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A Micro, Econometric Investigation of

The Impact of Industrial Policy on Technology Choice

by

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A number of developing countries now produce various types of industrial machinery, which are often priced well below the landed cost of similar, imported machines. Nonetheless, where not prohibited by government import controls, imported varieties continue to be purchased by many machinery users. Why imports continue is a question of considerable interest, for it could be due to any of a number of causes, including ill-advised government policy or the lower quality of indigenous machinery. This paper seeks an answer in a particular case, the choice between imported and locally made looms for textile weaving in South Korea.1 During the late 1960s and early 1970s, the period covered in our study, a domestically produced automatic loom sold for somewhat more than forty percent of the c.i.f. cost of an imported automatic loom; the cost of a domestically produced semi-automatic loom was even less, being slightly below thirty percent of the latter.

1. Analytical Framework

We will first outline our analytical framework in general terms, using textile weaving for examples where helpful. Casual empiricism would suggest a number of reasons why some producers continue to purchase more
expensive imported machines while others buy less expensive indigenous
varieties. Firstly, while appearing on the surface to be so, similar
imported and indigenous machines may not in fact be identical in all respects.
They need not be capable of producing an identical range of product specifi-
cations; nor need they be equally suited to produce each of the differentiated
products capable of manufacture using either. For example, the width of a loom
determines the maximum width of the cloth that can be produced; different looms may
have distinct comparative advantages among different grades of cloth distinguished
by the density of the weave and other characteristics. Or, for a certain
specification of the product, one machine may produce a higher quality output
than another. (Lest there be any confusion, "machine" refers not to a
particular individual machine, but rather to a specific model or specification;
similarly for "loom." ) Furthermore, similar machines need not have the same
complementary input requirements for labor by skill category, raw materials,
motive power, and so on. Likewise, maintenance requirements may differ among
similar machines, as may their expected economic lifetimes at date of purchase.
All of this is to say that one may expect a great deal of heterogeneity even
among machines that produce the same types of product.

It may also happen that the terms on which machinery can be purchased
from different suppliers are not the same. For example, machinery imports
can often be financed by suppliers' credits which carry lower interest rates
and more liberal repayment schedules than the medium-term domestic currency
credit needed to finance the purchase of indigenous machinery. 1/ Because of

1/ The effects of this in the South Korean case are analyzed in Frank, Kim,
and Westphal [1975], Chapter 7.
invested licensing or credit relationships, induced demand, they may not have
equal access to different sources of finance. In turn, market segmentation
may lead different producers to pay different prices for ostensibly identical
complementary inputs. Wages may vary by region or by size or establishment;
certain types of raw materials may be more readily available and at cheaper
prices for some producers than for others; electricity rates may vary by
locale and amount consumed; and so on. Equally, market segmentation can lead
to different ex-factory prices for the same product depending upon where and
by whom it is produced.

According to the specific economic environment in which each
operates, therefore, the profit motive may lead individual producers to
choose different machine specifications even to produce identical products,
because of segmented input markets (including that for credit). Or, the
profit motive may lead them to produce distinct differentiated products for
which different models of machine have peculiar comparative advantages, perhaps
but not necessarily because of segmented product markets. In general, one
may expect the choice of product specification and the choice of machine
specification to be inextricably intertwined, so that the producer’s choice is
not simply one of selecting the cost minimizing technique to produce a given
product specification. Of course, it must also be admitted that some,
but probably not all, producers may select among models on grounds other than
profit maximization, which might serve as well to explain the continued
import of machinery.

On the assumption that the individual producer maximizes his
firm’s net worth, economic theory states that he will choose the benefit, i.e.,
the present value of the expected future stream (not of output, revenue and profit),
associated with each machine against its cost, i.e., purchase price, in order to select the model having the highest benefit-cost ratio. To investigate the influence of various elements on the choice of machine specification, therefore, it is necessary to simulate their impact on the benefit-cost ratios associated with the available models. Furthermore, simulating benefit-cost ratios under the specific circumstances confronting each producer permits a test of the hypothesis of net worth maximization. This is the route followed in our study.

