IDRC-171e

Absorption and diffusion of imported technology

Proceedings of a workshop held in Singapore, 26-30 January 1981

The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in five sectors: agriculture, food and nutrition sciences; health sciences; information sciences; social sciences; and communications. IDRC is financed solely by the Parliament of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America, and the Middle East.

Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa

IDRC, Ottawa CA

IDRC-171e

Absorption and Diffusion of Imported Technology : proceedings of a workshop held in Singapore, 26–30 January 1981. Ottawa, Ont., IDRC, 1983. 112 p. : ill.

/Science policy/, /technology transfer/, /choice of technology/, /technological change/, /South Asia/, /Indonesia/, /Korea R./, /Philippines/ — /small-scale industry/, /textile industry/, /self-reliance/, /employment opportunities/, /foreign investments/, /case studies/, /comparative analysis/, /list of participants/.

UDC: 62.001.1

ISBN: 0-88936-298-X

Microfiche edition available

IDRC-171e

Absorption and Diffusion of Imported Technology

Proceedings of a workshop held in Singapore, 26–30 January 1981

Contents

Foreword 5

Introduction 7

ADIT: A Review 13

Case Studies

Accumulation of technological capability and assimilation of imported industrial production systems in the cotton textile industry in Bangladesh
Quazi H. Ahmed 21

Absorption and diffusion of imported technology: a case study of four industries in Sri Lanka
Marga Institute 28

Some issues pertaining to technical change in the cotton textile sector in Sri Lanka
W.D. Lakshman 37

Absorption, assimilation, and diffusion of imported technology in Pakistan: a case study of the textile and pharmaceutical industries
Firasat Ali and Jamal Ahad Khan 41

Technological change, transfer, and diffusion in the textile industry in India
Amitav Rath 49

Technology and market structure under government regulation: a case study of the Indian textile industry
Ashok V. Desai 61

The Philippine ADIT project: a summary paper
Luke Kho and Lope Cuaresma 73

Absorption and diffusion of imported technology: a case study in the Republic of Korea
Woo Hee Park 79

Analysis of systems behaviour in the absorption and diffusion of imported technology
Suck-chul Yoon 90

Comparative Studies

Similarities and differences: the Indonesian case
Nilyardi Kahar 95

Japanese investments in South Asia from a global perspective
W.D. Lakshman 97

Comparative analysis of technology policies of ADIT network countries
Quazi H. Ahmed 105

Workshop Conclusions 109

Participants 112

Accumulation of Technological Capability and Assimilation of Imported Industrial Production Systems in the Cotton Textile Industry in Bangladesh

Quazi H. Ahmed[1]

For many years, concerns about the effects of technology transfer have concentrated heavily on the relatively short-run costs of transfer. These costs may be considered under the headings of direct and indirect costs (UNCTAD 1972). Direct costs include (1) payments made for importing capital goods; (2) payments made for technical services in preinvestment, investment, and operational phases; and (3) payments made for the right to use patents, licences, know-how, and trademarks. Indirect costs include (1) charges resulting from overpricing of imported intermediate products and equipment (hidden cost or price markups); (2) charges arising from profits on capitalization of know-how (equity participation in place of, or in addition to, other means of payments for the transfer of technology); and (3) charges in the form of some portion of repatriated profits of wholly owned subsidiaries or joint ventures, the establishment of which does not include specific provisions for payments for the transfer of technology.

There has also been concern about the effects of transferring technology in terms of the "appropriateness" of the production system transferred in light of the factor availability and other conditions of the importing economy. The concern has focused mainly on capital-intensive versus labour-intensive techniques.

The output from the technology transfer process is not only the physical components of technology (i.e., the production systems and machinery) but also the technical knowledge and skills relevant to the particular production system. A more recent concern about technology transfer has been to understand how, and to what extent, it contributes to the local accumulation of technical knowledge and skills, which constitute the technological capability of the importing society.

