International Competition in the Footwear Industry
Keeping Pace with Technological Change

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INTERNATIONAL COMPETITION IN THE FOOTWEAR INDUSTRY: KEEPING PACE WITH TECHNOLOGICAL CHANGE

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PREFACE

Competition in a period of rapid technological change is the subject of this and three companion reports. Four relatively mature industries of considerable interest to less developed countries were chosen to investigate whether organizational and technological innovations are of any relevance to them. The answer is a resounding yes. Organizational changes, automation, and use of new materials to change the production process and to transform the product itself were found to be of tremendous importance in each sector. These changes quite overwhelm simple differences in factor costs.

This research was financed by the World Bank's Research Committee, to which we are all very grateful. Numerous colleagues have supported this work and we would like specially to thank Nancy Barry, Carl Dahlman, Sandra Salmans, and Masami Shimizu. Our greatest debt is to managers and engineers in dozens of companies in six countries who spent their valuable time with us.

International Competition in Printed Circuit Board Assembly.
International Competition in the Bicycle Industry.
1. INTRODUCTION

1.1 Overview

Diffusion of innovation proceeds at varying rates in different countries, creating differences in the productivity with which resources are used, and hence affecting the competitive position of nations. At this moment, there is a special ferment in the world of manufacturing as organizational innovations, automation, and new materials are transforming not only the manufacturing process but also, in many cases, the product itself. The speed at which these innovations are absorbed is likely to have a significant impact on a country's ability to compete. Developing countries face a special challenge as they determine how best to keep pace with the changes.

In this study, we project the effect of innovative manufacturing technologies on the long-term productivity of firms and countries. We believe that, through such analysis, we are enriching the debate on differences in international productivity, and suggesting new policy directions to improve productivity in developing countries.

Manufacturing processes worldwide are being transformed by complementary developments. Perhaps the more important relates to organizational change within the firms. Pioneered by the Japanese and associated with various names, such as total quality control, kaizen and just-in-time, it has set new standards for scrap management, machine reliability, inventory control, and worker training and participation. Firms successfully adopting these practices have uniformly reported large gains in productivity.

The other major influence on manufacturing has come from micro-electronics-based technologies. These technologies are permitting increased automation of a wide range of operations in many industries. Ultimately, it is expected that, in specific sectors, electronics controls could transform discrete (or batch) production into an almost continuous process requiring limited human intervention.

What implications does this have for the footwear industry? Will the advent of new technologies pose a threat to footwear manufacturing in developing countries? If so, what options are available to companies in these countries and how can these options best be exploited?

In this report (as in companion reports), our central task is to account for differences in costs of production across countries and to predict how the level and structure of costs will evolve as organizational changes and automation diffuse more widely. The evolution in costs will influence production and trade patterns. We relate our findings on technology trends to trends in international trade. The systemic nature of the technological change is emphasized. Hence the need for better information, long-term international relationships with producers and buyers, improved worker training and incentives, and the key role of infrastructure are discussed in the concluding chapter.
1.2 World Market Trends

International trade in footwear exploded in the mid-1980s, after a period of relative stagnation. In 1983, shoes worth $10 billion crossed international borders. By 1987, the value of trade had doubled to $20 billion. Markets in the United States, Europe and Japan shared in this expansion. Since 1987, however, trade has again slowed down, as Table 1.1 indicates. The quantity of shoes purchased by the United States actually fell in 1987, 1988 and 1989; European imports declined in volume and value in 1989. Only Japan has continued as a steadily growing market.

Table 1.1: MAJOR IMPORTERS OF FOOTWEAR

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<tr>
<td>World</td>
<td>10.7</td>
<td>10.1</td>
<td>10.3</td>
<td>10.5</td>
<td>11.9</td>
<td>13.1</td>
<td>16.4</td>
<td>19.7</td>
<td>21.4</td>
<td>21.9</td>
</tr>
<tr>
<td>United States</td>
<td>2.8</td>
<td>3.0</td>
<td>3.3</td>
<td>3.6</td>
<td>5.0</td>
<td>5.9</td>
<td>6.7</td>
<td>7.4</td>
<td>8.1</td>
<td>8.3</td>
</tr>
<tr>
<td>Japan</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.8</td>
<td>1.1</td>
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<tr>
<td>West Germany, France, and United Kingdom</td>
<td>3.9</td>
<td>3.2</td>
<td>3.2</td>
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<td>3.2</td>
<td>4.6</td>
<td>5.8</td>
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<td><strong>Unit Value index (US 1980=100)</strong></td>
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<tr>
<td>United States</td>
<td>100</td>
<td>90.3</td>
<td>93.0</td>
<td>91.2</td>
<td>93.1</td>
<td>127.3</td>
<td>125.1</td>
<td>133.3</td>
<td>144.0</td>
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<tr>
<td>Japan</td>
<td>76.6</td>
<td>78.5</td>
<td>84.0</td>
<td>82.8</td>
<td>84.8</td>
<td>93.2</td>
<td>98.3</td>
<td>122.4</td>
<td>145.1</td>
<td>149.1</td>
</tr>
<tr>
<td>West Germany, France, and United Kingdom</td>
<td>154.4</td>
<td>134.5</td>
<td>128.9</td>
<td>132.9</td>
<td>130.7</td>
<td>123.4</td>
<td>171.9</td>
<td>194.5</td>
<td>200.6</td>
<td>197.4</td>
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Note: Footwear Trade is the sum of SITC categories 85101 and 85102.
Source: UN Comtrade Database, Geneva.

Many factors have contributed to this sluggishness. The U.S. market for shoes appears to be finally saturated. Per capita consumption of leather-based athletic shoes has fallen in the last few years. Rising prices of inputs and a weaker dollar have contributed to stemming the seemingly endless demand.

Increased competition in a sluggish market has forced companies to raise their investment substantially in "high-tech" and marketing. The latest footwear products have been described as: "Not just athletic shoes, they are space age wonders that boast such features as air-cylinder suspension systems, anatomically molded ankle collars, outrigger soles and adjustable support straps" (Business Week, August 28, 1989). In addition, major companies, such as Nike, are building obsolescence into their products by changing most of their line every six months. Such an aggressive approach does not come cheap, and the costs of entry into the athletic footwear business are sharply higher.

The turbulence of the athletic shoe market does not extend to most other shoe products. However, product differentiation is a key element of corporate strategy and international trade in all categories of footwear. Trade in differentiated footwear is particularly evident in Europe. European countries ship relatively high-priced and differentiated products across
borders, mainly to each other. The average price of a shoe purchased by major European countries is more than 50 percent higher than that of a shoe imported into the United States or even Japan. As growth in the shoe market slows, product differentiation will be used increasingly as a competitive tool.

Trends in product differentiation and rapid obsolescence are being aided by new technological developments. The most significant innovations have been computer-aided-design (CAD) and microcomputer-based management systems. CAD seems tailor-made to the footwear industry. It allows designers to create new styles on computer without constructing many prototypes. It also converts designs into patterns, and grades the patterns by computer, thus speeding up the design process. CAD systems can save time, labor and material, as well as improve quality. Microcomputer-based management systems, more generally, are relevant for various industrial processes; they include software for accounting, materials management and production scheduling and inventory control.

Other technologies that either save labor or reduce the cycle time of production include computer-controlled stitching (which can lead to productivity increases of at least 25 percent), numerically-controlled upper roughing (which automatically directs a brush to roughen part of the upper to provide a base for cementing), injection molding (which automatically molds a shoe bottom to the upper), and automatic sole laying (which determines the contour of a shoe's bottom and adjusts accordingly in attaching the sole).

Admittedly, there are limits to both the new technologies and their degree of acceptance by industry. Stitching, the most labor-intensive aspect of shoemaking, is still largely unautomated. And most of the technologies require large-scale production and long runs to be cost-effective; thus they have been adopted only by the largest footwear manufacturers.

However, the advent of these technologies has had the effect of reviving the moribund footwear industry in the United States - and raising an unexpected competitive challenge to firms in NIEs and LDCs. In the short term, the low cost of production will continue to work in favor of NIEs and LDCs. But in the long run, mass producers in developed countries could gain a competitive advantage over even low-cost LDCs.

1.3 Location of Production

For years, the direction of footwear manufacturing - from high-wage, developed country to low-wage, developing country - has been one of the industrial world's more predictable trends. Although styles and materials might change each season, it seemed inevitable that the labor-intensive business of shoemaking would shift increasingly each year to nations with large, inexpensive pools of labor.

Two new participants of significance have emerged in the league of major exporters: Portugal, exporting mainly to Europe, and China, exporting to the United States and also to Japan. Other challengers waiting in the wings are Thailand and Indonesia. Since 1987, China has come to dominate export markets and will soon export more shoes than any other country.
Already in the first quarter of 1990, China was the second largest exporter of shoes (after Taiwan) to the United States. (See Appendix A on China.)

The movement of the footwear industry toward lower-wage countries is often initiated by manufacturers in the newly industrializing economies (NIEs) -- some of whom make shoes under contract for Nike, Reebok International, and other large companies headquartered in developed countries (DCs). A number of Korean footwear companies, including the HS Corporation, perhaps Korea's largest exporter of shoes, are involved in some form of manufacturing, including joint ventures, in Indonesia. Scores of Taiwanese footwear companies have recently moved into China, often because of Taipei's restrictions on direct investment in China--through Hong Kong-based partners.

Yet now, footwear manufacturing, as tradition-bound as virtually any industry, is in the throes of change that could slow, if not reverse, that trend. Recent technological changes such as computer-aided design and manufacturing (CAD/CAM) and laser cutting have suddenly made it feasible for companies in developed countries to reclaim their domestic market, if not to compete overseas.

As a result, the U.S. industry, which had been contracting steadily since at least the late 1960s, is actually recovering lost ground --reopening plants, increasing employment, raising its rates of factory utilization and productivity.

For long the world's largest importer, the U.S. has started buying fewer shoes. U.S. imports of shoes rose rapidly in the early 1980s (doubling from 300,000 pairs per year to 600,000 between 1980 and 1984). Between 1987 and 1989 imports declined, though they increased again in 1990. (Because of differences in classification, U.S. import statistics show a very sharp fall between 1987 and 1988 and a continued decline in 1989).

Three factors appear to account for the recent trends in U.S. footwear imports. First, the large expansion in consumption following the introduction of many new types of shoes seems to have run its course. After rising sharply, per capita consumption has stabilized. Second, the devaluation of the U.S. dollar has made imports more expensive.

And finally, U.S. shoe producers have become more competitive. U.S. footwear production, having spiralled downwards for over two decades, has steadied itself and may even have risen somewhat. U.S. production of nonrubber footwear increased 6 percent in 1988 to about 235 million pairs --the first increase since 1976, and a reversal of the downward trend that began in 1968, when U.S. production peaked at 642 million pairs. U.S. exports are also up substantially, although from a very low base.

The adoption of microelectronics-based technologies has had some effect in sustaining the competitiveness of developed country firms. Large firms that have survived the onslaught of low-wage competitors have made the most significant investments in automation. These firms are simultaneously adopting just-in-time type practices. Some of them already have close links with suppliers and retailers, further strengthening their position. With a
clearer emphasis on product differentiation, DC firms could certainly stem the
historic decline of the industry, even reverse it.

Trade in unfinished footwear is another dimension of strategy that
is likely to support the production capabilities of developed country
producers. Such trade has always been important in Europe and has also grown
significantly over the 1980s (Table 1.2), increasing by about 40 percent
between 1987 and 1989 while finished shoe trade grew by 10 percent.

Table 1.2: TRADE IN PARTS OF FOOTWEAR

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<tr>
<td>Value of World Trade (US$ billion)</td>
<td>0.65</td>
<td>0.67</td>
<td>0.76</td>
<td>0.85</td>
<td>0.92</td>
<td>1.08</td>
<td>1.36</td>
<td>1.60</td>
<td>1.89</td>
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<tr>
<td>Market Share (%)</td>
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<tr>
<td>Dominican Republic</td>
<td>1.66</td>
<td>2.15</td>
<td>3.38</td>
<td>3.09</td>
<td>3.72</td>
<td>3.39</td>
<td>4.83</td>
<td>4.93</td>
<td>4.96</td>
</tr>
<tr>
<td>Portugal</td>
<td>1.85</td>
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<td>2.58</td>
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<td>India</td>
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<td>7.47</td>
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<td>7.00</td>
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<td>7.38</td>
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<tr>
<td>Korea</td>
<td>6.41</td>
<td>4.30</td>
<td>4.32</td>
<td>3.81</td>
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<td>4.31</td>
<td>4.50</td>
<td>5.41</td>
<td>5.63</td>
</tr>
<tr>
<td>Taiwan</td>
<td>6.48</td>
<td>6.67</td>
<td>7.18</td>
<td>8.51</td>
<td>9.11</td>
<td>10.27</td>
<td>9.17</td>
<td>10.11</td>
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Source: Comtrade Database, Geneva.

At least a part of trade in unfinished shoes reflects an attempt
to take advantage of cheap labor for the truly labor intensive elements of
footwear production. Much as in garments, U.S. producers ship cut footwear
parts to low-wage locations, principally the Dominican Republic in recent
years, where the shoe is sewn. Under Section 807 of the U.S. Tariff Schedule,
import taxes are paid only on the value-added in the foreign location. Once
the shoe is back in the United States, operations such as bottoming, finishing
and packing, which are less labor-intensive than sewing, are performed.

Since 1986, imports of unfinished shoes into the United States
have grown faster than finished shoes (particularly rubber and plastic shoes).
Imports of parts and unfinished shoes are at least partly responsible for the
growth in U.S. output of athletic footwear and slippers. If the benefits of
the Caribbean Basin Initiative are extended to shoes, trade in unfinished
shoes will receive a further boost.

Trade in unfinished shoes tends to be with countries that are
geographically close. India used to be the largest supplier of unfinished
shoes to the U.S.; however, the Dominican Republic has very rapidly displaced
India, which has seen its U.S. sales shrink even in absolute terms. In
Europe, the largest beneficiaries of the rapid rise in such trade have been
Portugal and Spain, and Japan relies principally on South Korea and Taiwan.

1.4 Scope of the Study

The bag of strategies for an international firm, therefore,
contains rapid design changes and product differentiation, low-wage production
location and automation. Our focus in this report is principally on the
emergence of low-wage producers as major exporters and on the possibility that automation may curtail or reverse that development. We will also examine the potential role of NIEs both as production centers and as mediators between low-wage producers and international markets.

