespread adoption.

During the 1950–57 period, there were important innovations in production techniques. Many innovations were aimed at shortening the production process and/or making various processes continuous. Examples include new techniques in the combined process of woolen textiles to reduce the process from nine to six steps; and new techniques in drafting cotton threads, to reduce wastes and increase drafting power [6, 1958, No. 1, p. 6]. There were also new techniques in spooling and winding yarns, resulting in reduced wastes. The essence of these new winding techniques lies in the operation of connecting yarns. In dyeing, a much publicized innovation was hydrogen peroxide bleaching which simplified the production process and saved equipment and material.

Unlike heavy industries, technological development in textiles from 1950 to 1957 was not directed at acquiring the most up-to-date equipment and machinery. Major innovations were mostly new working methods (which made possible a more effective use of human resources and existing equipment), and modifications of existing machinery and equipment to increase plant efficiency and production capacity. By world standards, the technological level of the Chinese industry was low at the end of the First Five-Year Plan. The government admitted that mechanization of the industry should have moved at higher speed [30, May 15, 1956]. Many production processes (e.g., slubbing and roving) were not continuously performed by a single machine [30, May 15, 1956]. In many areas of the textile industry, the degree of mechanization and automation was very low. In the silk sector, for instance, operation was still mainly by hand, and in the dyeing and printing sector some workers still had to work in high-temperatures and smoke. There was practically no technological development in the knitting sector [14, p. 11].

Notwithstanding these difficulties, a high rate of growth in output and productivity was reported in the textile industry. This can, perhaps, be explained by the fact that the textile industry is basically labor-intensive, and that the low ebb of economic activity in China in 1949 is a base year for temporal comparison.

II. THE GREAT LEAP PHASE

During the Great Leap, a new policy line was adopted to accelerate industrial development.[10] The most salient policy was the development of local, small-

[10] Known as "the general line for socialist construction," adopted in the Second Plenary Session of the Eighth National Congress of the Chinese Communist party in May 1958.

scale enterprises with indigenous production methods. As expected, the textile industry was affected by this new policy line,[11] under which innovation by workers and three-into-one (cooperation of leadership cadres, technicians, and workers) became a guideline for technological development. Despite continuous reports of increases in labor productivity in the textile industry during the Great Leap, few significant innovations were detected. Perhaps, the most significant was the introduction of synthetic fibers. During the Great Leap, developments in operational technology were not particularly pronounced.

As we have seen, major emphasis during the first plan quinquennium was on more effective use of available vegetable and animal fibers. As early as 1955, the importance of synthetic fibers was stated at the National People's Congress. In the Second Five-Year Plan,[12] the development of synthetic fibers was given the highest priority in the chemical industry. Such a high priority for development of synthetic fibers was attributable primarily to decreased output of cotton fibers in 1956.[13] Bad harvests during 1960–63 gave further impetus to a more rapid development of synthetic-fiber manufacturing.[14]

The shift from natural to synthetic fiber in the textile industry during the second plan period is shown by the following statistics. In 1953, the percentage share of cotton fiber of all fiber types used in the industry was 95.9, and this figure dropped to 90.6 in 1958 [31, p. 105]. Two estimates have been made on the production of synthetic fibers in China in 1958. R. Kojima estimated it at one thousand metric tons, which is 2.9 per cent of all fibers used [17, p. 130]; H. Miyashita estimated production at 1,600 metric tons, or 4.6 per cent of all fibers used [24, p. 140].

The increasing use of synthetic fibers in the textile industry was an important development. It has made supply of raw materials more dependable, and the end product more diversified and of better quality. Thus, the use of synthetic fibers is an important landmark in technological change for textiles during the second plan quinquennium.

At the same time, artificial fibers such as acetate and rayon continued to increase in importance. It is estimated that 10 thousand metric tons of artificial fibers were produced in 1958 as against the output of 4.7 thousand metric tons in 1957 [17, p. 130].

With the belief in innovation by workers and in labor-intensive technology during the Great Leap, little progress was made in the design of large-scale capital equipment in terms of either automation or simplification of production

[11] "A high rate of development in the textile industry also needs to walk with two legs," in [6, 1958, No. 22, pp. 1–9]. Reportedly seven hundred small textile production units were established in Kirin Province alone.