This study does not focus directly on the transfer and accumulation of knowledge and skills but instead on various aspects of techno-economic performance of the textile industry. The study suggests that there are "symptoms" that are likely to indicate the extent to which industry has accumulated relevant technological and techno-managerial capabilities. This, in turn, may indicate whether technical knowledge as well as technical systems have been acquired, absorbed, and diffused during the process of technology transfer. The question of whether or not there is evidence to suggest that the acquisition, absorption, and diffusion of technical knowledge is a matter of significant concern for the cotton textile industry in Bangladesh is investigated. By focusing on the extent to which the imported production systems have been effectively assimilated within the economy, an affirmative answer to this question has been reached.

The term "assimilation" is used to cover different aspects of techno-economic performance — aspects that reflect the extent to which the imported production systems have become viably rooted within the importing economy. The following aspects of performance (i.e., the symptoms of assimilation) will be discussed: (1) levels of efficiency in operating the production systems that are set up as a result of the technology transfer process; (2) rate of change in production efficiencies; (3) degree to which the techniques are structurally integrated within the economy

[1]Associate Professor, Institute of Business Administration, University of Dacca, Bangladesh.

with respect to current inputs for production (e.g., raw materials and spare parts) and with respect to inputs for investment in new mills and in capacity expansion of existing plants (e.g., machinery and equipment and investment-related technological and techno-managerial services); (4) extent to which endogenous processes of incremental technical change are developed locally in order to provide improved techniques for expansion of the industry; and (5) extent to which a technical change can draw upon a local process of more radical innovation to provide successive improved technical change.

(1) Production efficiencies are reflected in machine productivity, labour productivity, capacity utilization, and wastage rates expressed in physical units. If these efficiency indicators are up to the "standard," then it may be concluded that the imported system has been assimilated at least to some extent within the local environment. Standard levels of performance (e.g., output rate, wastage rate) are normally specified by the supplier of the production system. Manpower requirements to operate the system are also given by the supplier. It is possible, therefore, to compare the performance of the system with the specified standards. Alternatively, one can compare the performance with that of other countries that are using the same techniques of production and are (were) at a "similar stage in the development" of a particular industry as the economy under consideration. Any deviation from the standard level of performance will warrant some explanation.

(2) In a dynamic industrial economy, production techniques are not operated at static levels of efficiency. Even without investment in new techniques of production, it is possible to raise production efficiency continuously as a result of "learning" and incremental technical change. This phenomenon has been demonstrated in a number of empirical studies, both in developed and developing economies. Among these, Hollander's (1965) study of Dupont rayon plants and the study of Katz et al. (1978) of a rayon plant in Argentina are illuminating. In Hollander's study the contribution of ongoing technical change within existing plants was found to be overwhelmingly important for substantial cost reduction over time.

(3) Structural integration will be indicated by the extent to which the imported system draws on local rather than imported inputs, i.e., raw materials, spare parts, and intermediate goods. When a production system is imported in developing economies, large portions of these inputs are imported as well. As the system becomes structurally integrated within the economy, however, large portions of the imported inputs are produced locally and used successfully without lowering the efficiency of the system. The degree of success in this regard will depend upon the extent to which various kinds of technological capability are built up around the initially imported system. It will also depend on many other factors, e.g., the technological capability of other sectors that might provide these inputs and the types of programs offered by educational/vocational training institutions. This process of integration is likely to be cumulative — the greater the structural integration achieved, the fewer the imported inputs required for the subsequent importation of similar production systems.

After the importation of a particular production system for the first time, it may be possible to learn sufficiently from the system to allow for the replication of the technique (partly or wholly) with the help of locally supplied goods and services for expansion of capacity. The case of "reverse engineering" followed by Japan (Cooper 1973) during their period of industrialization illustrates one way this can be achieved. It may also be possible to develop the capabilities to carry out locally, at least, some of the activities that are required to expand capacity and that were previously carried out by foreign personnel at the initial stage, e.g., feasibility studies, providing consulting services, developing specifications, designing the plant and its component elements, and producing capital goods. This is possible only when conscious efforts are made to reduce dependence upon foreign know-how and techniques.