Being internationally competitive takes a lot of doing: materials must be procured efficiently from domestic and overseas sources, production must be organized efficiently and staff motivated appropriately, links with buyers must be maintained to obtain timely information on trends in demand, and so on. We are in no position to analyze the entire chain of activities. Our focus is on the manufacturing process (See Figure 1).

There can be little doubt that efficiency in manufacturing will be a key ingredient of success, at least for the less developed and newly industrializing countries. It is our conjecture, moreover, that certain underlying principles of manufacturing (efficient management and good flow of information) hold equally for other components of the value chain.

A related boundary on the quantitative exercise is our focus on production costs. We have emphasized above that competition is multi-faceted and depends on the firm's ability to respond flexibly to customer needs, implying that low costs are not the only factor determining competitive ability. We have been able to quantify costs in very great detail, as will become evident in the following chapters. However, quantifying the benefits of flexibility and superior product characteristics is much more difficult. This is unfortunate since many of the more innovative processes we study lead primarily to gains in flexibility and product enhancement. Our approach has been to discuss quality and flexibility with ordinal measures and, more importantly, to discuss the trade-offs between product characteristics, flexibility, and cost. For example, when a process leads to an obvious improvement in product characteristics but limited increase in production cost, then it is relatively safe to conclude that the process is likely to diffuse widely.

1.5 Country Stylizations

It is a long-held principle among economists that systematic differences in operational efficiency across countries cannot persist over long periods of time. Any such differences, according to the conventional wisdom, would soon be wiped out by economics' invisible hand. Leamer 1984, for example, says that unless there exist "biological differences" between the nationals of different countries, or "effective counterintelligence agents," all economies should be equally efficient in the tasks they perform.

Like other researchers, however, we have observed empirically that this mind set does not correspond to reality. In this sector and others, we find that some of the newly-industrializing economies operate at a consistently higher level of efficiency than other country types. They invest more effectively, learn faster, and stabilize their production at higher levels of efficiency.
It would be pointless to dismiss such differences as illusory. Indeed, we strongly believe that, by examining their causes, we can enrich the debate on international productivity differences.

In this and companion studies, the firm has emerged as a dynamic organization, even in those industries previously thought to be mature. The successful firm is in a constant state of flux as it introduces and absorbs technical and, above all, organizational innovation: automation in design and manufacture, design for manufacture, quality control and inventory management.

For the firm, then, the learning curve is extremely steep - but so is the reward. In fact, it is probably safe to say that the firm's position on the learning curve is more critical to its success than other, exogenous factors. Firms - notably LDC manufacturers - that are only at the beginning of the curve are substantially less efficient than those at the end, and not even cheap labor - as in the case of LDCs - can make up the differences.

Accordingly, we set ourselves the task of accounting for efficiency differences in terms of operational characteristics, and then discussing how performance, as defined by those characteristics, could be improved. We do not trace the learning curve, or limit our analysis to the beginning and end. Rather, we observe the process at several points in time - almost like snapshots - and discuss, in a qualitative way, how to advance from one to the next.

In our quantitative exercises, therefore, we introduce important stylizations regarding the level of efficiency attained. Of the three groups of countries we study, we assume the newly-industrializing economies (NIEs) to be the most efficient. These were represented in our study by South Korea and Singapore. Although our interviews in Japan provided us with substantial information on the frontiers of production technology, the benchmark cost estimates for developed countries (DCs) are based on conditions in the United States. Less-developed countries (LDCs) are represented by Mexico and Indonesia. After demonstrating the impact of inefficiencies, we examine cost differentials across groups if they all operated at the NIE level of efficiency. That comparison allows us to study the effect of factor costs--the costs of labor, land and capital--and technology choices.

1.6 Plan of the Study

Product and manufacturing strategies of a sampling of firms visited for this project are described in the next chapter. On the basis of these visits, the manufacturing literature, and our engineering knowledge and experience, we created benchmark factory cost models defined at a fine level of specification (Chapter 3). These benchmark models are intended to replicate production costs of "representative" factories in the countries visited. A series of cost scenarios based on the adoption of modern management practices and new hardware technologies are examined in Chapters 4 and 5. Throughout, the lessons from our cost models are illustrated with concrete case studies based on our field visits and the industry literature. The concluding chapter comments on the shifts occurring in the competitive abilities of different country types.
Figure 1.1
2. THREE MANUFACTURERS: A STUDY IN CONTRASTS

2.1 Objectives

In the following chapters, we will simulate changes in unit costs when alternative techniques are adopted by stylized, country-specific benchmark factories. The discussion here provides some of the basis for stylizations discussed later in the report. We summarize first the basic pattern of technology adoption by companies visited for this project and then discuss in some detail three companies, each representing one of the three country types. The objective is to relate the choice of production technique to the company's economic environment, product strategy, and human resource strategy.

Thirteen shoe producers in six countries were studied in considerable depth, usually over a day with some follow-up questions and visits. In addition, similar interviews were conducted with 29 other firms (in the electronics assembly, bicycle, and steel industries), and the stylizations that emerge for shoe production conform with the overall project results.

The manufacturers we visited were chosen for their representativeness of one of the three country types. Extensive consultation with industry and country experts, review of the industry literature, and our industrial consulting experience was the basis for choosing particular firms. The visits were not intended to generate primary data on the basic manufacturing process; that was derived from our experience and expertise. The visits were intended, instead, to enhance our grasp of the range of manufacturing competence. Within a country type, factories in the four industries resembled each other more closely in terms of key operational characteristics than did factories in the same industry across country types. Thus, the relatively modest number of visits to manufacturers in each sector was effectively amplified by visits to manufacturers in other sectors.

2.2 Technology Usage Summary

Before examining in detail three footwear companies, one each in the three country types, consider first the summary of technologies in use at the footwear factories visited. See Table 2.1.

Computer-Aided Design (CAD) is well on its way to becoming an industry requirement, but Computer-Aided Manufacturing (CAM) for cutting and automation for sewing are spreading only slowly. This is consistent with our results on the limited impact of such automation technologies. CAD is being used less for immediate cost reduction and more for the learning it is supporting as firms prepare to introduce automation down the line.

Though, as expected, DC firms are most advanced in design and manufacturing automation, NIE firms have made greater progress in the area of
internal quality control and inventory management. These efforts do not strictly correspond to the purist's view of total quality control (TQC) or just-in-time (JIT) techniques. However, they were sufficiently developed to give the NIE firms a solid cost advantage over firms in other countries.

As we shall discuss below, consciousness of product quality assurance programs has risen greatly in the United States and formal procedures are being instituted widely in footwear and other industries. However, our observation is consistent with that of others who also find NIEs to have taken the lead over some DCs in shop-floor planning and reduction of waste (see Womack and associates 1991).

JIT is not merely an inventory reduction method but is also an institutionalization of continuous learning through incremental changes. Unlike MRP, which is serves as a high-level database and provides overall materials management function, JIT emphasizes focus on shop-floor practices. JIT is a tool for the systematic elimination of waste in all aspects of manufacturing. It is clear both through the factory visits and through our consulting experience that the NIE firms have progressed beyond U.S. firms in this regard. This is reflected, as will be discussed in the next chapter, in indicators such as lower scrap, shorter cycle times, greater machine reliability at the NIE factories when compared with the U.S. factories.

2.3 Developed Country Firm: Company A

Company A is a large manufacturer of leather dress shoes, with sales of over $100 million from its footwear division. It operates many factories, the newest of which is 10 years old, along with component factories that supply its sub-assemblies. The Company has been making shoes for over 100 years and is well-established in its domestic market.

Company A was the most advanced firm we visited. It has a large research and development department that is aware of modern manufacturing technologies and strategies, and has begun to plan and implement some of these technologies within its design and manufacturing processes.

Our visit included an extensive tour of Company A's "showcase" factory. It employs 350 people and has a capacity slightly greater than the 1.1 million pairs produced by the MANUCOST benchmark model.

---

1/ Firm J, an LDC firm, made an injection molded shoe and hence process automation there was of a very different character than the sewing operation in other firms.
The highly competitive, fashion-conscious market for leather dress shoes has forced Company A to be design-driven. The initial shoe design is created on a three-dimensional CAD system developed in-house by software engineers. Company A's management believes the design and development of a CAD system are justified solely on the system's merits as a design aid, and that its ability to decrease significantly the lag time between design and production is critical to the company's success. In the future, Company A hopes to eliminate the need for a shoe prototype by creating and presenting a computerized three-dimensional "solid" representation of each new style.

The CAD system performs a number of non-design functions, too. It creates the patterns (as flat representations) required to produce the base shoe, and then "grades" these patterns across all shoe sizes. Each pattern can be downloaded to a laser cutter which, in turn, cuts highly accurate patterns from which the dies required for manufacturing can be machined.

Although Company A has gained extensive technical expertise and knowledge from developing a CAD system capable of limited CAM interfacing, the company has not yet extended this technology to its shop floor. However, management is currently justifying the implementation of a CAD/CAM system that can optimize die placement at the synthetic cutting stage of insole production. Our CAD/CAM scenario suggests this will give the Company a significant competitive advantage through savings in labor and materials.

The factory operation itself is less highly automated. Stitching is extremely labor-intensive, although some of the machines have been retrofit with sewing guides that allow "automatic" stitching of fancy details on the upper. Because of the labor intensity of the closing operation, the
Company imports a significant percentage of its uppers. Company A has researched the potential for automating the stitching operations, and has concluded that revolutionary techniques, such as stitching from one side of the material, must be developed.

The lasting department is the most advanced area of this factory. The relatively new (less than five years old) lasting machines are designed for flexibility; they can be quickly set up to accommodate any size or style of shoe. A rack conveyor system automatically transports the shoe assembly directly to the necessary operations. Each operation, however, requires skilled employees to load, adjust, operate, and unload both the lasting machines and the heat treating processes.

It is not until the packing department that the shoes are inspected for quality. The problem with such a system is that the value-added manufacturing operations have already been performed; thus, scrapping or repairing a defective shoe is expensive. Quality is an important, but not a driving, force at Company A. Its shoes sell for $30 to $60, and consumers view them as being of "reasonable" quality.

Company A has several inherent advantages that should help it adapt well to JIT. First, its size puts it in a strong position to demand that suppliers make JIT deliveries of components and raw materials. Second, since it manufactures many of its components in-house, it could work to coordinate delivery times between its shoe and its component factories. Third, the Company owns its own retail outlets, allowing it to coordinate final goods shipment from the production line directly to the store, rather than the current practice of shipping from a centralized warehouse.

However, the Company must eliminate several obstacles before it can completely assimilate JIT. It now contracts out at least half of the components required for shoe production, using many different suppliers of each component to reduce risk. JIT implies a move to single-source suppliers - in-house as well as external - to encourage long-term relationships.

A second obstacle is the instability of the women's shoe market. JIT requires fairly constant demand and stable lead times, criteria that may be difficult to attain. Thus the Company must have control of its manufacturing processes such that lead times are stable, and then work to establish constant demand. Still, the Company would benefit from working toward JIT while keeping these issues in mind.

2.3 Newly Industrializing Economy Firm: Company D

Company D is a large Korean manufacturer of leather athletic shoes. It targets 20 percent of its production for the domestic market and 80 percent for export by acting as a contractor for footwear firms headquartered in the United States. The Company has been making shoes for over 40 years and is well established in both markets.

The Company is a progressive firm that understands current manufacturing technologies and practices, and is struggling to determine what
role new technologies will play in its future. It has a large research and development department which manages projects involving new materials, product testing, and production process control. The Company has begun to plan and implement some new technologies for product design and manufacturing. For example, it is beginning to research ways to automate its stitching department, as rising labor costs are making this area prohibitively expensive.

Company D is manufacturing-driven, but has plans to increase the importance of design. Currently it uses designs and patterns supplied by U.S. contractors. However, it is interested in expanding its own product line, and hopes to move away from the need for "reverse engineering" and, eventually, produce its own original designs. Accordingly, Company D is presently evaluating the purchase of a CAD system.

Management believes that CAD will facilitate product design as well as increase the precision of its patterns. The company does not now plan CAM or CAE (Computer Aided Engineering) interfaces, as it understands these applications to be extremely limited due to the problems inherent in leather. It recognizes that there are a number of obstacles to the successful implementation of CAD. First is the lack of technical expertise in CAD in Korea. The company plans to use in-house training programs to develop this expertise. Second, the cost of integration is high. A CAD system incorporating those features the company wants sells for about $400,000.

Our CAD/CAM scenario suggests that the Company consider integrating CAD/CAM with CNC cutters to reduce labor costs at the synthetic cutting operations. The resultant savings will offset the capital investment in the system. As the cost of labor rises in NIEs, further automation may eventually become cost-justifiable.

Company D is also working with a U.S. manufacturer to develop a synthetic leather, termed "action leather," which would eliminate the problems caused by the inconsistencies inherent in real leather. The goal is a consistent material that would replace full grain leather in strategic areas of the shoe. This material, or one like it, could revolutionize the footwear industry.

2.4 Less Developed Country Firm: Company G

Company G is a mid-size Mexican manufacturer of fabric tennis shoes. It produces only for its domestic market, due to import restrictions (on fabric) in the United States, and targets its shoes to the low- to medium-price market. It produces ten different styles, all of which have been "reverse engineered" from current U.S. designs. The Company is planning to expand as its present factory cannot meet domestic demand. Company G's shoes sell for about $3.00/pair, and durability and price, not style, are the key factors influencing consumers' selection.

The firm has computerized its bill of materials, payroll, and simple production plans. That is the extent of its adoption of new technology. Company G's manufacturing process is labor-driven and unautomated. For example, the factory uses neither conveyors nor assembly lines, preferring to move materials manually between operations. The injection molders used for
its shoe fabrication, though relatively "high-tech," require an operator on each machine.

Raw materials inventory varies between two and six weeks depending on economic factors. When inflation is high the company will purchase as much raw material as possible to protect itself from potential cost increases. To maintain optimal inventory, the company must balance inventory holding costs against the rate of inflation. Turnover of the final goods inventory is every two weeks. The main purpose of this inventory is to help the company process and group orders to facilitate distribution.

Our JIT scenario found companies in LDCs can gain a significant competitive advantage by minimizing their inventories, and thus their inventory holding costs, which are increased by high rates of interest and inflation. Company G has nearly achieved a JIT environment primarily because the strong demand for its product allows it to operate at full capacity while maintaining low inventory levels. The company's success is a tribute to the effects of implementing JIT, and shows how LDCs can implement procedures often thought to be exclusive to more advanced countries.