[12] The plan was first submitted at the Eighth National Congress of the Chinese Communist party in September 1956.

[13] [31, p. 105]. Cotton fiber output dropped from 1,518,500 metric tons in 1955 to 1,445,000 in 1956.

[14] See [17, p. 154]. According to R. Kojima, the production of cotton fiber in thousand metric tons was 1,169 in 1960, 1,040 in 1961, 1,238 in 1962, and 1,500 in 1963.

processes. Development in operation technology in the textile industry during the Great Leap was mainly along labor-intensive lines.

The three "great working methods" developed during 1950–57 (the Ho Chien-hsui working method, the 1951 weaving method, and the 1953 textile machinery maintenance method) were again emphasized during the Great Leap. This re-emphasizing of the three "great working methods" was formulated at a textile conference in 1959 jointly organized by the Textile Bureau and the National Committee of Textile Trade Unions [15, Nov. 20, 1959]. The conference asserted that based on the past eight years' experience, the Ho Chien-hsui working method and the 1951 weaving method were found to be most suitable for multi-frame production in the textile industry. The emphasis on working methods during the Great Leap was in line with the prevailing policy of mobilizing and making the most effective use of the mass reserves of labor.

Since technology policy during the Great Leap was to develop labor-intensive innovations, little effort went into development of automatic textile machinery. On the other hand, development of high-speed textile machinery became a major objective in the technological development of the textile industry during the Great Leap. This was evidenced in the emphasis on the "four highs," i.e., high speed, high level of production, high quality, and high level of skill. However, the objective of high speed in the textile industry was achieved not so much through the importation of modern high speed machinery, nor through domestic design and construction of such machinery, but through the modification or improvement of existing machinery and equipment. Very often such modifications were not based on knowledge from formal technical and engineering training but based on experience of the masses. Many attempts were beyond the realm of technical feasibility. It was reported, for example, that during the Great Leap the average speed of flyer frames for medium counts reached 350 revolutions per minute and the maximum, 800 revolutions. The speed of weaving machines was increased from 180 to 220 revolutions per minute [29, Aug. 30, 1958] [33].

Although modifications of existing machinery and equipment to attain higher speed brought about increased output in the short run, they could not be relied upon to sustain the growth and efficiency of the industry in the long run. Breakdowns due to high wear and tear of modified machinery and equipment were frequently reported. Such breakdowns caused by increased speed of machinery gave rise to technical problems, including the increased breaking of threads, shuttles jumping out, and an increase in lower quality products [29, Aug. 30, 1958] [33].

The introduction of new textile machines was also reported [7, Dec. 6, 1959]. In fact, most of them such as the high-production carding machine, and the high-power drafting machine, were introduced by the end of the First Five-Year Plan. A variety of hand-operated and labor-intensive textile machines were developed and widely used by the small and medium-sized production units in the local sector during the Great Leap. Many types of manual cotton ginning machines were built and praised highly. The design and construction details of a hand-operated cotton ginning machine with stone wheels built in Shensi, for instance, were publicized in other parts of the country for its production [29, Nov. 28, 1958].

A more promising technological development in the textile industry during the Great Leap was the use of the hydrogen-peroxide bleaching method. It was developed to enable bleaching time to be reduced from twenty-thirty to two-three hours [7, Dec. 6, 1959]. In addition, a new bleaching method using sodium compounds was introduced, which further reduced bleaching time to one hour [33]. Metallic salts were successfully used to replace a great number of dyes. These innovations helped to greatly reduce costs, inasmuch as most dyes were previously imported [29, May 31, 1958]. A dyeing factory in Peking discovered a method of using supersonic waves to break down the dye particles. This new technique reportedly made possible an increase in efficiency of forty to eighty times in comparison with the old technique of using ball grinders [7, Dec. 6, 1959]. The relatively high rate of technological development in the dyeing and finishing sector of the textile industry was, to great extent, sustained by the fast growing chemical industry in China.