(4) After a production system has been imported and installed, it may be possible not only to improve the efficiency of the system that was initially imported and to replicate that system for capacity expansion but also to develop improvements for incorporation into new plants. Such technical change may be considered "minor" or "major" (Hollander 1965). A minor technical change involves an "incremental" or "evolutionary" alteration in the existing techniques. A major change, on the other hand, involves a significant departure from the existing methods. Continuous efforts to bring about incremental technical change may result in a significant increase in efficiency. If such technical changes are effected with the help of endogenous resources, then the resultant improved technique and the accumulated capability may also be utilized effectively for the expansion of the industry. The ability to effect change will vary from economy to economy due to the variation in availability of skills, supporting services, leader-

ship quality, type of contractual agreement with the technology supplier, and a host of other reasons that are very specific to the economy under consideration.

(5) Major technical change involves a significant/radical departure from existing methods and is, therefore, relatively difficult to accomplish (Hollander 1965). To accomplish major technical change, continuous support from research and development groups (both internal and external) may be essential. The degree to which support comes from local research and development and other related sectors to carry out major technical change is also an indication that substantially dynamic processes of local technological capability have been accumulated. The extent to which these different kinds of activities are carried out locally can be said to indicate the degree to which initially imported technical systems have been "assimilated" within the economy.

The degree of assimilation that is effected will depend upon many factors. This study focuses on the fact that it will, in part, be a function of the level and composition of local technological capabilities. In turn, the levels and compositions of local capabilities that are accumulated will depend on various factors. Firstly, they may result from local efforts to accumulate technical knowledge and skills. Secondly, they will depend upon the acquisition and absorption of technical knowledge and skills from the technology transfer process. The optimum combination of these two efforts may lead to desired levels and structures of capability accumulation and, hence, toward desired degrees and patterns of assimilation of the imported technology. Thus, the so-called technology transfer process may provide two outputs for the technology importer. Firstly, it will usually provide a particular production system (i.e., a textile mill or part of one) that may or may not, subsequently, be assimilated in the various ways mentioned earlier. Secondly, the transfer process may provide an output of technical knowledge, skill, and experience. The extent to which the technical system is assimilated will depend, in large part, on the extent to which knowledge and skill are acquired by and absorbed within the local economy.

In light of the indicators of assimilation mentioned earlier and the actual performance of the textile industry in Bangladesh, it appears that the imported technical systems have been poorly assimilated, which suggests that there has been very limited accumulation of local technological capability. In view of this, it is suggested that the way in which local technological capability is accumulated and, more specifically, the role that is played by the technology transfer process should be examined in detail in subsequent work.

Only the levels of production efficiency, the rate of change of production efficiencies, and the degree to which the techniques are structurally integrated within the economy will be discussed here. By limiting the study to these three aspects there are some comparable data, particularly the levels and trends of production efficiencies, available from published sources from industrially developed countries that allow some direct comparisons of levels and trends of performances to be made.

Historical Background of the Textile Industry

The cotton textile industry in Bangladesh is an import-substitution industry. At the time of independence of Pakistan and India, in 1947, Bangladesh (formerly East Pakistan) had only 10 cotton textile mills, with an installed capacity of 109 740 spindles and 2717 looms. This installed capacity was increased to 750 000 spindles and 7000 looms in 1969–1970 and 982 000 spindles and 8000 looms in 1977–1978 (spread over 48 mills). Growth of this sector up to 1970 (i.e., during the Pakistan regime) took place in the private sector. However, after the liberation of Bangladesh (i.e., after December 1971), the running as well as the development of the industry has been the responsibility of the Government of Bangladesh. Easy credit, cheaper imports of capital goods (due to overvalued local currency), a protected market, and the potential for high profit were the attractions for the private investors in the cotton textile sector during the period up to 1970.