Company G prides itself on providing a quality product at the lowest possible price. However, its only method of quality control in manufacturing is the final inspection of the completed shoe just prior to packing. At this stage 1.5 percent of the shoes are scrapped, at considerable cost to the company. Further efforts at quality control such as that suggested in our future best practice scenario, could help Company G reduce final inspection costs and scrap rates by building quality into the product.

Based on our scenario analysis, increasing the span of control significantly decreases management costs, although this may not be as critical for Company G as for a manufacturer in a high-wage DC. Still, Company G has implemented some systems that increase its span of control. For example, the routing sheet that it attaches to all material that proceeds through production helps the shop floor worker understand which operation is to be performed next. This system, in effect, transfers some control to the employees, although foremen are still needed on the shop floor.

The company is trying in two ways to exploit the benefits of economies of scale. First, it operates its capital-intensive machinery, the injection molders, two shifts per day, while operating the rest of the equipment one shift per day. Thus it needs fewer injection molders. Second, the company plans to increase its production capacity soon by 30 to 40 percent, to meet increased product demand; this will involve the purchase of two more injection molders and new sewing machines.

In summary, Company G is not advanced technologically, but it has a firm grasp of what is necessary to manufacture fabric tennis shoes in an LDC. Our automation scenario confirms that neither advanced machinery nor automation is cost-justifiable in an LDC footwear company. Company G demonstrates that careful inventory control, efficient use of inexpensive labor, and strong management practices can result in a successful LDC footwear company.
3. FOOTWEAR MANUFACTURING: THE BENCHMARK

3.1 Background

To analyze the impact of innovation on the footwear industry, it is necessary to move from real-world case studies to stylized representations of manufacturing operational parameters (benchmark models) and input costs in each country type. It is only by doing so that we can introduce controls, eliminate extraneous variables and thus analyze the impact of change.

A benchmark factory for a particular product in a given country is intended to represent a prototypical firm manufacturing that type of product in the country. Thus, a benchmark model does not represent any particular firm. The purpose of the benchmark models is twofold: to replicate the relative ranking of LDCs, NIEs, and DCs in terms of unit costs, and then to serve as the basis for simulating the effect on firms of the new technologies.

It is useful to clarify the relationship between a "benchmark" factory and "optimal" technique of production. Since input costs vary in the three country types, we would expect that techniques of production most commonly in use reflect those differences. Our benchmarks show that the technique in use does, in general, vary by country type. DC techniques, in particular, are significantly different from techniques in the other country types, with the one exception of shoes, where the benchmark factory even in the DC is assumed to have the same technique as in the other two country types. The difference between LDC and NIE benchmarks is smaller. In one case, printed circuit board assembly, we have two benchmarks for the NIE, one embodying the same technique as in the LDC and the other embodying a more advanced technique.

The benchmark factories in the three country types are assumed here to produce the same product. This is necessary for making international cost comparisons. The list of types of footwear is almost endless: men's leather dress shoes, women's leather pumps, women's vinyl pumps, leather moccasins, leather athletic shoes, fabric tennis shoes, plastic sandals, and so on. Within each shoe type, there are thousands of possible combinations of styles, sizes, components and manufacturing processes.

We have chosen to focus on the men's leather dress shoe. Most other types of footwear, including leather athletic shoes and fabric tennis shoes, can be produced by using a subset of the processes required for producing a men's leather dress shoe. A detailed investigation of the men's leather dress shoe will therefore help us examine the implications of organizational and technological change in the most comprehensive manner.

Finally, we assume that firms in all countries can access material inputs at the same price, thus focussing our spotlight on the manufacturing process.
3.2 Manufacturing Processes

Table 3.1 presents an intimidating list of the processes required to manufacture a typical pair of men's leather dress shoes (Kaplan, 1985). These processes may be summarized for our purpose into five manufacturing departments. Figure 3.1 illustrates the material flow between those departments.

First, the cutting department cuts the patterns for the upper of the shoe from leather hide or synthetic material. The cutting operation, commonly referred to as "clicking," may be done in many different ways, ranging from hand-cutting with a knife, to a semi-automatic press with dies, to a numerically-controlled laser or water-jet cutter (Footwear Mfg., 1986) (Interviews, 1988). Each process has its advantages and disadvantages, as we will discuss later.

Due to its variations in grain, color and thickness, cutting the leather is a highly skilled operation. Recently the shoe industry has been researching ways to modernize this process (Interviews, 1988). For example, vision systems could potentially detect variations inherent in the hide. Such information could then be downloaded, via an optimal cutting position algorithm, to a numerically-controlled press that could cut the required pieces automatically. For now, however, the process remains highly dependent on the "feel" of a human operator.

After cutting, the patterns are bundled, placed in bins and transported to the sewing department. In the sewing department, the edges of the patterns are skived (pared) and then sewn together to form the upper. Sewing of the upper is the most labor-intensive part of the entire shoemaking process.
Table 3.1: PROCESSES REQUIRED TO PRODUCE MEN'S LEATHER DRESS SHOE

<table>
<thead>
<tr>
<th>Seq. No.</th>
<th>Operation</th>
<th>Seq. No.</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cut Vamp</td>
<td>47.</td>
<td>Ck In &amp; Put up Btn Stk</td>
</tr>
<tr>
<td>2.</td>
<td>Cut Qtr</td>
<td>48.</td>
<td>Cement Outsoles</td>
</tr>
<tr>
<td>3.</td>
<td>Cut Tong</td>
<td>49.</td>
<td>Bevel Insoles</td>
</tr>
<tr>
<td>4.</td>
<td>Cut Box Toe</td>
<td>50.</td>
<td>CK In/Btn Stk 2/pr</td>
</tr>
<tr>
<td>5.</td>
<td>Cut Thermo Counter</td>
<td>51.</td>
<td>Insert Cntr</td>
</tr>
<tr>
<td>6.</td>
<td>Cut Vmp Ling</td>
<td>52.</td>
<td>Tack Insole</td>
</tr>
<tr>
<td>7.</td>
<td>Cut Qtr Ling</td>
<td>53.</td>
<td>Mould Backpart</td>
</tr>
<tr>
<td>8.</td>
<td>Cut Tong Lin</td>
<td>54.</td>
<td>Forepart Last</td>
</tr>
<tr>
<td>9.</td>
<td>Cut Socklining</td>
<td>55.</td>
<td>Side Last/Thermo Kam</td>
</tr>
<tr>
<td>10.</td>
<td>Cut Heelstay</td>
<td>56.</td>
<td>Full Tacks</td>
</tr>
<tr>
<td>11.</td>
<td>Cut Qtr Dblr</td>
<td>57.</td>
<td>Inspect &amp; Uc</td>
</tr>
<tr>
<td>12.</td>
<td>Cut Sockling U'lay</td>
<td>58.</td>
<td>Dump Last</td>
</tr>
<tr>
<td>13.</td>
<td>Cut Shank Cover</td>
<td>59.</td>
<td>Mull Upper</td>
</tr>
<tr>
<td>14.</td>
<td>Stamp Qtr Lng Incl MM</td>
<td>60.</td>
<td>Rough</td>
</tr>
<tr>
<td>15.</td>
<td>Skive Box Toe</td>
<td>61.</td>
<td>Stale Shanks</td>
</tr>
<tr>
<td>16.</td>
<td>MM, VP, Chrs, Tong</td>
<td>62.</td>
<td>Cement W/F</td>
</tr>
<tr>
<td>17.</td>
<td>Emboss Socklining</td>
<td>63.</td>
<td>Lay Outsoles</td>
</tr>
<tr>
<td>18.</td>
<td>Cutout Socklining</td>
<td>64.</td>
<td>Cover Shanks</td>
</tr>
<tr>
<td>19.</td>
<td>Ink Vmp</td>
<td>65.</td>
<td>Bin Outsoles</td>
</tr>
<tr>
<td>20.</td>
<td>Ink Tong</td>
<td>66.</td>
<td>Pull Last/Cut String</td>
</tr>
<tr>
<td>21.</td>
<td>Cutout &amp; Trace Vamp</td>
<td>67.</td>
<td>Chg Racks</td>
</tr>
<tr>
<td>22.</td>
<td>Trace Qtrs</td>
<td>68.</td>
<td>Nkw Heel/Bookup</td>
</tr>
<tr>
<td>23.</td>
<td>Skive Tong</td>
<td>69.</td>
<td>Naumkeag Btm</td>
</tr>
<tr>
<td>24.</td>
<td>Skive Wings of Vamp</td>
<td>70.</td>
<td>Stain 2 Costs</td>
</tr>
<tr>
<td>25.</td>
<td>Skive Frnt &amp; Back Of Qtrs</td>
<td>71.</td>
<td>Polish Bim</td>
</tr>
<tr>
<td>26.</td>
<td>Rough Vmp</td>
<td>72.</td>
<td>Box Unit Sole &amp; Heel</td>
</tr>
<tr>
<td>27.</td>
<td>Cam &amp; Apply Qtr Dblr</td>
<td>73.</td>
<td>Sckling W/Foam Inlay</td>
</tr>
<tr>
<td>28.</td>
<td>Apply BoxToe</td>
<td>74.</td>
<td>Flame</td>
</tr>
<tr>
<td>29.</td>
<td>Cm Vmp Lng Eye Qtr Lng</td>
<td>75.</td>
<td>Pump Form</td>
</tr>
<tr>
<td>30.</td>
<td>Tps Qtr Lng Eye Area</td>
<td>76.</td>
<td>Tree</td>
</tr>
<tr>
<td>31.</td>
<td>Tape Toplines</td>
<td>77.</td>
<td>Second Cond</td>
</tr>
<tr>
<td>32.</td>
<td>Split Heelstay</td>
<td>78.</td>
<td>Dress</td>
</tr>
<tr>
<td>33.</td>
<td>S' Tong Lin To Tong</td>
<td>79.</td>
<td>Tre-Spray</td>
</tr>
<tr>
<td>34.</td>
<td>St Heelstay to Qtr Lin</td>
<td>80.</td>
<td>Final Spray</td>
</tr>
<tr>
<td>35.</td>
<td>St Vp-Qtr Lng/Bld Tng</td>
<td>81.</td>
<td>Brush Upper</td>
</tr>
<tr>
<td>36.</td>
<td>Close Scks</td>
<td>82.</td>
<td>Repair</td>
</tr>
<tr>
<td>37.</td>
<td>Rub and Tape</td>
<td>83.</td>
<td>Stamp Forepart</td>
</tr>
<tr>
<td>38.</td>
<td>St Vamp to Qtrs</td>
<td>84.</td>
<td>Wax Upper</td>
</tr>
<tr>
<td>39.</td>
<td>French Bind w/o Cord</td>
<td>85.</td>
<td>Brush Upper</td>
</tr>
<tr>
<td>40.</td>
<td>French Fold Qtrs</td>
<td>86.</td>
<td>Lace</td>
</tr>
<tr>
<td>41.</td>
<td>Inlay &amp; Top St In Lining</td>
<td>87.</td>
<td>Inspect</td>
</tr>
<tr>
<td>42.</td>
<td>Eyelet</td>
<td>88.</td>
<td>Pack w/Seal</td>
</tr>
<tr>
<td>43.</td>
<td>Lace</td>
<td>89.</td>
<td>Stamp</td>
</tr>
<tr>
<td>44.</td>
<td>Bal Barr Tong</td>
<td>90.</td>
<td>Bin Scking/n'Lay</td>
</tr>
<tr>
<td>45.</td>
<td>Packout</td>
<td>91.</td>
<td>Mk boxes &amp; Lids</td>
</tr>
<tr>
<td>46.</td>
<td>Ck In Service &amp; Transport</td>
<td>92.</td>
<td>Stock Fitting</td>
</tr>
</tbody>
</table>

Source: J.B. Kaplan and Company, Inc.

Among the technological advances occurring in sewing are computerized stitchers for fancy details and conveyor systems to carry the components from one operation to the next (Footwear Mfg., 1986) (Interviews, 1988). However, most companies still use manual sewing machines and manual transport, because of the significant capital investment involved in updating the department.
After sewing, the completed uppers are grouped with the required lasts and soles, so that they may move as one lot to the lasting process. A last is a plastic, wood or polyurethane model of a foot. In the lasting department, the components of the shoes are assembled on the last, and attached by means of a series of tacking, stretching and heat treating operations. Together these operations create the "fit" or comfort of the shoe. Therefore the shape of the last is critical to the quality of the final product. Recent advances in lasting technology have improved machine flexibility such that each machine can handle many designs and sizes quickly and efficiently. After the upper has been assembled on the last, the outsole and heel arrive from inventory and are attached to the semi-assembled shoe.

In the fourth department, the finishing room, the completed shoe is buffed and polished, and the last is removed. Inspectors check the shoe for defects in finish, and then send it to the packing department, where it is inspected for the last time before being boxed and sent to final goods inventory.

3.3 The Benchmark Factories: Physical Indicators

We have developed stylized representations of manufacturing operational parameters (benchmark factories) and input costs in each country type. These parameters are inputs to ManuCost, a software package that models manufacturing costs. ManuCost estimates work-in-progress (WIP) and value of scrap to arrive at total costs. Figure 3.2 is a schematic diagram of the cost model.
The key element of the ManuCost approach is that production is modeled as a dynamic process that occurs over a period of time. This provides the basis for the work-in-process (WIP) cost category, which does not exist in aggregative models that rely only on measures such as capital-output ratio. The physical performance characteristics of machines and labor, along with a specification of how materials move from one stage to another, create the basis for quantifying waste in the system. This model structure also enables us to evaluate savings (or cost increases) that accrue when the process is simplified or a technological change, such as a more highly automated piece of equipment, is introduced into the process. See Appendix B for more details on ManuCost.

We have developed three benchmark factories, one for each country type. Table 3.2 specifies annual production and the input requirements for meeting that production level. All factories are assumed to produce the same number of shoes: 1.1 million a year in lot sizes of 36 shoes. The table also specifies operational parameters, such as cycle time (the time taken for a shoe to be assembled), machine reliability, and process yields (proportion of shoes not requiring rework). Differences in these operational characteristics determine the differences in the level of efficiency.

For the benchmark models, we have assumed that firms in all three country types are using essentially the same production technique. This is supported by our observation that there is a broad similarity in equipment use and process layout in firms across countries. The more innovative firms have
introduced new technologies in the past several years, but they are few in number. For the purpose of the benchmark, therefore, none of the newer technologies is part of these representations.

The basic difference between the countries then stems from the efficiency with which resources in the different country types is used. In the language of economists, the traditional technology for shoemaking offers limited scope for substitution between inputs. Hence we would expect to see essentially the same process (or technique) in different countries. However, firms do systematically vary in the efficiency with which they use their resources.