III. THE THIRD AND FOURTH FIVE-YEAR PLAN PHASE

Conforming to the world trend in textiles, cotton fibers have been rapidly substituted with artificial and synthetic fibers in China since the Great Leap. To some extent, the use of artificial and synthetic fibers was accelerated by persistently bad cotton harvests from 1960 to 1963. By 1965, it was estimated that 50 thousand metric tons of artificial fibers and 44.5 thousand metric tons of synthetic fibers were produced. The former was 10 per cent and the latter 8.9 per cent of all fibers produced by the Chinese textile industry [17]. Such high percentages of artificial and synthetic fibers used meant that by 1965 China had mastered not only the control of manufacture but also the technique of weaving, printing, dyeing, and other processes. Most developments were indigenous. Most techniques were acquired by continuous experiment and research. Research centers for synthetic textiles were set up in Shanghai and Peking.

Operation technology developed during the Readjustment Period (1961–64) laid heavy emphasis on material saving and quality improvement [12, pp. 15–17]. The material saving campaign was widespread during the Readjustment phase, especially in light industries which relied on material supply from agriculture. There were successive bad harvests during the 1960–63 period. The emphasis on quality improvement was a reaction to increased production of inferior products during the Great Leap. To achieve these goals, new working methods and production techniques were introduced. Since the textile industry was labor-intensive and thus contained a high proportion of workers, revolution in working methods tended to revitalize the majority of workers and at the same time helped to improve product quality [20, p. 6]. An example was the improvement in the operation of gears. It improved the technique of single operations, such as evaluating and promoting the fusion of coarse yarns and the fusion of fine yarns without white spots on point connection parts [19, p. 6]. Numerous production techniques were developed. Throughout the process from cleansing cotton to weaving fine yarns, the construction of cotton rolls and the control mechanisms was improved in all phases. Many new types of fine yarn gasket sheaths were developed to improve the specific gravity of the first-grade yarn strands. The printing and dyeing factories also improved their water cleansing process and the balance of post-completion treatment [20, p. 7]. All these improvements helped to save materials and improve quality.

At the same time, attention was drawn to technological change to increase labor productivity. This was attained through fuller utilization and improvement of existing equipment, simplification of production processes, and introduction of new machines [12, pp. 15–17]. Apparently, considerable success was achieved in improving existing equipment and machinery. A large number of fine yarn shuttles and thread picking shuttles in many textile factories were changed to ball-bearing shuttles. This change resulted in a 10 per cent increase in shuttle speed, a 5–7 per cent reduction in fuel consumption, and a 50 per cent reduction in the use of shuttle lubrication [18, Feb. 1962]. Vacuumatic continuous pick-up needles were used in cotton-combining machines. The use of this new type of needle increased productivity by 3 per cent as a result of a lowered frequency in picking-up needles [18, Sept. 19, 1962]. In many garment factories in Shanghai, old-fashioned K-machines were remodelled into double-stitch-double-skip and triple-stitch-triple-skip machines [20, p. 8].

Turning to the reduction of production phases many technical processes at the various stages of spinning and weaving were reduced to a single, continuous process, as a result of technical reforms. The following were notable examples [20, p. 9] [29, Mar. 24, 1961] [15, Mar. 23, 1962]: (1) the design of single-process cotton-cleansing machines, (2) the adoption of the combination process of three ups and four downs or four ups and three downs, (3) the change from double-process coarse yarns to single-process coarse yarns, and (4) the new technique of combining two into one coarse yarn instead of combining three into two coarse yarn.

In the printing and dyeing sector, a single continuous process combining caustic soda rolling, steam refining and bleaching was adopted. This new technical method reduced refining and bleaching from three-five stages of intermittent processing to continuous processing, thus reducing the complete production stage from twenty-four to four hours.

New machines aiming at mechanizing manual operations were introduced to many sectors of the industry. In the manufacture of silk goods, hand-operated spinning machines were gradually replaced by automatic spinning machines. In the printing and dyeing sector, electronic-controlled roll-dyeing machines were introduced. These new machines enabled automatic direction change to be made, as well as automatic counting, and automatic temperature control. Each worker could then handle three to four machines instead of two. The color discrepancy caused by mistakes in great-figuring was successfully eliminated. Many printing and dyeing plants replaced hand-operated processes like dyeing, water-cleansing, acid-application, and soap-cleansing by machines.