Development and expansion of the cotton textile industry in Bangladesh took place through the importation of machinery, mainly from Japan and the United Kingdom. A small portion of the machinery was, however, supplied from within Bangladesh. In addition to capital goods, investment-related services (i.e., services for the selection, installation, and commissioning of machinery) were also imported. Local engineers and technicians have now acquired these skills and the importation of such services has virtually been eliminated.

Prior to 1971, raw cotton used to be bought from West Pakistan (a domestic source of supply), but after the break with Pakistan it was imported from different countries throughout the world. Most spare parts were also imported. Textile mills in Bangladesh lost a large number of non-Bengali managers and technicians during

and immediately after the War of Liberation of Bangladesh. This created a short-term vacuum of techno-managerial skills within the industry.

Based on the target (set by the government) of 12 yards (11 m) per capita availability of cloth, the Bangladesh Textile Mills Corporation will be required to set up a total of 39 spinning mills of 25 000 spindles each by 1985. This will cost approximately Tk4524 million (U.S.$262 million) in total, of which about Tk1397 million (U.S.$81 million) will be required in foreign exchange. In addition to this huge amount of money, the Bangladesh Textile Mills Corporation will also be required to train and develop (or import) technical and managerial manpower to run these units efficiently within a short period of time. Therefore, both the history of the industry and the likely future expansion present considerable problems for the technology policymakers in relation to the sector.

Levels and Trends of Indicators of Aggregate Industrial Performance

Analysis of the performance of the industry as a whole showed a general downward trend over time. Machine productivity, labour productivity, and capacity utilization were used as the efficiency indicators for this analysis. Values of these indicators are shown in Table 1.

The fluctuation of spindle productivity from 1961–1962 to 1976–1977 was not statistically significant. On the other hand, the decline of loom productivity during the same period was found to be significant at the 1% level ($t = 5.25$, $r^2 = 0.70$). The decline of capacity utilization based on installed spindles was found to be significant at the 5% level for the period 1960–1961 to 1977–1978 ($t = 2.26$, $r^2 = 0.29$), whereas it was not significant on the basis of installed looms. However, the decline of capacity utilization from 1960–1961 to 1969–1970, based on installed looms, was found to be significant at the 1% level ($t = 3.52$, $r^2 = 0.64$).

International Comparison

The performance of the Bangladesh textile industry was also compared with the textile industries of Japan, the United Kingdom, and the USA on a limited scale. On the basis of spindle productivity, labour productivity, and proportion of running to installed equipment (i.e., spindles and looms), the performance of the Bangladesh textile industry was found to be lower than the performance of the textile industries in these three countries, e.g., Fig. 1 compares the spindle productivity between the United Kingdom and Bangladesh.

Structural Integration between Textile Production and Other Forms of Production

Very little integration of imported textile production systems with other forms of production (e.g., spare parts, accessories) in the economy of Bangladesh has been observed. Backward

Table 1. Trends of the indicators of aggregate industrial performance.

Year	Machine productivity (index)				Labour productivity (index)		Capacity utilization (percentage)			
							Spinning		Weaving	
	Spindle		Loom		Spindle		Installed	Operating	Installed	Operating
1960–61	—		—		—		58	59	93	93
1961–62	100		100		—		59	62	90	90
1962–63	102		87		—		49	60	74	74
1963–64	105		75		—		54	62	48	48
1964–65	89		75		—		46	50	39	39
1965–66	101		78		100		50	57	27	53
1966–67	98		86		76		50	60	31	55
1967–68	103		75		74		52	61	30	52
1968–69	107		69		86		58	66	35	61
1969–70	117	100	76	100	108	100	63	71	34	79
1972–73	78	67	36	53	53	49	42	57	33	58
1973–74	95	81	61	91	52	48	47	60	45	64
1974–75	99	84	57	85	56	52	50	60	48	68
1975–76	95	81	58	87	—	—	48	58	42	60
1976–77	94	80	55	82	—	—	44	48	45	68
1977–78	—	—	—	—	—	—	41	50	41	66