Several features of Table 3.2 are especially noteworthy. The LDC factory is significantly less efficient than its NIE counterpart in the use of capital and labor. To produce the same level of output, the LDC firm uses not only more labor but also more equipment than does an NIE firm. NIE firms use less equipment because their machines are more reliable, work faster (shorter cycle times), and are repaired faster.

There are other sources of inefficiency in the LDC plant. Slack work methods and inadequate attention to testing lead to greater wastage of material. Higher scrap, longer cycle times, lower machine reliability and larger buffers, lead to greater work-in-progress and hence further increase the use of capital, an LDC's most expensive resource. Higher raw material and finished goods inventory in LDCs similarly increase capital use.

Finally, LDCs, like DCs, have a smaller span of control (the number of employees that report to the next higher level of management). A larger span of control leads to a "leaner" organization. It is characteristic that in an LDC or a DC, seven persons report to an immediate superior. However, in an NIE, a supervisor has 10 persons working under him.
## Table 3.2: MANUFACTURING PARAMETERS FOR BENCHMARK MODELS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LDC</th>
<th>MIE</th>
<th>DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating schedule</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days per year</td>
<td>240</td>
<td>288</td>
<td>240</td>
</tr>
<tr>
<td>Hours per day</td>
<td>9</td>
<td>8</td>
<td>7.5</td>
</tr>
<tr>
<td>Staffing--Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Span of control g/</td>
<td>404</td>
<td>312</td>
<td>458</td>
</tr>
<tr>
<td>No. direct labor b/</td>
<td>7</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>- Skilled</td>
<td>167</td>
<td>129</td>
<td>192</td>
</tr>
<tr>
<td>- Semiskilled</td>
<td>59</td>
<td>47</td>
<td>66</td>
</tr>
<tr>
<td>- Unskilled</td>
<td>94</td>
<td>77</td>
<td>108</td>
</tr>
<tr>
<td>No. Indirect labor g/</td>
<td>84</td>
<td>59</td>
<td>82</td>
</tr>
<tr>
<td>Absentee rate</td>
<td>32</td>
<td>0.5%</td>
<td>2%</td>
</tr>
<tr>
<td>No. of machines d/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment value b/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total value (S000)</td>
<td>1,285.8</td>
<td>1,072.4</td>
<td>1,412.4</td>
</tr>
<tr>
<td>Annualized (S000)</td>
<td>631.9</td>
<td>528.3</td>
<td>628.9</td>
</tr>
<tr>
<td>Reliability g/</td>
<td>30/6</td>
<td>180/4</td>
<td>150/8</td>
</tr>
<tr>
<td>Sample cycle times f/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper stitching</td>
<td>6.8</td>
<td>6.1</td>
<td>6.8</td>
</tr>
<tr>
<td>Skiving</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Material inputs g/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leather hide</td>
<td>260.00</td>
<td>260.00</td>
<td>260.00</td>
</tr>
<tr>
<td>Synthetic sheet</td>
<td>13.50</td>
<td>13.50</td>
<td>13.50</td>
</tr>
<tr>
<td>Board</td>
<td>105.00</td>
<td>105.00</td>
<td>105.00</td>
</tr>
<tr>
<td>Accessories</td>
<td>4.75</td>
<td>4.75</td>
<td>4.75</td>
</tr>
<tr>
<td>Sample yields g/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at leather cutting</td>
<td>70%</td>
<td>80%</td>
<td>70%</td>
</tr>
<tr>
<td>at final inspection</td>
<td>98%</td>
<td>98%</td>
<td>94%</td>
</tr>
<tr>
<td>Lot size</td>
<td>36</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Inventory (months) b/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw materials</td>
<td>2.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Finished goods</td>
<td>4.0</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Facility area (sq.ft.)</td>
<td>75,000</td>
<td>60,000</td>
<td>75,000</td>
</tr>
<tr>
<td>Land &amp; Buildings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Value (S000)</td>
<td>675.0</td>
<td>720.0</td>
<td>800.0</td>
</tr>
<tr>
<td>Annualized (S000)</td>
<td>126.0</td>
<td>120.0</td>
<td>132.0</td>
</tr>
<tr>
<td>Admin. Costs (S000/Year)</td>
<td>486.4</td>
<td>497.6</td>
<td>606.4</td>
</tr>
<tr>
<td>Annual Production (‘000s)</td>
<td>1,100</td>
<td>1,100</td>
<td>1,100</td>
</tr>
<tr>
<td>In-house buffers (days)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediate assemblies</td>
<td>6.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**g/** The number of employees (labor or staff) that report to the next higher level of management.

**b/** These numbers are derived from the modeling process. They depend on the manufacturing parameters and the desired production rate.

**g/** This includes the numbers of supervisors derived from the Span of Control parameter.

**g/** This number is derived from the modeling process. It depends on the manufacturing parameters and the desired production rate. It is a total across all types of machines. A detailed breakdown by type of machine is in the Appendix.

**g/** The first number is the average number of hours between failures of a machine, and the second is the average time to repair the machine, also in hours.

**f/** These are in minutes, for selected operations. Details for all operations are in the Appendix.

**g/** These are selected examples of yields. Details for all yields are in the Appendix.

**b/** These are for inventory before and after the shop floor operations. Inventory on the shop floor (i.e., shop floor WIP) is calculated by the model.
3.4 Input Costs

The cost of labor, capital, and land and facilities is specified in Table 3.3. These numbers, like the operational parameters discussed below, are based on the interviews but are necessarily stylized, given the variation within country types. The stylizations accord with generally perceived opportunity costs of these inputs. Interest rates are highest in the LDC and lowest in the DC; the ordering of labor cost is reversed. The "long-term" interest rate is used to value fixed capital and the "short-term" interest rate is used to value inventory and work-in-progress (WIP). The virtue of our modeling procedure is that sensitivity of total costs estimates to variations in input prices can be easily assessed.

<table>
<thead>
<tr>
<th>Table 3.3: Economic Parameters for Benchmark Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>Production Labor (wage in $/hour)</td>
</tr>
<tr>
<td>Skilled</td>
</tr>
<tr>
<td>Semiskilled</td>
</tr>
<tr>
<td>Unskilled</td>
</tr>
<tr>
<td>Benefits Rate</td>
</tr>
<tr>
<td>Indirect labor g/ Salaries ($000/year)</td>
</tr>
<tr>
<td>Benefits Rate</td>
</tr>
<tr>
<td>Long-term interest rate %</td>
</tr>
<tr>
<td>Short-term interest rate %</td>
</tr>
<tr>
<td>Facility cost ($/sq. ft.)</td>
</tr>
</tbody>
</table>

* The figures shown are the ranges of salary for different categories of employees. Actual salaries and the number of employees in each category are shown in the Appendix. Also see the entry and related footnote for number of indirect labor in Table 3.4

Costs of equipment and land and buildings are the sum of depreciation (using the "straight-line" depreciation method) and interest costs with respect to the current valuation of the asset. Thus if equipment has a value of $V, a depreciation life of Y years, and the "long-term" interest rate is i%, the annualized cost will be \( V(1/Y + i/100) \). Different types of equipment are assumed to have different depreciation rates and these are not reported here.

Unlike other inputs, which have been specified in physical terms, material inputs have been specified in US$/shoe. This has been done mainly to avoid clutter, since the list of actual inputs is long. The benchmark assumes that prices of inputs are the same in all country types, and so the equality in the dollar value of inputs across country types also implies that the quantity of inputs is the same. This is not necessarily a realistic assumption. It is likely, for example, that certain inputs (such as leather hides and accessories) are more expensive in an LDC than in a DC from which they are transported. However, since our main focus is on the manufacturing process, we have chosen to control the material prices at the same level in all countries.
It should be noted though that certain indirect costs of importation (and delays involved in that process) are included in the higher levels of inventory in LDCs. Moreover, the input costs specified here should be interpreted as the minimum required for every finished shoe. In addition, as discussed below, much material is wasted during the production process. The lower the production "yields", the greater the wastage. We indicate a wide range of yields, the lowest prevailing in the LDC Manual factory. As a consequence, greater scrap raises the effective material input per unit of output.

3.5 Benchmark Costs

The manufacturing parameters (Table 3.2) and the economic parameters (Table 3.3) are the inputs to ManuCost, which estimates the work-in-progress and the value of the scrap, based on the operational characteristics specified, to arrive at final costs of production. ManuCost also tracks the time during which labor and capital equipment are actually being used. On that basis, it is possible to break down the use of labor and equipment into what we term "productive" and "unproductive" use.¹ When machine or workers are not being used, we term them "unproductive." ManuCost is capable of providing costs accumulated at different stages of production. We present only the costs of producing the entire product. In the following chapters, the benefits of working with a finely specified production process will become evident.

The NIE factory is the most cost competitive (Table 3.4). Higher unit costs in the DC are explained directly or indirectly by higher labor costs. Even the higher value of scrap in the DC is a reflection of the value added (and hence essentially labor costs) in the material wasted and discarded.² The DC firm is also somewhat less efficient than the NIE firm in terms of manufacturing parameters such as cycle times, yields and inventories.

That LDC costs are higher, compared with NIE costs, is more directly attributable to inefficiency. The basis for this inefficiency was described above when discussing the manufacturing parameters. Two significant

¹ "Non-productive direct costs" are computed for both equipment and labor. Examples of non-productive times are equipment waiting for labor, equipment that has failed, and unused capacity of equipment or labor. Higher non-productive costs reflect an imbalance in the production line or production inefficiencies due to machine down time.

² During the entire accumulation process, whenever scrap is generated in manufacturing, the full value of the scrapped items is noted. The valuation of scrap includes the cost of raw materials as well as any direct and indirect costs accumulated in that item. For example, labor and capital costs incurred on the production of the item scrapped are included in scrap value. Moreover, if, at an intermediate step, additional raw material is required due to high scrap in the process, this additional cost will not show up in the "material" category but, rather, in the "valued scrap" category.
cost disadvantages that result from these inefficiencies are in scrap costs and WIP costs.\(^3\) These more than wipe out any advantage in labor cost. As can also be seen, in the traditional form of this industry, the costs of equipment, facilities and administration are virtually negligible in all three country types.

### Table 3.4: Costs Predicted by Benchmark Models

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost Per Shoe (in USS)</th>
<th>Percentage of Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LDC</td>
<td>NIE</td>
</tr>
<tr>
<td>Material</td>
<td>12.32</td>
<td>12.32</td>
</tr>
<tr>
<td>Direct Labor</td>
<td>0.62</td>
<td>0.90</td>
</tr>
<tr>
<td>Direct Equipment</td>
<td>0.41</td>
<td>0.37</td>
</tr>
<tr>
<td>Non-productive Direct Labor</td>
<td>0.27</td>
<td>0.39</td>
</tr>
<tr>
<td>Non-productive Direct Equipment</td>
<td>0.14</td>
<td>0.09</td>
</tr>
<tr>
<td>Indirect Labor</td>
<td>0.96</td>
<td>1.16</td>
</tr>
<tr>
<td>Land and Buildings</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Administrative</td>
<td>0.40</td>
<td>0.43</td>
</tr>
<tr>
<td>Inventory and WIP</td>
<td>2.18</td>
<td>0.65</td>
</tr>
<tr>
<td>Valued Scrap</td>
<td>4.57</td>
<td>2.59</td>
</tr>
<tr>
<td>TOTAL</td>
<td>21.99</td>
<td>19.00</td>
</tr>
</tbody>
</table>

A final feature of these cost estimates that should be noted is the high proportion of material costs. As we shall see in the following chapters, despite the importance of labor costs in DCs, technical change and especially new organizational practices, have been directed significantly towards lowering material costs. Hence, many of the new organizational practices have direct relevance for developing countries.

The low share of labor cost in the total cost of producing shoe implies that rising wages in an NIE are not likely to be sufficient to make the LDC or DC competitive with an NIE. For example, it would take a doubling in NIE wages to raise costs to the LDC level. Similarly, if NIE wages remained unchanged, DC wages would have to be reduced by half to reach NIE cost levels.

\(^3\)/ The quantity of WIP predicted in the manufacturing model, and the short-term interest costs, leads to the WIP carrying costs. The calculation is more complex than a simple multiplication for two reasons: i) The WIP carrying cost at the first operation increases the valuation of the WIP for the second operation, and so on, and thus the WIP carrying cost needs to be computed progressively; and ii) The presence of rework leads to "feedback" where the outputs of a downstream operation affect the inputs of an upstream operation. This requires a system of equations to be solved to get the WIP valuation.
3.6 Scale Economies

Our estimates show that for the benchmark technologies, the cost curve essentially flattens out at about 1.1 million shoes a year, implying that no real cost advantage can be obtained by producing more shoes in a single factory. In practice, much larger factories are observed. For example, HS Corporation of Korea produces 30 million shoes a year. The economies derived from such a large scale relate more to marketing and sourcing of inputs than to manufacturing. NIE firms, such as HS Corporation, also view their growth as a mechanism for widely advertising their product quality attainments in order to eventually launch their own brand-name products (See Box 3.1).

3.7 Discussion of the Benchmark

With their relatively high wages, how can companies in developed countries such as the U.S. and Japan compete in the labor-intensive footwear industry? Some companies cannot. Numerous DC firms have closed down in the past few years. Most of these have been small firms. For example, Nunn Bush, a Wisconsin manufacturer of leather dress shoes, recently announced that competition from overseas manufacturers was forcing it to close its doors. But other companies have overcome the wage differential by emphasizing either their efficiency as manufacturers or their effectiveness as marketers, or both.

To manufacture efficiently, companies must use both technology and people well. Currently, high technology in footwear is most apparent in design. But to remain competitive, manufacturers in DCs have begun to modernize the actual production process as well.

DC manufacturers have also used product differentiation and marketing strategies to offset the disadvantage of higher wage costs. For example, marketing programs in the United States have emphasized such phrases as "made in the USA" and "hand-crafted quality." Such programs, when used in conjunction with established brand names, have proven effective (Interviews, 1988).

U.S. footwear manufacturers are also taking advantage of the proximity of low-wage countries like Mexico and the Dominican Republic. In the case of leather dress shoes, the uppers are designed and the patterns cut at a U.S. company, sent to a low-wage subcontractor for stitching, and returned to the U.S. company as a subassembly for final production. In each case the most labor-intensive process in shoemaking bypasses high-wage labor.