Another important technological change in the textile industry during the Readjustment Period was the design of new products. With the advance in manufacture of synthetic fibers, textile products made of synthetic fibers developed rapidly. By 1965, the industry was able to have matched specifications and color ranges for all types of cotton, wool, silk, and dacro-linen, as well as vinylon and brocade mixtures. In order to meet market demand, test-manufacturing of special kinds of processing goods was conducted. Such products included chlorine-resistant woven latex goods, fancy-gloss textiles, high-grade fine-combed shrink-resistant shantung, khaki, permanent-press cotton cloth, tooth-edged handkerchiefs, spiral-designed bath-towels, and photoprinted silk for umbrellas.

In general, the Readjustment Period witnessed a number of important technological innovations in all branches of the industry. In many ways, technological change during this period was based on specialized technical and engineering skills and was more labor-saving in nature [25] [5, pp. 16–18]. To a great extent, this was in contrast to developments during the Great Leap. There seemed, however, to be some problem in the process of technical reform. Available information shows that technical reforms were not developed with sufficient balance among enterprises, i.e., technological innovations tended to be rapid in some enterprises and slow in others. Another problem was that many technical reforms had not been put together into an integral system, thus preventing the most effective use of individual innovations. Lastly, by the end of this period there was a feeling among the planners that most of the masses had not been mobilized [1]. The result was another change in China's technology policy during the 1964–66 period, when mass-innovation was again given an important role in technological development.

The 1964–66 period was known as the design reform phase. In this phase, while small innovations were much publicized, there was little said of specific innovations based on formal engineering services. To emphasize the role of mass-innovation, there was a movement among Chinese workers "to compare, learn, overtake, help, and surpass" [22]. There are ample reports on the success of this movement.

Innovations reported during this period revealed two interesting characteristics. First, it was most unusual for reports on rise in productivity and change in technology to contain any detailed description of specific innovations. Almost invariably, the report mentioned merely the number of items improved and the resulting increase in productivity. Second, a significant proportion of reported technological innovations took place in silk goods, knitting, and printing and dyeing. It is of interest to note that in 1958 all these sectors were regarded as the most technologically backward. This perhaps indicates that economic planners in China wished to pursue a more balanced technological development among different sectors of the industry.

During the Cultural Revolution during which the working class seized leadership in most plants, considerable technological development took place in some industries including textiles [2]. Notable innovations in the textile industry during the Cultural Revolution included (1) China's first highly mechanized artificial fiber plant established in Fukien in early 1968 with an annual output capacity of two thousand metric tons of artificial fibers [15, Oct. 25, 1968], (2) China's first ramie textile plant set up in Kalgan in 1968 [7, Nov. 5, 1958], (3) a high-speed fine-yarn spindle with production capacity of 45 kg. per 1,000 spindle hours constructed by Shanghai textile workers [15, May 20, 1970] [8, Oct. 13, 1969], and (4) a new type of high-power carding machine nine times more efficient than the 1955 carding machines [8, Mar. 10, 1969].

The 1969–72 period was one of recovery from the Cultural Revolution and the beginning of the Fourth Five-Year Plan. This period was essentially a continuation of the preceding period as far as the nature of technological development was concerned. In a more obvious way, mass-innovation and specialized engineering and technical disciplines were regarded as complementary. The three-into-one cooperation was again emphasized [10, pp. 16–19]. With considerable success in design reform since 1964 and the development of scientific and technical education since the Great Leap, China had reached a new stage in technological development during which innovations were based on indigenous design and were so constructed to suit domestic conditions. Many technological innovations in the textile industry during the 1969–72 period lend support to the above statement. In the spinning and weaving sectors, much progress was made in increasing spinning and weaving speed, and in promoting mechanization and automation. For example, in raising the revolution per minute of ring spindles, Chinese technicians and workers were able to make the machine exceed the 13,000 revolution-per-minute limit without using foreign technique [10, p. 16]. In many cases, the design of new innovations was unorthodox from the point of view of Western technology.