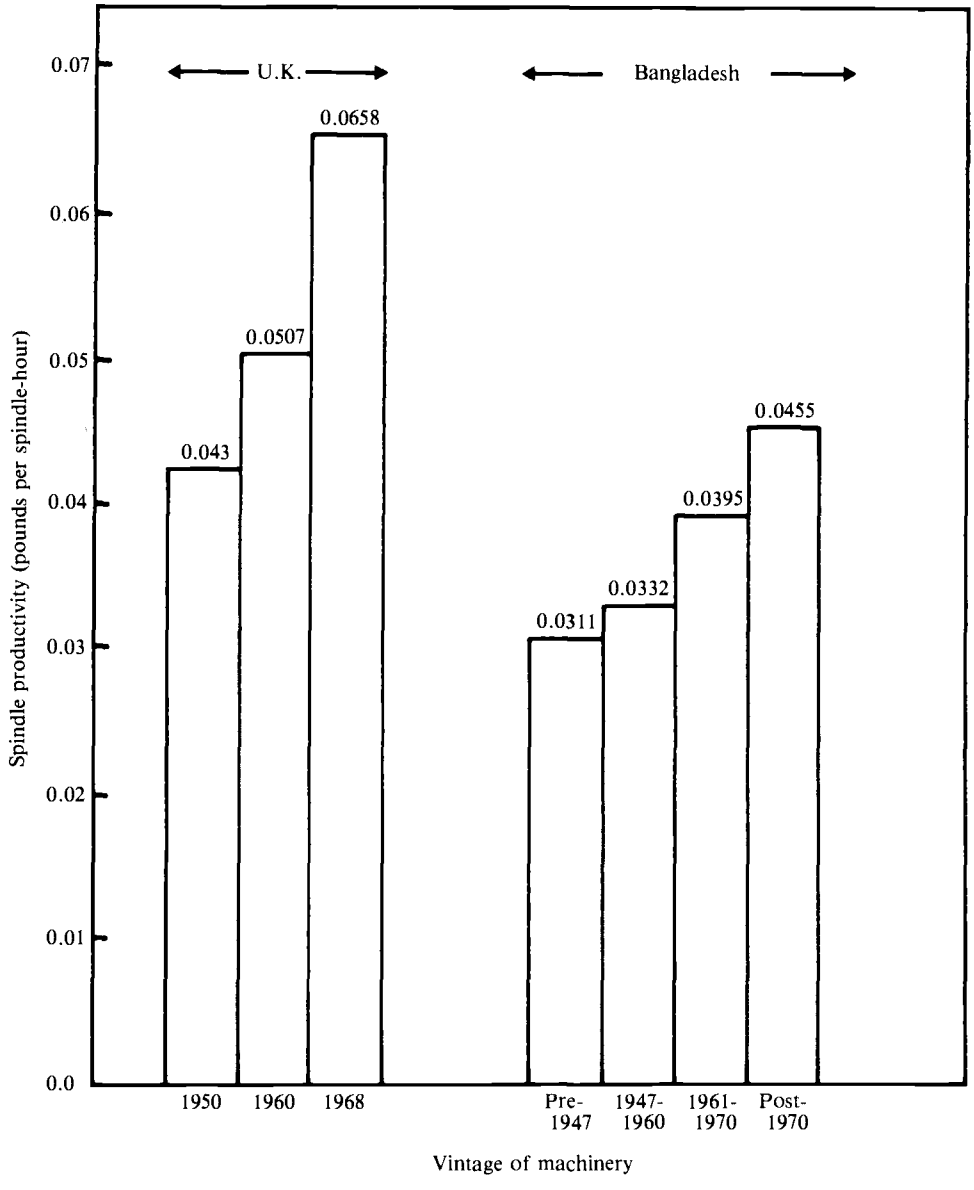

Fig. 1. Intervintage comparison of productivity (20-count yarn).

linkages with the capital goods manufacturing sector have been very unsatisfactory. Services related to the erection and commissioning of textile machinery are, however, available from within the economy.