For NIEs, manufacturing efficiency is absolutely crucial; design, although increasingly important, remains a secondary concern. NIEs have traditionally been followers reacting to new product developments in other countries. Typically, the U.S. or Japan supplies the design, contracts out production to the NIE shoe company, and markets and distributes the finished product under their brand name at home.
In Korea, Reebok is the HS Corporation. The company, which employs 19,000 people in Pusan, manufactures 30 million pairs of shoes annually, most of them athletic shoes. Ninety percent are Reeboks, produced under a three-year contract; the remaining 10 percent go to Nike, previously HS's biggest customer. HS alone accounts for 23 percent of Korean shoe exports by unit volume, and 20 percent by dollar sales; nearly all its production goes abroad, with 55 percent to the U.S., 20 percent to Japan and 15 percent to Britain.

As a mass producer, HS is in a good position to exploit economies of scale - and is planning to do so, with its own line of LeCaf-brand shoes. But first HS will have to develop certain capabilities that, as contractor to Nike and Reebok, it has not needed until now. Because HS gets its drawings and patterns from abroad, for example, it has never adopted a CAD/CAM system; now it is putting one in place. The company plans to use it to make LeCaf's upper patterns.

By launching its own line, HS is not only seeking to exploit economies of scale; it is also trying to protect itself from competition from lower-wage countries. HS notes that Nike came into Korea when labor costs there were low. Now that Korea's wage rates are rising rapidly, to about $15 per day for a worker with average skills, companies such as HS may find it harder to compete with manufacturers in LDCs. In fact, HS itself is considering building a plant in Thailand, where wages are about one-third to one-half those of Korea and raw materials are also cheaper.

We can expect, therefore, that companies like HS will specialize in international sourcing of materials and other inputs and also in distributing brand name products. They will also provide production expertise to their subsidiaries and affiliates. It is likely, moreover, that they will continue to produce shoes in their home base, though the type of shoe being manufactured there will be higher quality than in their LDC factories.

This practice has enabled NIE shoemakers to become "experts" in footwear manufacturing. This is especially true in the athletic shoe sector. One Korean manufacturer, though currently working as a contractor for U.S. firms, maintains that its "ultimate goal is to elevate the product quality and reputation of the company to the level of world's best footwear company by being the leader in innovative design and function of its product" (Interviews, 1988). The auto and electronics industries have similar aspirations.

The production process in an LDC is similar to that of NIE and DC shoe companies, but the skills of management and workers are at a much lower level. Low cost is not generally adequate compensation for low quality of the
labor force. Indeed, low cost labor can be a hindrance if adaptation to change is inhibited.

Although advanced management practices and technologies can, in theory, be accessed by LDC shoe companies, they are often ignored because management lacks the technical expertise to implement them or is too busy trying to keep the company afloat. Often the companies' choice of technology is limited by government mandates that they buy their equipment from domestic suppliers, who may be unreliable or even unaware of the latest technologies. While these manufacturers have standard shoemaking machinery, seldom is this coupled with the efficient use of low-cost automation (mechanical aids and pneumatic controls) so prevalent in NIEs.

Technical expertise is scarce, and those who have it are often the companies' managers or owners. They cannot singlehandedly run a complex manufacturing system. Nonetheless, it is important that these companies develop the knowledge needed to understand and implement new technologies. For example, efficient low-level technology has allowed the BATA factory in Jakarta, Indonesia, to dominate its domestic market and contemplate selling overseas. (See Box 3.2.)

The success of some LDC footwear manufacturers shows they have the potential to produce quality shoes at competitive prices. The Emyco shoe factory in Leon, Mexico, recently announced exports of one million pairs of leather dress shoes to the North American market under the company's own label (Moffett, 1989). Brent Gardner, vice president of a retail shoe chain, states, "I'd say that Emyco consistently produces the finest quality product of any shoemaker in its price range. It was a big surprise." How to reach that position is a central theme of this report.
BOX 3.2: A PARAGON OF EFFICIENCY IN INDONESIA

Most Indonesians think that BATA is an Indonesian company and, in fact, the Jakarta factory - which opened in 1931 - was the first in the BATA group to develop and install a machine that vulcanizes its rubber footwear right on the conveyor line. BATA, a Canadian transnational corporation operating in over 80 countries, is the world's largest manufacturer of footwear. But as the vulcanization example suggests, it has been exceptionally successful in producing shoes in less developed countries such as Indonesia, where both indigenous and foreign manufacturers have run into problems.

The Jakarta factory is a model of an efficient factory in an LDC. For its rubber footwear, BATA has a mixing room, in which it produces its own rubber compounds. It uses 24 tables for the curing process and at least ten presses to stamp out the unit soles. The components, packed in boxes, are then sent to various stations for sewing. After the upper has been stitched and glued to the sole, the shoe is ready to be vulcanized. It is placed in a vulcanizing boiler for one hour, after which it is cooled and moved on to the finishing process. The shoes are automatically "set" as they pass through this operation.

For its leather footwear, BATA has also modernized operations in the last few years, improving electrical wiring, importing dies and lasts, and using some simple, low-cost automation techniques to feed machines.

Most of the shoes made at the Jakarta plant are functional, sandals and slippers, and nearly all the production is sold domestically--largely through outlets under the BATA name. But the BATA group has global ambitions for its Indonesian operation. The plant produces higher value-added shoes than most Indonesian footwear manufacturers, and is targeting its men's leather shoes for export.
4. LEARNING TO PRODUCE

4.1 Objective

The state of manufacturing practice in a firm or a country is the result of organizational and shop-floor learning that has been undertaken in the past. The learning experiences of others may sometimes be embodied in advanced machines, reducing the further need for "soft" investments in worker training, improved work practices, and organizational changes. However, a central proposition of this study is that these so-called soft investments, for which we use the short-hand term "learning", are critical to international competitiveness.

We view learning as a process of experimentation aimed at increasing productivity. As such, it is something of an art form. However, modern tools and practices embodied in, for example, Total Quality Control (TQC) and Just-in-Time (JIT) provide structure and content to the learning process by specifying the elements of training, organizational change and infrastructure needed to continuously improve the production process.

In this chapter, we evaluate the quantitative impact of improved production practices that overcome inefficiencies in the production system. The procedure we follow is to generate a set of "scenarios." These are "what-if" exercises and, as such, are purely accounting devices that say nothing about how the transition is made from one state to another. Hence, after demonstrating the quantitative importance of changes in factory operating procedures and practices, we discuss issues relating to their implementation.

The first set of scenarios brings the LDC and DC factories on par with the NIE factories in terms of manufacturing parameters. The manufacturing parameters of the NIE factory can be considered the "current best practice," so this set of scenarios brings everyone to the current best practice. The cost difference that remains at the end of this sequence is due to economic parameters, not manufacturing parameters.

However, the current best practice in the NIEs is a moving target. Observed trends in the literature and our field interviews suggest clearly that further improvements in production management will occur in the next five years. These are modeled as future best practice.

When we "move" a factory from its benchmark level of efficiency to current best practice and then to future best practice, we are assuming that the relevant learning process is in place. Learning, however, is not a trivial task, and it is costly for both the firm (e.g. investment in training) and the economy (e.g. provision of relevant infrastructure). These costs are not easy to quantify, and so are discussed qualitatively. It could be concluded that these costs are so high that LDC firms should not be producing even a product as technically mature as the one considered in this study. Or, on a more positive note, we could conclude that significant efforts to generate such learning are needed urgently if LDC firms are to be competitive in international markets.
4.2 Current Best Practice

The following changes were implemented (sequentially):

**Improved process efficiency:** Scrap rates, machine reliability and in-house buffers all brought to the NIE levels. We start with these changes because these are internal to the firm and presumably under greatest control by the firm.

**Reduced inventories:** Raw materials and finished goods inventories brought to the NIE levels. These changes typically require cooperation from suppliers and buyers and from the transportation and communication system. However, high inventories cannot entirely be charged to shortcomings of others. Better production management, greater specialization in procurement and composition of production can all help in inventory reduction.

**Reduction in cycle times:** Process cycle times brought to the NIE levels. Once production is streamlined and inventories reduced, the cycle of production becomes shorter and that brings additional benefits.

**Improved management and overall operation:** Span of control, absenteeism, facility area, and days worked per year, all brought to the NIE levels. For the DC, days worked per year was left at 240 (working on Saturdays was felt to be a unrealistic addition for a DC factory).

The effects of all these scenarios on the cost of a shoe are summarized in Table 4.1.

<table>
<thead>
<tr>
<th>Table 4.1: IMPROVED PRODUCTION AND MANAGEMENT PRACTICES</th>
<th>Cost Per Shoe (in US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario</td>
<td>LDC</td>
</tr>
<tr>
<td>Benchmark (as before)</td>
<td>21.99</td>
</tr>
<tr>
<td>Steps to current Best Practice:</td>
<td></td>
</tr>
<tr>
<td>Internal process improvements</td>
<td>19.71</td>
</tr>
<tr>
<td>Reduced inventories</td>
<td>18.55</td>
</tr>
<tr>
<td>Reduced cycle times</td>
<td>18.39</td>
</tr>
<tr>
<td>Improved management</td>
<td>18.04</td>
</tr>
</tbody>
</table>

Recalling that the practices are introduced cumulatively, an LDC shoe producer saves $4 per shoe (an 18 percent decline in cost) by improving production and management practices. More than $2 of the savings comes from internal process improvements such as reduced scrap rates, higher machine reliability and lower in-house buffers. Once all the production and management inefficiencies have been removed, an LDC, not surprisingly, becomes the most efficient producer.
A DC firm also gains significantly from the same improvements. If firms in all country types operated at the same level of efficiency, the international cost differences would be much less than they are in practice. A possible interpretation of this observation is that, even in a mature product such as a shoe, production learning is not trivial. Countries that have invested in the learning process (the NIEs) have developed a cost advantage that they are able to sustain by continuously redefining the frontiers of the possible, even within the context of "mature" technology.

4.3 Future Best Practice

We expect such redefinition of the frontier to continue. Looking five years into the future, we develop a second set of scenarios. These scenarios take the manufacturing parameters of all the factories from the current best practice defined above, to a possible "future best practice." The following changes are implemented simultaneously:

- A further reduction in scrap rates (yield at cutting raised to 85 percent; at final inspection, to 98 percent), improvement in machine reliabilities (new parameters: 320/2), and reduction of in-house buffers to 1 day.
- Raw material and finished goods inventories brought down to 0.5 and 0.75 months respectively.
- Process cycle times reduced by another 10 percent.
- Span of control raised to 20 and facility area reduced by a further 15 percent.

When these changes are implemented, an NIE would lower costs by an additional $1.70 per shoe (a 9 percent decline), to $17.30. See Table 4.2. An LDC that remains at the benchmark costs will produce a leather dress shoe costing $4.70 more than the ever-leaner NIE firm. A cost difference of that magnitude would mean that the LDC would find it almost impossible to enter international markets. When we allow also for the near certainty that the NIE would be delivering a more consistent product on time, the competitive position of a lagging LDC becomes completely unsustainable.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>LDC</th>
<th>NIE</th>
<th>DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>21.99</td>
<td>19.00</td>
<td>26.94</td>
</tr>
<tr>
<td>Current Best Practice</td>
<td>18.04</td>
<td>19.00</td>
<td>23.22</td>
</tr>
<tr>
<td>Future Best Practice</td>
<td>16.47</td>
<td>17.30</td>
<td>20.65</td>
</tr>
</tbody>
</table>

An interesting consequence of the move to future best practice is the further narrowing of international cost differences. The streamlining allows the DC not only to reduce its inventories and scrap but also its labor.
cost. While DC firms will still not be able to meet low-wage competition head-on, they will be more successful in differentiated product markets.

4.4 The Learning Process

Japanese and other East Asian firms have made an art form of continuous incremental change that, over time, leads to major gains in productivity. The art is being gradually codified into techniques covered under the rubric of just-in-time (JIT), of which total quality control (TQC) is a subset.

These modern techniques of organizational change offer significant possibilities for manufacturers in LDCs. Our cost analysis has shown that adoption of these techniques restores the cost advantage of LDCs over NIEs. Scrap and inventory reduction under JIT are especially beneficial to LDCs. Reduction in waste confers an obvious benefit and high interest rates make it punitive to maintain large inventories.

The deceptive charm of JIT also is that there appear to be no costs associated with implementation. However, implementation of any change is an expensive activity and JIT is no exception. More importantly, JIT implementation is expensive in a resource that LDCs are not well-endowed with: human capital. Implementation requires tuning the technology to the organization and tuning the organization to the technology (Leonard-Barton 1988 and Schroeder, Gopinath and Congden 1989). The skills required for such tuning include both formal training (to understand the principles underlying the technology and the theory of organizations) and experience in implementing change.

In addition, there are costs due to lost production during the period of implementation and more conventional costs of buying new equipment and hiring consultants.

It is also good to keep in mind that implementation of new technologies and practices in LDCs occurs in a context that is not conducive to change. The ability to source inputs in a timely manner from specialized producers is critical to the full implementation of JIT. This requires good physical communication, but it also requires the growth of specialized suppliers working in a cooperative mode with their buyers. Infrastructural deficiencies, regulatory barriers, and constraints on input supplies are some of the handicaps from which firms in developing countries suffer. Firefighting on these fronts is very expensive in terms of scarce managerial and entrepreneurial resources.

We discuss below these specific costs of JIT implementation in some detail.

Training and Organizational Change

While popularly viewed as an inventory reduction practice, JIT is an organized process of incremental change aimed at creating a closely integrated flow of work. JIT requires microscopic attention to detail and is aimed at streamlining procedures, reducing set-up times and scrap rates,
improving machine reliability, reducing variability of production flow, and such like. Such internal efficiency measures make lower inventories possible; in turn, lower inventories unmask further inefficiencies and force changes. Greater decentralization of decision making (reduced span of control) reinforces these efforts by generating more information from the shop-floor, feeding the process of continuous minor modifications.

The process of implementing JIT is experimental in nature; however, well-defined techniques exist for such experimentation. The JIT toolbox consists of: industrial engineering techniques to reduce machine set-up times and facilitate easy changeovers in the use of machines; methods for streamlining plant layouts; techniques for quality control and maintenance; and organizational and engineering techniques for simpler product design (Zipkin 1991). Thus the most important investment required for implementing JIT is human capital. Only a workforce that is well-educated and trained can use these tools effectively.

Training takes many different forms. Workers may be sent to external institutions, such as local community colleges and vocational schools. Within the firm, formal courses may be organized or training may be imparted in many informal ways.