As in the 1964–66 period, silk-products, knitting, and printing and dyeing achieved relatively high rates of technological development from 1969 to 1972. In the silk-product sector, one important innovation was a new process by which silk could be derived from cocoons in warm water instead of boiling water, thus greatly reducing fuel consumption [7, July 16, 1970].

One of the most important innovations during this period was undoubtedly the "one-stage" printing-dyeing technique [15, May 5, 1970] [8, May 18, 1970, p. 12] [10]. According to the old printing-dyeing technology, grey cloth had to go through singeing, boiling in soda, bleaching, and a number of other steps.[15] The whole process took thirty-six hours and turned out a thinner, less durable cloth. In addition, the old technology was complicated, done on different machines in separate stages making job a heavy one for workers and consumed large amounts of coal, soda, and water. In 1969, the textile workers in Shanghai developed the one-stage technique which successfully eliminated singeing and boiling-out, and performed the other ten processes by one continuous printing and dyeing machine under automatic electronic control. This new technology reduced the entire process to only twenty minutes, and cut the consumption of

15 There had been some technical reforms in bleaching before 1966, but not the complete printing-dyeing process.

coal and electricity by half, and of water by 70 per cent in addition to saving large amounts of soda and other inputs. Moreover, the finished product was 20 per cent stronger. By March 1970, 77 per cent of cloth for domestic sale was produced by this new technique of printing and dyeing.

Another outstanding development in the textile industry during the 1969–72 period was the building of textile machines by the plants themselves. This development aimed at (1) solving the pressing problem in the supply of textile machinery created by the rapid expansion of the industry, and (2) bringing the development of new equipment and machinery especially suited for conditions in China in line with the practice of "on-the-spot" designing.

IV. SUMMARY AND CONCLUSIONS

Despite the high priority given to heavy industry, textiles in China were not neglected by economic planners. The growth of the industry has been outstanding in terms of increase in output, in labor productivity, and technological development. During the First Five-Year Plan, technological innovations were mostly in working methods and improving existing machinery and equipment. The degree of mechanization and automation remained low at the completion of the First Five-Year Plan. The Great Leap witnessed a change in technology policy toward labor-intensive techniques based on mass innovation. There was a revival of the emphasis on the "three great working methods" developed in the 1951–53 period in order to achieve the most effective use of the mass labor reserves. New production techniques and new machines introduced had, in general, a bias towards labor-intensiveness. Technical reform was often aimed at achieving high speed. While this undoubtedly was the correct line for the textile industry to follow, during the Great Leap this objective was achieved not on the formal technical and engineering basis, but on the basis of the masses. Under these circumstances, inefficiency and breakdowns were inevitable. Thus high-speed movement had dubious results. The notable success during the Great Leap was, perhaps, the introduction of synthetic-fiber manufacturing and an increased use of synthetic and artificial fibers in the manufacture of final products.

During the Third and Fourth Five-Year Plans, technological development in the textile industry passed through four stages. The first stage (1961–64) saw China's first serious attempt to mechanize the textile industry. Considerable success had been made during this Readjustment Period, though most of new inventions were based on foreign design and some were even direct imitations. The second stage (1964–66) witnessed a revival in the emphasis on mass innovation. A more promising development during this period was greater emphasis on technological development in the silk-product sector, the knitting sector, and the printing and dyeing sector, all of which prior to 1964 were the most technologically backward sectors in the industry.

The Cultural Revolution did not disrupt technological development in textiles. In the latest period (1969–72), mass innovations and formal technical and engineering disciplines were regarded as complementary. Instead of direct imitation of foreign technology, new techniques were developed and new machines produced to suit domestic conditions.

Under the Communist regime, technological development in the textile industry may not be the fastest, but is steady and continuous. Even during the turmoil of the Cultural Revolution, important technological innovations were made. Unlike other industries such as iron and steel, machine-tool and chemical fertilizer, Soviet aid played little part in the rapid and continuous technological development of textiles. On the one hand, this may have retarded the rate of technological change in the textile industry since it was deprived of the advantage of direct borrowing of foreign technology. This, perhaps, explains the slow progress of the industry in mechanization and automation before 1960. On the other hand, the absence of Soviet aid and direct transfer of technology may be a blessing to the long-run development of the industry, as China is given an opportunity to develop the kind of technology that suits her best.

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