Plant Level Analysis

The above findings on the performance of the industry led to the conclusion that imported cotton textile manufacturing technology has been poorly assimilated in Bangladesh. A detailed analysis was carried out to identify the reasons for such a poor performance of the Bangladesh textile industry. The performance data from 12 sample mills were analyzed. Three independent variables (age, size, and machine heterogeneity) were identified to explain the variations of the performance indicators in different mills. Machine productivity, labour

productivity, wastage rate, and the proportion of idle to installed equipment were used as measures of performance. Both statistical and nonstatistical tests were carried out to examine the relationships between the independent variables and the measures of performance. In general, no strong relationships (except in one case) between the independent variables and measures of performance were observed. However, weak relationships between the vintage of equipment and spindle productivity and idleness of spindles, a weak relationship between machine heterogeneity and spindle productivity, and a strong relationship between size and proportion of idle to installed looms were found. These results are summarized in Table 2.

Analysis of the average performance of groups of mills having different (average) heterogeneity revealed that the performance of the less heterogeneous groups was significantly lower than that of the more heterogeneous groups.

From the stepwise multiple regression analysis it was found that all three independent variables (age, size, and heterogeneity) combined explained 93% of the variations of the proportion of idle to installed looms at the 0.8% level. Variations of the other dependent variables (i.e., spindle productivity, loom productivity, and proportion of idle to installed spindles) were not found to be significantly influenced by these independent variables.

The two "best" and two "worst" performing mills in each of the spinning and weaving operations were identified based on the composite index of performance (computed for this purpose). The three above-mentioned independent variables were not able to explain the performance pattern of these best/worst mills.

Techno-Managerial Capability and Assimilation of Imported Industrial Technology

Having found that the three independent variables were unable to explain the performance pattern of the mills, a fourth type of explanation was examined, i.e., the intermill variation of performance is probably due to the differences in quality of available techno-managerial knowledge and skills. A brief discussion, on a general level, of the possible influence of the availability of the right type of technical and managerial skills (both inside and outside the mills) on the performance of the mills revealed the significance of this fourth explanation. A preliminary description relating the extent to which technological and managerial capability had been accumulated within Bangladesh was looked at. Only three aspects were examined: (1) the extent and nature of local efforts to accumulate and diffuse technical knowledge and skills, (2) the extent to which technical knowledge and skills were acquired and absorbed through the process of technology transfer, and (3) evidence of the accumulation of the capability to effect change.

The only significant local effort to accumulate and diffuse technical knowledge was found to be in the activities of the College of Textile Technology. Because the technical and managerial training programs of the Bangladesh Textile Mills Corporation headquarters have just been geared up, a definite comment on the effectiveness of the programs could not be offered.

With respect to the absorption and diffusion of technical knowledge and skills from the technology transfer process, it was found that some degree of accumulation of technical knowledge and skills has taken place, e.g., local technical people are capable of providing services related to the investment phase, manufacturing some of the spare parts, and duplicating simple machinery (e.g., reeling machines). In addition, some fragmentary evidence indicating dynamic technical change has been found, e.g., changing of the lift size of the spindles and increasing the speed of warping machines to increase productivity.

Table 2. Summary results of statistical analysis.