Japanese scholars have emphasized that the so-called informal training is probably the most important and most effective form of training for improved shop-floor productivity (Koike 1988). The important observation is that improvements are brought about by line workers who do not necessarily possess industrial engineering diplomas and degrees. However, effective supervisory support is crucial.

Informality in this context does not imply a lack of training plan or direction. Paradoxical as it may sound, informal training requires a strong institutional commitment and well-defined process. Limited reliance on the classroom is the main reason for using the term "informal". Mentoring by supervisors, collaborative problem solving with peers (quality-circles), job rotation through the plant and the firm are the more important elements of informal training.

The message on training is clearly out. U.S. firms attempting the adoption of JIT techniques are making serious efforts to institutionalize formal and informal training processes within firms.

A closely related concern that interacts with training is the need for organizational change. Delayering the traditional organizational pyramid by expanding the span of control yields significant cost savings in companies located in all country types, but especially in those countries (DCs and NIEs) where the cost of management is high. Take the example, of a factory employing 385 line workers. Using a span of control of ten; the plant require 35 first level, four second level, and zero third level managers. Table 4.3 shows that a relatively small change in the span of control produces a dramatic change in the number of managers required.

The greater gains from reduced span of control arise in the form of better information generation and decision-making. Workers close to the
shop-floor have superior information on the work process and are potentially better positioned to rapidly analyze the information and take corrective measures before problems cumulate (see especially Aoki 1990 on such benefits in the Japanese context). These gains, however, are hard to quantify.

Table 4.3: SPAN OF CONTROL EFFECTS

<table>
<thead>
<tr>
<th>Managerial Level</th>
<th>Span of Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Third-Level</td>
<td>13</td>
</tr>
<tr>
<td>Second-Level</td>
<td>39</td>
</tr>
<tr>
<td>First-Level</td>
<td>116</td>
</tr>
</tbody>
</table>

The pressure to increase span of control grows when greater emphasis is required on reducing lead times, improving quality, and increasing product variety. No longer is time available for problem-solving decisions to filter through several layers of management and companies must flatten their traditional hierarchy. They must train production workers in problem-solving techniques and, at the same time, empower them to implement solutions. Autonomy and decision-making authority must be transferred from management to the shop floor (Deming, 1986).

However, the ability to delegate depends heavily on the quality of both management and labor. Management needs to be trained in the tools of JIT and thereby simplify the tasks to be performed. On the other hand, workers need skills to take on the responsibility of interpreting the operation of the factory and discovering creative solutions to problems.

Given the limitations of both managers and workers, increasing the span of control may not be cost effective. Savings are possible only when greater responsibility can be safely delegated to the production line employee. This creates particularly severe pressures on LDC firms to invest in training. However, the ability to train is constrained by low basic educational attainments of the employees. Limited knowledge exists on the form and magnitude of training incentives to which LDC firms respond, and this is clearly an important area for further investigation. (See Box 4.1)

Productivity "Dip" and Other Investments

In addition to the costs of training often overlooked is the cost of disruption in the manufacturing process that JIT causes by reducing inventories. Drastic inventory reduction, resulting in a shortfall of raw materials, will create idle stations and disrupt production - potentially to such a point that the problems incurred will cost the company more than the benefits to be derived from JIT. Known as the "productivity dip," this disruption is common and should be addressed prior to JIT implementation (Suri and DeTreville, 1986).

The financial costs of such disruption may be minimized by proceeding sequentially. Experience has shown that JIT should be implemented in stages, in carefully selected areas, rather than being adopted immediately,
company-wide (Barrett, 1988). A step in the successful implementation of JIT is a carefully chosen pilot project. A pilot project helps gain the confidence of both managers and workers, and provides training to engineers and employees (Love, 1988). Starting with internal efficiency measures, over which the firm has more control, is a logical approach to implementing JIT.

**Box 4.1: HIGH COST OF CHEAP LABOR**

Wage rates are low, but labor is not inexpensive at the F.S. Santosa footwear company in Jakarta, Indonesia. The company, which employs between 500 and 600 people, faults their poor education and high turnover for the inconsistent quality of the 100,000 shoes the factory produces each month.

Santosa argues that it is hard to train workers because of their limited education; the average employee has completed only primary school.

The weakest link in the labor chain, according to Santosa’s owner, is the lack of middle-level workers who would convey orders from top management to the line workers. Santosa believes that the best way to find workers in this category is to develop them in-house.

Shop floor workers need continual attention, in Santosa’s view. Their limits have severely circumscribed Santosa’s ability to adopt more advanced technologies. The most high-tech machine at Santosa now is the injection molder, and even that is not currently in use; skilled operators are a rarity.

For all Santosa’s complaints, the low wage rate makes footwear production highly viable. Santosa is able to export 85 percent of its production to Europe, Japan and the U.S. Unless product quality problems are addressed, however, competition from China, Thailand, and other Indonesian firms could limit future growth.

Consultancy costs of developing and implementing JIT can be significant. In addition, LDCs tend to have underdeveloped consultancy services, particularly those directed towards small and medium-sized firms. Programs that tap and train private individuals (retired executives, university professors and graduate students, vocational school trainers, and capital goods suppliers) to work with small and medium-sized firms could have big payoffs.

A network of government and industry run technology diffusion centers may act as a substitute (OTA 1990 and Cole 1989). National Bureaus of Standards and public and private productivity organizations, often organized by industry groups, play a very important role in technology diffusion. In Japan, for example, external consultants are used to a much smaller extent.
than in the United States. Diffusion centers are both a source of expertise and also a forum for exchange of lessons learnt.

Though JIT techniques are directed primarily at changing the organization, new machinery is often required (Zipkin 1991). Improving the quality of machinery is sometimes a prerequisite to achieving lower set-up times and greater machine reliability. Often production capacity also needs to be increased as inventories are being lowered in order to accommodate sudden surges in demand.

**Infrastructure**

Besides the obvious need for transport and communications infrastructure, unreliable suppliers also impede the movement toward JIT in LDCs. Manufacturers we interviewed most often cited the lack of reliable suppliers as an impediment to JIT in an LDC company. This perception needs to be interpreted cautiously. We have discussed above the importance of many internal improvements which lead to substantial productivity gains.

Manufacturers that have recently implemented JIT programs have reduced the total number of their suppliers, established long-term relationships with the remaining suppliers, and created certification programs for key suppliers.

Such programs are not without precedent even in LDCs. Recently, Caterpillar Inc., in conjunction with P.T. Natra Raya of Indonesia, has begun to qualify suppliers for its Indonesian factories. There are few such qualified suppliers in Indonesia now, but Caterpillar has offered training and technology to those suppliers willing to work toward qualification. Caterpillar thus hopes to manufacture in Indonesia internationally competitive products and components (Cat World, 1989).

Programs that supplement the initiatives of major international companies such as Caterpillar are needed to diffuse widely international standards in quality control practice and provide certification services. Such programs are, in principle, no different from the general technology diffusion programs described above.

4.5 **Summary**

JIT may be considered the institutionalization of a learning process within the firm. Economists are used to thinking of "learning" in a somewhat mechanistic manner. Learning is often viewed as a costless by-product of production or investment. If that were the case, Eastern European firms would be amongst the lowest cost producers in the world. The reality is that learning is an expensive process requiring considerable experimentation with the production process and, more fundamentally, with the organizational structure of the firm.

JIT implies one or both of the following propositions: 1) human capital requirements, in particular, but also the need for physical capital are so strong, even for so-called "low end" products, that most developing countries do not have a real comparative advantage in simple manufactured
goods; 2) to overcome this disadvantage, access to international sources of knowledge and increased domestic investment in knowledge creation, with a clear focus on improving basic manufacturing productivity, must be a major priority for LDCs.

The implication is that greater experience with modern industrial practices is needed in a setting where such experience can be absorbed. Close links with foreign firms that possess the knowledge needed for efficient absorption is likely to be a must.

In the early 1980s, JIT was labeled a strategy possible only in the restrictive operating conditions prevalent in Japan. Yet today, U.S. manufacturers provide the success stories so abundant in the literature. They are learning to better manage suppliers, train employees and update their manufacturing techniques. Not long ago the U.S. manufacturing environment was classified as not conducive to the use of JIT. Today the same is being said of the LDCs.
5. AUTOMATION AND NEW MATERIALS

5.1 Objective

In the previous chapter, we discussed so-called "soft" changes to the production system. In our discussion we indicated that "soft" should not be read as "easy." In this chapter we analyze the effect of changes in machines and materials.

Many of the technologies discussed in this chapter have emerged only in the last five years and their adoption has so far been spotty. There is a general belief in their potential but a limited understanding of how soon that potential will be realized.

In the last section of this chapter, we venture into further uncharted territories with our "blue-sky" scenarios. These represent our reading of technologies currently under development and likely to enter the production process in the next five years.

5.2 Cutting Automation: CAD/CAM

Computer-Aided Design (CAD) is "the use of computer systems to assist in the creation, modification, analysis, or optimization of a design", while Computer-Aided Manufacturing (CAM) is "the use of computer systems to plan, manage, and control the operations of a manufacturing plant through either direct or indirect computer interface with the plant's production resources" (Groover and Zimmers, 1984). Combining CAD and CAM to integrate the design and manufacture of products is a first step toward Computer Integrated Manufacturing (CIM).

We made several changes to the benchmark leather shoe model to simulate the implementation of a CAD/CAM system. First we incorporated a $400,000 CAD system into the benchmark factory (Interviews 1988). As a stand-alone tool—that is without the CAM interface—CAD is difficult to justify solely on cost savings. However, some companies we interviewed cited intangible savings and improvements in design lead time and pattern grading, coupled with the promise of future CAM integration, as justification for stand-alone CAD systems.

The second addition to the benchmark factory was computer numerically controlled (CNC) cutters. CNC cutters provide the required CAM interface: instructions from the CAD system are downloaded to computer controlled cutters. These are used to cut the leather into the required patterns. Traditionally, cutting is a skill-intensive task. A master cutter knows from experience how to save on material. The CNC cutter has certain quantifiable advantages over a master craftsman using a manual press. First, cutting algorithms optimize die placement during cutting, resulting in about a 10 percent materials saving (Kaplan 1985). CNC cutting, however, is more applicable to synthetic materials than to leather; on account of its unpredictable surface, leather continues to require a human operator for correct positioning of the cutter.
Second, the CNC cutters require approximately one-half the processing time of a manual cutter. Thus, in the synthetic cutting department of the benchmark factory, the number of cutters can be reduced from 16 to eight. Third, fewer employees are needed to operate the machines. The manual cutters require one employee per machine while CNC cutters require only one employee per four machines. With upgrading from manual to CNC cutters, the primary responsibility of the operator changes from die placement and machine operation to system monitoring and set up assistance.

CNC cutters range in price from $25,000 to over $250,000, depending upon size and features. We assumed a price of $100,000. Subsequently, we analyze the effect of lower and higher CNC prices.

In Table 5.1 are presented the estimates of production costs after the introduction of cutting automation. An interesting conclusion follows. Even in a high-wage DC, the impact of this form of automation is very limited. Total costs do not change down to the last penny! Labor costs and scrap value fall somewhat and capital costs and engineering costs (indirect labor) rise to offset that decline. In an LDC or NIE, costs actually rise.

<table>
<thead>
<tr>
<th>Table 5.1: COSTS AFTER CUTTING AUTOMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost Category</strong></td>
</tr>
<tr>
<td>Material</td>
</tr>
<tr>
<td>Direct Labor</td>
</tr>
<tr>
<td>Direct Equipment</td>
</tr>
<tr>
<td>Non-prod. Direct Labor</td>
</tr>
<tr>
<td>Non-prod. Direct Equip.</td>
</tr>
<tr>
<td>Indirect Labor</td>
</tr>
<tr>
<td>Land and Buildings</td>
</tr>
<tr>
<td>Administrative</td>
</tr>
<tr>
<td>Inventory and WIP</td>
</tr>
<tr>
<td>Valued Scrap</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

We performed a number of sensitivity tests to assess the robustness of this conclusion. Realistic changes in the number of operators do not have much impact. Likewise, when the cost of numerically controlled cutters falls to $25,000 (and efficiency of the cutter remains the same), unit cost of a shoe falls by only about 20 cents. Alternatively, if the cutter cost rises to $200,000 then, even in a DC, automation leads to higher costs.

To summarize, CAD/CAM cannot currently be justified in footwear on the basis of cost savings. Labor accounts for the primary cost reduction. Material savings—which CAD/CAM can achieve—remain insignificant, due to the unique properties of leather. It should be noted that in garment production,
modern cutting machines allow far greater material and savings and significantly lower unit production costs (Mody and Wheeler 1987).

However, cost savings are not the sole justification for CAD/CAM. Non-quantifiable improvements, such as reductions in design lead times, improved pattern grading and pattern development, and enhanced prototypes, have been used to justify CAD/CAM system in some footwear companies (Interviews, 1988). The over-riding question when assessing the intangible benefits of CAD/CAM is: how critical is product design to a company's competitive position? Most of the companies we visited in NIEs and LDCs produce designs in one of two ways: they either "reverse engineer" shoes obtained from the U.S. or Europe, or they perform "contract production," manufacturing shoes designed outside the company. Reverse engineering in the shoe industry involves copying a shoe design by breaking down an existing shoe into its components. The individual components are then used as patterns for dies, from which similar patterns can be cut.

Whether the company uses reverse engineering or contract production, original design is not critical to its competitive position. Therefore a CAD/CAM system is not justified. However, if the quick development of new designs and prototypes, as in women's shoes, is central to a company's success, a CAD/CAM system may be justified on intangibles.

Other factors in assessing CAD/CAM are the availability and cost of technical expertise. A CAD system requires trained operators. Similarly, CNC cutters need technical support for system installation and machine maintenance. Such expertise is lacking now in many of the companies and countries we visited.

5.3 Assembly Automation

In this scenario, we automate several operations in the assembly of the upper and the shoe. The level of automation at present achievable is even lower than in cutting. In fact, we find here that automation can actually disrupt the production process and increase scrap slightly, thereby raising costs even in a DC.

In the fitting department, we introduced automated stitchers capable of both decorative and programmable stitching (both stitch length and speed). These machines reduce processing time and also reduce labor by a small amount labor. Traditionally, fitting is the department most resistant to automation (and also the most labor-intensive), due primarily to inconsistencies in the leather and the three-dimensional shape of the shoe. Other improvements we incorporated into the fitting department included advanced skiving and embossing machines.