Variable pairs	Correlation coefficient (r)	Coefficient of determination (r^2)	Level of significance (%)
Age of machine and spindle productivity	0.6842	0.468	1.5
Age and proportion of idle to installed spindles	0.6981	0.487	5.4
Heterogeneity of machine and spindle productivity	0.6714	0.457	5.7
Size and proportion of idle to installed looms	0.8714	0.759	0.5

Conclusions

From this preliminary investigation it has been found that imported cotton textile technology has been poorly assimilated in Bangladesh. The extent and nature of technological and managerial capability accumulation seems to have been inadequate with respect to both local efforts and acquisition from the technology transfer process. This has probably been a major reason for the unsatisfactory degree of assimilation.

Cooper, C. 1973. Science, technology and production in the underdeveloped countries: an introduction. In Cooper, C., ed., Science, Technology and Development. London, England, Cass & Co. Ltd., 7.

Hollander, S. 1965. The sources of increased efficiency: a study of Dupont rayon plants. Cambridge, Massachusetts, The MIT Press, 189–207.

Katz, J., Gutkowski, M., Rodrigues, M., and Goity, G. 1978. Productivity, technology and domestic efforts in research and development: the growth path of a rayon plant. Buenos Aires, Argentina, Economic Commission for Latin America (ECLA), 80–89. (Mimeo)

United Nations Conference on Trade and Development (UNCTAD). 1972. Guidelines for the study of transfer of technology to developing countries. Geneva, Switzerland, UNCTAD Secretariat, 25–26.

Comments: Ashok Desai

Levels of technological performance or capability can be judged with respect to differing degrees of competence in: (1) operating a plant, (2) duplicating or expanding a plant, (3) transferring a technology, and (4) innovation.

The comments that follow are based upon material in the comprehensive Bangladesh report, the numbers in parentheses indicating the appropriate page number in that report.

(29) Table 2.4 — The count composition of the output changed radically toward coarse counts in the 1960s. What is the explanation? Exports to India are unlikely to explain the change.

(39) Spindle productivity increased in the 1960s. This may be related to the falling average count of yarn.

(45) The fall in labour productivity after liberation was clearly due to the large increase in the labour force. In fact, the most interesting questions to ask are: How did the enterprises adjust themselves to the overstaffing? How did they maintain output? What did the new workers do? How was work shared? What did the overstaffing do to management control?

(47) The figures of standard machine output are too modest.

	Spindles (lb)	*Looms (yards)*
Bangladesh standard	*75*	*10000*
Indian average	*110*	*28000*

Even mills in Bangladesh were producing 23 000 yards/year/loom (21 031 m/year/loom) in the early 1960s.

(50) Something odd is happening in weaving. Output per operational loom declined from 23 000 yards (21 031 m) in 1960–1961 to 10 000 yards (9144 m) in 1964–1965, rose again to 20 000 yards (18 288 m) in 1969–1970, and was not much lower in the 1970s. The proportion of installed looms in operation, however, fell enormously. Why, then, were the new looms installed? Why did mills buy them while they had idle looms?

(79) In contrast to looms, where the operational looms' average output was steady but there was a large proportion of idle looms, spindle capacity utilization was fairly high but the productivity per operating spindle was low. Why was it low?

(117) It is futile to look for economies of scale in spindle or loom output, for there are none. A large mill has an advantage in upstream operations — blowroom, cotton blending, carding — and downstream operations — finishing and dyeing.

(123) Does the correlation of age and spindle productivity refer to operating spindles or total? It would be better to correlate separately the proportion of operating looms and spindle productivity. Primary comparisons between mills are hazardous because the influence of non-technological factors is unlikely to be cancelled or averaged out.

(153) In the correlation of length of spindle and productivity, the regression coefficient would be more interesting than the correlation coefficient. In general, multiple regressions are more informative than stepwise simple regressions, and full regression estimates should be given.

(154) Automatic looms, at least the earlier models, were no faster than plain looms; their output per shift could not be expected to be higher. Labour productivity with automatic looms, however, should have been higher than with plain looms.

It seems that Bangladesh would provide valuable case material by answering the question: How is a technology adapted to a sudden increase in overstaffing?