In the lasting department, we added technological advances to improve machine flexibility (Interviews, 1988, Rubery and Wilkinson, 1987). New lasting machines, capable of handling many designs and sizes quickly and efficiently, further reduce processing times. We also introduced advanced roughers capable of automatically adjusting to variations in the quality and thickness of leather, thereby further improving cycle times.
A final modification to the benchmark model was the addition of nine engineers to help install and integrate the new equipment.

Though the improvements result in decreased processing times, only about a 20 percent reduction in operators can be expected to occur. We have been conservative in estimating for reduction in operators. However, a somewhat larger reduction will not change the cost estimates significantly.

Table 5.2 summarizes the results of assembly automation along with other variations studied. At this time, automation clearly has minimal impact on lowering production costs; in fact, they rise slightly. Much greater mileage is to be gained from implementation of improved work practices discussed in the previous chapter. As a general point, it is also the case that any gains from automation are greater when automation is introduced after streamlining the production process. Prior streamlining prevents disruption and unexpected increases in scrap and inventory.

<table>
<thead>
<tr>
<th></th>
<th>LDC</th>
<th>NIE</th>
<th>DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>22.0</td>
<td>19.0</td>
<td>26.9</td>
</tr>
<tr>
<td>Only Cutting Automation</td>
<td>22.2</td>
<td>19.2</td>
<td>26.9</td>
</tr>
<tr>
<td>Only Assembly Automation</td>
<td>23.1</td>
<td>19.5</td>
<td>27.1</td>
</tr>
<tr>
<td>Total Automation*</td>
<td>23.4</td>
<td>19.7</td>
<td>27.3</td>
</tr>
<tr>
<td>Improved Future</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best Practice**</td>
<td>16.5</td>
<td>17.3</td>
<td>20.7</td>
</tr>
<tr>
<td>Improved Practices plus</td>
<td>17.0</td>
<td>17.5</td>
<td>20.6</td>
</tr>
</tbody>
</table>

* Both cutting and assembly automation
** As defined in Chapter 4, it includes internal efficiency improvements and inventory reduction.

5.4 The Future and "Action Leather"

Though our results provide little immediate solace to those seeking to automate their way to competitiveness, enough change is occurring at present to warrant a continuing assessment of emerging technologies. Here, we glance into our crystal ball.

Three forces are likely to change simultaneously the nature of competition in the shoe industry.

- The availability of CAD and the increasing emphasis on user comfort (such as shock absorption and rebound capabilities) are increasing potential for product differentiation, rapid changes in style and even rapid obsolescence of certain types of shoes (primarily athletic). Ordering cycles as short as three days are being targeted so that production can track evolving demand as closely as possible.
Computer-based production technology is improving rapidly. Commonly accepted standards are being set for fully computer-integrated manufacturing. Diffusion of these standards will provide a fillip to equipment manufacturers. Quick size and model changes using bar codes on lasts, automated material flow technology using robots, automated stitching, and laser cutting are some of the technologies being actively tested on experimental production lines (see DiMaria 1988 for trends in Europe, Pulda 1989 for developments in Korea and Box 5.1 for ongoing changes in the United States).

Perhaps the most "blue-sky" of all technologies is "Action Leather," an inexpensive leather laminated with polyurethane. Action leather is presently half the price of full grain leather, and is used in small amounts in athletic footwear. Being much easier to process than full grain leather, it offers tremendous possibilities for automation. The big question mark here, of course, is the acceptability of such leather to consumers.

Armed with these technologies, what cost reductions can producers realistically achieve in the next five years? The results are presented in Table 5.3. The estimates assume a cumulative adoption of all the practices and technologies described in this report. Thus, moving from the benchmark, first the "future best practices" of the previous chapter are assumed to be adopted; then the future level of automation is introduced (Future Automation Scenario); and finally, action leather is substituted for natural leather. It should again be emphasized that we view both "future best practice" and "future automation" as feasible in the next five years.
Table 5.3: "BLUE-SKY" TECHNOLOGIES IN DCs

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>Future Best Practice*</th>
<th>Future Automation**</th>
<th>Future Automation with &quot;Action Leather&quot;**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>12.32</td>
<td>12.32</td>
<td>12.32</td>
<td>8.67</td>
</tr>
<tr>
<td>Direct Labor</td>
<td>3.52</td>
<td>2.52</td>
<td>1.01</td>
<td>0.95</td>
</tr>
<tr>
<td>Direct Equipment</td>
<td>0.43</td>
<td>0.42</td>
<td>0.81</td>
<td>0.95</td>
</tr>
<tr>
<td>Non-prod. Direct Labor</td>
<td>1.43</td>
<td>1.20</td>
<td>0.39</td>
<td>0.34</td>
</tr>
<tr>
<td>Non-prod. Direct Equip.</td>
<td>0.27</td>
<td>0.09</td>
<td>0.29</td>
<td>0.35</td>
</tr>
<tr>
<td>Indirect Labor</td>
<td>2.42</td>
<td>1.25</td>
<td>1.46</td>
<td>1.48</td>
</tr>
<tr>
<td>Land and Buildings</td>
<td>0.11</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Administrative</td>
<td>0.51</td>
<td>0.52</td>
<td>0.53</td>
<td>0.54</td>
</tr>
<tr>
<td>Inventory and WIP</td>
<td>1.14</td>
<td>0.22</td>
<td>0.20</td>
<td>0.14</td>
</tr>
<tr>
<td>Valued Scrap</td>
<td>4.78</td>
<td>1.74</td>
<td>1.98</td>
<td>0.57</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>26.94</td>
<td>20.65</td>
<td>18.78</td>
<td>14.10</td>
</tr>
</tbody>
</table>

* As described in Chapter 4, it includes internal efficiency improvements and inventory reduction.

** Includes "Future Best Practice" as defined above.

In the Future Automation Scenario, it is assumed that automation is extended to several more operations (e.g., tacking, insertion and packing) and to a far greater depth than is practiced today. On the conservative side, it is assumed that hardware costs would be comparable to today's, though we allow for a 50 percent reduction in the cost of the CAD system. Machine cycle times are reduced by an average 25 percent, while labor times are reduced by a further 30 percent over the previous total automation scenario (which reflects current practice). In addition, via the use of new materials and technologies, as well as a maturing of existing technologies, we assume a 25 percent decline in the cost of lasts and dies.

Introduction of "future automation" creates a real impact. Lower labor costs, lower inventories and reduced scrap value contribute to cost reduction of about 10 percent, from $20.65 to $18.78. In a sector like footwear, such cost reduction is non-trivial and it is not surprising that companies that have survived the onslaught of low-wage competition are pursuing it with vigor.

When "action leather" is added to the list of possibilities, a further substantial decline follows. The basic material cost falls and scrap rates also decline because the material is of uniform grain and thickness and can therefore be treated and cut much like a synthetic.

A new material that could be treated as a synthetic with constant properties would have dramatic implications for the role of automation. Such a development would have an immediate impact on the cutting departments of DC companies as CNC cutters with optimal cutting algorithms could be incorporated, saving both material and labor.
Box 5.1: AUTOMATION IN MISSOURI

The Brown Shoe Company, a subsidiary of the Brown Group of St. Louis, Missouri, has gone far to turn a traditional, labor-intensive industry into a business committed to microelectronics. It has invested heavily in technology, an outlay justified not only by the high wages of a developed country but also by the company’s size; it owns 16 shoe factories and four component factories, and had sales - including retailing - of nearly $1 billion in 1989.

To produce the patterns for its outsoles, for example, Brown uses a laser cutter. The $100,000 cutter takes digitized shapes and, via a material saving nesting algorithm, cuts the patterns at a rate of four to six inches per second. Because the laser projects a one-inch beam, multiple layers can be cut.

Brown is currently looking into a $250,000 laser cutter from Hughes. It has also tested a $150,000 waterjet cutter that uses a .004 inch jewelled orifice to perform the cutting operation; it will cut almost anything, but the water saturates the edges of the pattern as it is being cut.

The research and development laboratory at Brown employs about a dozen people—electrical, software, and mechanical engineers—who concentrate on the automation of old and new equipment, new materials and chemicals, and computer development. The researchers designed Brown’s own CAD system, writing the insole algorithm themselves, and use the cathode-ray tube as the starting point for any new shoe.

Sooner rather than later, Brown hopes it can eliminate prototypes altogether, and do all its styling by computer. It already has the ability to take the 3-dimensional computerized design and, using a digitizer, flatten it into the two dimensions needed for patterns for its shoes.

Leather also poses many problems for the industry as it is expensive, inconsistent, difficult to manipulate, and often in short supply (Rubery and Wilkinson, 1987). The environmental controls established to monitor the tanning of leather hides have worsened the leather shortages in some countries, and generated price increases. These and other problems might be solved by a new material, if it is accepted by the consumer.

"Blue-sky" results have been presented only for DCs. But the implications for other countries are straightforward. The future automation technology will save costs primarily in DCs. The technology clearly substitutes capital for labor, raising capital costs and lowering labor costs per shoe. While all automation increases the relative role of capital, in
some other sectors we have studied (certain garment operations and mini-steel processing), unit capital costs actually fall after the introduction of automation. In those cases, it makes sense to adopt the newer technology even in a low-wage country.

However, shoemaking seems more akin to textile manufacture where automation primarily substitutes for labor without lowering unit capital costs (see Mody and Wheeler 1987 on textiles). Thus in shoemaking, evolving technologies will increase the menu of techniques from which firms can choose and we can expect to observe very different techniques in use in different countries.

"Action leather," on the other hand, saves primarily on material cost and scrap value, and so would be adopted by all firms irrespective of their labor and capital costs. Plans to automate will, however, increase the attractiveness of "action leather."
6. CONCLUSIONS

Even in a relatively mature industry, the potential exists for substantial differences in the use of productive resources. These differences can overwhelm any advantage accruing from low input (e.g., wage) costs. As our snap-shots, or scenarios, showed, technical change (occurring in both "soft" practices and "hard" equipment) can easily magnify initial productivity differences if speeds of adoption vary.

We should reemphasize that our scenarios of new technologies were meant to depict engineering practice that is considered well within reach, now or in the next five years. As such, the range of productivity differences depicted here should be considered within the realm of current possibilities. Towards the end we took the liberty of examining more speculative, "blue-sky", scenarios which, if they come about, could create further productivity gaps.

A central implication of this study, therefore, is that factors that impede the diffusion of knowledge are likely to have a powerful effect on international competitive ability. As the speed of change and the knowledge-intensity of production increase, the effects of differences in knowledge will become more potent.

From the perspective of this report, knowledge absorption is impeded by inadequate human capital, organizational inertia, and deficiencies in infrastructure (including networks of supplies and sources of marketing and production information).

One conclusion of our study could be that the knowledge content of even mature, traditionally "labor-intensive" sectors is so high that many low-wage countries have no real comparative advantage in these sectors. An alternative, more positive, view is that efforts directed at creating a broad knowledge infrastructure could have a major pay-off. The example of coastal areas of China discussed in this and companion reports indicates the importance of actively seeking foreign sources of knowledge in any such strategy. Below we discuss some general policy initiatives, but first, we summarize our more detailed results.

6.1 Technical Change

Even the relatively sedate pace of technical change in footwear production has had significant implications for international competitiveness of firms and countries. Steady and unsensational improvement in production practices have been the main drivers of change. Such change can be characterized as "learning-by-doing". We have predicted that learning-by-doing will continue and, indeed, accelerate as modern just-in-time practices become more widespread in the shoe industry. Even the efficient NIE producers will lower their costs by over 10 percent; gains could be greater for less efficient producers in LDCs and DCs.

Producers in developing countries can take a number of simple, low-technology measures to ensure that they remain competitive. Above all, they need to improve their access to raw materials, their quality control,
their inventory control and production scheduling, and the training and motivation of management and staff.

Automation technologies have so far had limited impact. However, there is enough ferment on experimental production lines in the United States, Europe and East Asia to suggest that we may see significant changes in the next five years. Gazing into our crystal ball, we find that real reductions in cost will occur in developing countries as automation technology matures and can be integrated across the production process. Adoption of these technologies will be accompanied by a stronger movement towards product differentiation strategies.

In the shoe industry, unlike some other sectors studied, automation will raise capital costs per unit produced and so is less likely to be adopted in low-wage countries than in high-wage DCs. We should, therefore, begin to observe a wider range of techniques for shoe production, as is happening in textile production.

If "action leather" is upgraded to become an acceptable substitute for full grain leather, the impact on the shoe industry could be truly revolutionary.

6.2 Players: Old and New

Competition is driving firms to look for new, low-cost production sites and, at the same time, find ways to automate production in high-wage countries. Among the low-wage countries, China and Portugal have made the most dramatic advances (See Appendix on China). In high-wage countries, many small firms closed during the 1980s, leaving larger firms to pursue the possibility of automation.

Footwear manufacture is undoubtedly a labor intensive process. But it does not follow that low-wage countries will necessarily dominate production and trade of footwear. The emerging constellation of a devalued U.S. dollar and new technological practices is once more making certain U.S. firms competitive. Production of leather shoes has not been easy to automate, although incremental progress is being made all the time. Exploiting the possibility of low-cost assembly in the Caribbean, U.S. firms are stabilizing and increasing production, while holding back imports. The continued development of computer based technologies and "action leather", as described in the "blue-sky" scenarios, will further strengthen their position.

A central implication of this report is that newly industrialized countries have built large market shares in a variety of products not only because they have had low wages but also because they have invested significantly in production engineering, raising the level of the workforce, developing input suppliers, and providing communications and transport infrastructure.

Countries with much lower wages have vied for increasing presence in international markets and have met with limited success. Only in the last few years have some low-wage countries made an impact on world markets. However, NIEs are not going to fold up and move on. They are setting new
standards for production management and are taking advantage of emerging opportunities provided by new technologies. In a world of increased product differentiation, they are likely to continue as major players.

NIE firms have also been in the vanguard of the movement to relocate some production to LDCs. Such arrangements are advantageous not only to the DC-or NIE-based shoe company, but also to the LDC startup. To acquire the manufacturing expertise, establish reputations for reliability and, ultimately, concentrate on higher value-added segments of the market, these producers need to establish links with foreign manufacturers. It is thus that they will get ready access to product design, manufacturing technology and distribution channels, too.

6.3 Policy Implications

The main thesis of this report has been that continuous learning to produce better shoes is a key component of success in international markets. We have also argued that such learning has occurred faster in the NIEs than elsewhere. The question may be asked: why do the natural forces of competition not induce learning more widely, particularly since much investment in hardware often is not required? Surely, the argument would go, firms competing for survival would see what is best for them and make the necessary changes.

Rarely can the required changes be quickly implemented. Western firms seeking quick fixes to compete against the Japanese have realized this truth rather painfully. The interdependent nature of the integrated manufacturing process raises a paradox. Learning inside the firm proceeds in small steps. However, to make learning possible, discrete changes need to occur inside the firm and in its environment.

An analogy is of help. For a firm to move from its conventional system of manufacturing with large internal and external buffers supporting the process to a new system in which such buffers disappear is akin to, but much wider-reaching than, an organizational shift from IBM PCs to Apple computers. Just as the latter shift requires file translations, new training and new methods of networking, a shift to integrated manufacturing requires new methods and procedures of documentation, new individual and group skills, new plant lay-out and new relations with buyers and suppliers. Such changes are extremely disruptive and impose high short-term costs on the organization. Besides direct costs of new software and training, indirect costs of lost production add up to substantial sums. Many firms have suffered large financial losses in the process of transition.

A central proposition of this study has been that learning is occurring increasingly through systematic techniques. While learning is a process of experimentation, the experiments themselves are conducted in well organized ways using tested tools and techniques. There are a few key reasons why these techniques are not widespread despite their proven efficacy. These relate to organizational and infrastructural inertia.

Thus the shift to integrated manufacturing within a firm must be supported by wider environmental changes that reduce the inertia. Better
educated workers, reliable and inexpensive transportation and communication, and industrial extension services are all elements of a support system.

The success of NIEs and, more recently, of China, must be seen in this context (see also Appendix on China). It should be remembered here that when we talk of China, we are referring principally to the regions on the east coast that have specialized in exporting. The four factors that have supported competitive exports are:

- long-term relationships with buyers
- investment in training
- development of communication and transportation infrastructure.
- institutional infrastructure (including support services and local specialized supplier networks).

While these are closely related and reinforce each other, historical evidence from East Asia suggests that they may come partly in sequence (Rhee, Ross-Larson and Pursell 1984).

Long-term relationships with buyers serve a number of important functions. They provide the information necessary to make the manufacturing changes. More importantly for the present discussion, they allow for the leeway in time and resources to tide the firm over the period of disruptive organizational changes. East Asian NIEs built such links with Western buyers. China has had the benefit of links with Hong Kong and Taiwanese firms.

Long-term links with buyers are only one way to achieve these goals. The central theme here is the need to be tied into the best international information networks and mechanisms that support organizational change within the firm. Singapore has relied more heavily than others on foreign investment for this purpose. All East Asian countries have extensive and effective industrial extension services and credit schemes that finance recommended improvements.

Training has been a major focus of international alliances and domestic extension efforts. A Taiwanese or Hong Kong firm that starts sourcing shoes, clothes, bicycles or electronics products from China typically invests substantially in training. Such training is not evident in a specific training budget. The Taiwanese (more so than the Hong Kong) firm locates half-a-dozen or more supervisors each with as much as 15 to 20 years of experience in the Chinese firms. These supervisors stay in the Chinese firms as long as two years even when only simple products involving repetitive tasks, such as shoes and garments, are being produced.

In addition to close international links, firms need an enabling environment in which training can be provided, organizational changes can be made, materials with consistent quality are readily available, and investments in learning processes that result in temporary losses represent a reasonable risk. Establishing such an environment requires changes in laws and regulations that place certain restrictions on firms when conducting their business.
Investment in infrastructure is another critical area for public policy. Asian NIEs have set very high standards in this regard. The scale and efficiency of Singapore's port are well known. In telecommunications, all Asian NIEs have taken advantage of new technologies and leapfrogged to the most modern equipment ahead of Western nations (Mody and Sherman, 1990).

A more general point is that any artificial barriers to the movement of information or goods and services will seriously hinder the ability of firms to organize their internal affairs efficiently. Lengthy import procedures or restrictions on location of production create the need to invest in buffer mechanisms which sharply reduce the capability and the incentives to reorganize for greater efficiency.
APPENDIX A: CHINA’S LEAD IS DUE TO LOW WAGES AND FOREIGN EXPERTISE

In international trade in footwear, it has become common for the leadership to shift from one newly industrializing economy to another. A new location has been found: China.

Only a few years ago, China was struggling to capture the interest of foreign name-brand shoe manufacturers - and when it succeeded in doing so, the results were sometimes disastrous. In 1985, a Shanghai-Hong Kong joint venture lost thousands of dollars when it was unable to ship 20,000 Nikes for a year. Then Nike went to a state-run factory in Fujian province, but reportedly became dissatisfied with production there. Even Japanese producers have faced an uphill task in China (see Box A.1).

Box A.1: MADE-FOR-JAPAN MOVES TO CHINA

In the 1970s, when footwear manufacturers in developed countries were shifting production to Korea and Taiwan, the Nisshin Rubber Company of Okayama, Japan, took the leap and began manufacturing in China. Today Nisshin produces 700,000 pairs of rubber shoes in Japan each year, and 2.3 million pairs in Anzan, China. All production is for the Japanese market.

Although Nisshin has been in China for about two decades, production quality problems continue. Shop-floor workers in China receive the same training as their counterparts in Japan but are less efficient and must be monitored closely to ensure low defect rates. Meeting delivery deadlines is also difficult from the Chinese factory.

Nisshin’s Japanese production is also labor-intensive and largely unautomated; however, it produces higher-priced and better quality than its shoes than the Chinese factory. Japanese production also has a quicker turnaround; shoes with shorter life cycles are made in Japan, not China. Technological standards in China are improving. And with labor in Japan becoming prohibitively expensive, the Japanese are shifting more made-for-Japan production to China.

Now the shoe is on the other foot. Since 1989, Nike has imported several million pairs of shoes from China, and it is steadily increasing its orders. And Nike is just one of several major Western companies producing footwear in China for export; others include Reebok, Kangaroos, Adidas, Puma, Converse and New Balance. Puma, having subcontracted production to Sino-Hong Kong and Sino-Taiwan ventures, is now setting up its own facility to produce 1.2 million athletic shoes annually.
In 1990, China became the largest single supplier of shoes to the U.S.; Chinese sales of non-rubber shoes was $1278 million up from $561 million in 1989. China also the largest supplier of rubber shoes. In 1990, according to the Footwear Distributors and Retailers of America, China accounted for 32 percent of all shoes imported by the U.S., and half of all low-priced shoes.

For China, seeking to become a major footwear manufacturer and exporter, cheap labor was only part of the answer. The rest was expertise—and that has been imported. China owes much of its transformation from would-be industrialist to premiere exporter to neighboring Taiwan.

In the past few years, Taiwanese shoe companies—stymied by rising wages and unfavorable exchange rates—have shifted production across the Formosa Strait to China's Fujian province. It has been reported that Taiwan's shoe manufacturers have located 60 to 200 operations to China, where manufacturing costs are said to be 20 to 30 percent cheaper. In 1989 Fujian was the country's largest shoe exporter, shipping $135 million worth of product to the U.S., Europe and other markets. (The province has also become a center for textile and garment manufacturing by the Taiwanese.)

Most Taiwanese factories in China are joint ventures with state-run agencies. Because Taiwan prohibits direct investment in China, manufacturers operate through a third party, typically a company in Hong Kong. Beijing, on the other hand, has encouraged foreign investors in joint ventures, with tax breaks, reduced duties and low or nonexistent import restraints on materials, machinery and personal goods. Most of the machinery and components are imported from Taiwan, although Taiwanese companies are reportedly considering investing in leather tanneries and other operations that would provide support to footwear manufacturing.

The tax breaks and other incentives give the China-Taiwan joint ventures a sizable edge over state-run factories. The joint ventures also tend to pay higher wages, presumably attracting better and more highly motivated workers. Western manufacturers say that the China-Taiwan factories are superior not only to the state-run plants, but also the China-Hong Kong operations, in quality control, variety of shoe production, delivery time, sample making and raw material sourcing. Small groups of resident Taiwanese continuously oversee operations, while at the same time they transfer their long years of experience.

So dramatic is China's rise as international shoemaker that it has inspired a proposal for a gigantic, $500 million Shoe City on the outskirts of Zhongshan in southern Guangdong province. The plan, only on the drawing board so far, calls for a vast shoe manufacturing complex that would turn out millions of high-performance athletic shoes for China and world markets.

The centerpiece of Shoe City would be a 1.5 million-square-foot shoe factory, fueled by its own power plant. Surrounding it in a horseshoe formation would be some 30 manufacturers of components and raw materials. The entire complex would employ about 500,000 Chinese workers, trained and managed by a team of Japanese—and, under an arrangement with the Guangdong government, paid 32 cents an hour. According to the American businessman who is promoting the scheme, more than a dozen branded athletic shoe firms are
interested in investing in the venture, which could begin operations in a couple of years.

Whether or not such a grandiose plan ever becomes reality, the very notion of Shoe City is a measure of the distance that China has come. However, its new position is far from secure.

In May 1990, China was recertified by the United States as a Most Favored Nation (MFN) trading partner, but only after a bitter fight in Washington. By law, no country that systematically violates human rights is eligible for MFN, and many members of Congress were still disturbed over the suppression of the Tiananmen Square student uprising in 1989. China's advocate in this matter was President Bush. If China were to lose its MFN status, tariffs on many types of Chinese-made shoes would rise substantially and, in some cases, they would more than double.

In 1991, the MFN issue has become even more bitter. The U.S. Congress has agreed to renewal of MFN status but with certain conditions on human rights. These conditions are likely to be unacceptable to China and President Bush is likely to veto the Congress proposal. However, he will have to make concessions on other fronts. The United States Trade Representative has assessed that many Chinese trade practices go against U.S. interests. President Bush will need to take strong action against these practices.
APPENDIX B: MODELING THE FACTORIES

An overview of the way a factory's operation can affect its performance is useful in understanding the modeling approach. Discrete manufacturing facilities typically possess complex system dynamics. Multiple products need to move through various types of work centers, and in doing so they compete for resources. Different products have different "cycle times" (the time to complete operations on one piece, also called "run times") at the various work centers. Changing a work center's readiness to work on a product, after it has completed a different type of product, requires a "setup"-which can be much longer than the cycle time itself. Equipment can fail unpredictably. Intermediate products can be below specifications and require rework or may even have to be scrapped altogether.

All of these factors cause delays or consume additional resources, add to the work-in-process (WIP) and material costs, and thus affect the overall capacity and efficiency of the factory. Many of the manufacturing alternatives that are available today aim at ameliorating these factors, and thus it is important to model their effects. Thus, to capture such effects accurately, one needs to construct a model of factory dynamics.

Rather than write from scratch a software package with such a model, we used an available factory modeling package called ManuCost from Network Dynamics Inc. (Burlington, MA).

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**Figure B.1 SCHEMATIC OF THE COST MODEL**
This factory modeling software package has a number of features that make it well-suited for our use:

- It allows detailed specification of operations and the links between them. At each operation, the resources used (equipment, labor and materials) are specified. Labor is split by skill category.

- The routings (the sequence of operations required, as well as the equipment on which they must be performed), yields (the proportion of good parts obtained from an operation), rework rates, and set-up and cycle times (defined above) for each operation on each available machine are also specified. If equipment is automated or semi-automated, these times can be separated into those when an operator is needed, and those when the operation can continue unattended.

- The model contains a set of dynamic equations. For given machine reliability rates, variability in arrival of material from one station to another, yields, set-up and cycle times, the equations predict the average utilization of various resources installed in the factory. The model is, therefore, able to estimate performance measures such as total production capacity, work-in-progress (WIP), specific equipment and labor utilization rates, and product lead times (the time it takes for an order to go through the entire factory).

- The package also incorporates an economic model that allows one to specify costs of various direct inputs (such as material, equipment and labor) as well as indirect inputs (such as management salaries and facility costs). It then combines the manufacturing model with the economic model to accumulate costs (including appropriately allocated indirect costs) through the production process, up through components, subassemblies and final products.

- A particularly interesting and important feature of the model is its system of scrap estimating. The model keeps track of scrap through data on yields and rework rates at each operation. The model not only estimates the material value of the scrap, but also keeps track of the value added at earlier stages that goes along with the scrapped material. Similarly, the model's ability to predict the quantity of WIP at each stage of production, leads to an accurate prediction of WIP carrying costs. As we shall see, these costs are important in determining opportunities for improvement.

- The package is based on the Rapid Modeling approach to manufacturing modeling, as distinct from the "discrete-event simulation" approach (e.g. see Suri 1989). Rapid Modeling is less ambitious, but as a consequence also requires less data and allows much faster turnaround for examining alternatives. This package has
been successfully used in manufacturing analysis by firms such as Alcoa, Digital Equipment Corp., IBM, and Siemens.

Note that the model is purely an evaluation tool. No optimization is done, only prediction. Thus if a desired production rate or other performance measure is not achieved, the analyst must decide on what alternative to try, and then modify the inputs accordingly. The performance reports provided by the model usually assist in directing the analyst towards the necessary modification. For example, if a production rate is not achieved, the model will show the bottleneck resource(s). The analyst can then explore various alternatives, the most obvious one being to add more resources.

Furthermore, in the benchmark cases, the set of alternatives may be limited by the observed data in the actual factories. However, in the scenarios for improvement, many other alternatives may be available, such as the use of methods to improve yields, or ways to shorten set-up or cycle times, or the use of new materials or automation. These alternatives require a wide knowledge of manufacturing processes as well as considerable design creativity, and thus render the use of an optimization scheme extremely difficult. Instead we use an iterative approach that allows the analyst to try alternatives until the desired performance indicators are obtained.

Relation to Activity Based Costing (ABC)

New accounting methods for manufacturing, such as Activity Based Costing (ABC), are gaining acceptance (e.g. see Cooper and Kaplan, 1988). While our approach is in the spirit of ABC, there are some important differences. ABC provides accurate cost analysis of existing operations, but would have been less appropriate for our "what-ifs". In most of the scenarios that we undertake, the structure and dynamics of the manufacturing system change in a nontrivial way. For example, new technology (e.g. fixtures and hydraulic clamps that reduce setup time) combined with a new operating approach (smaller lot sizes) can drastically decrease the amount of work-in-progress (WIP). It is important to model the manufacturing dynamics first, in order to predict the new resource utilizations and the new WIP, and then conduct the cost allocation on the outcomes. ABC is designed to do the latter, thus it can only be meaningfully applied to what-ifs that are "in the neighborhood" of the current process structure and system. Our approach predicts the new operating conditions first, and then does the cost analysis. However, both ABC and our methodology share an important attribute: they underscore the need for development of improved costing methods in evaluating manufacturing alternatives.
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