In order that the simulations be meaningful, they must incorporate a great deal of specific detail concerning the characteristics of machine models and the products that may be produced using them, as well as those of the required complementary inputs. Equally, firms may differ in important respects, for example size, and this needs to be taken into account, as do the factors determining the prices paid and received by each firm for its inputs and outputs respectively. Among the latter factors must be counted such things as the organization of individual markets, whether competitive or not, and the operation of government policy. To achieve the required level of specificity requires not only a case study approach, but also a special purpose survey to elicit information regarding all of these elements. Particularly important is machine level data from firms pertaining to technological relationships using different machines.

To obtain the necessary data, one of the authors (Y. Rhee) surveyed 79 textile weaving firms in South Korea in early 1973. The observations cover the preceding three years, and encompass 233 models of loom and 539
differentiated products. The survey included items for wool, silk, and other synthetic fabrics as well as cotton and cotton-blend fabrics. (Cotton-blend refers to a blend of cotton and polyester.) However, here we present only the results for the latter, for which the sampling ratio is by far the highest. The results obtained in the former cases do not differ qualitatively from those for cotton and cotton-blend textiles. The next section of this paper summarizes the salient findings of the survey concerning the differences among imported and indigenous looms and the associated differences among the firms using each.

Based on machine level data collected through the survey, technological relationships were estimated using the framework of process analysis and applying econometric techniques. These relationships distinguish among loom and fabric specifications, and they are at the heart of our benefit-cost ratio simulations. As there is not space here to provide the full details of this part of our investigation, section 3 below simply illustrates the approach using one relationship, that determining the number of looms tended by one operator. Section 4 then discusses the use of hedonic regression techniques to investigate the structure of prices among differentiated yarn inputs and fabric outputs. This part of the study serves two purposes: first, it is necessary to remove the "noise" from the price observations reported by the firms, as these were found to contain a great deal of random variation; and, second, it provides supplementary evidence regarding the non-technological determinants of the observed structure of prices.

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1/ The total number of looms included in the sample is 14,322, out of a population, in 1973, of 63,128 in South Korea.
The central findings of our study are given in sections 5 and 6. The former presents simulated benefit-cost ratios under two sets of circumstances, those actually confronted by individual producers and those that would have been confronted had the government pursued a neutral policy, including the substitution of shadow prices for market prices and the enforcement of perfect competition among producers. Various market distortions are distinguished and numerical estimates of the importance of each with respect to the choice between imported and indigenous looms are presented. While section 5 focuses on the impact of government policy, section 6 contrasts a simulation of the structure of fabric prices under perfect competition with the observed structure to indicate the influence of cartelization in the textile markets. Finally, the conclusion summarized our most important results and indicates where further work would be desirable.

2. Differences Among Looms and the Firms Using Them

In our analysis, we have found it convenient to group looms according to a three way classification -- original versus second-hand purchase, domestically produced versus imported, and automatic versus semi-automatic. As to the latter distinction, it pertains to whether the shuttle is changed automatically or manually when its yarn is exhausted; the shuttle is passed from side to side mechanically in all of the looms we have investigated. Table 1, which provides the summary statistics around which the discussion in this section revolves, indicates that our observations fall in five out of the eight possible cells. There are no observations for second-hand automatic looms or newly imported semi-automatic looms. We should also note that the second-hand, imported semi-automatic looms were
purchased on the domestic second-hand market from textile producers who imported them new, so that they were not second-hand when originally imported.

We may first observe that there are differences among the firms that have chosen different technologies. (A group of looms embodies a particular technology according to our terminology.) Automatic looms are generally used by corporations whereas semi-automatic looms are favored by firms organized under single proprietors or partnerships. As might thus be expected, the firms employing the automatic technologies are generally much larger than those using the semi-automatic technologies. In our investigation of technological relationships, however, we found that the most significant differences were associated not with the size of firm but instead with whether the firm maintains an office separate from the principal's residence. Corporations per force maintain non-residential offices, but so too do a number of medium and small non-corporate firms. The largest concentration of firms having residential offices is found among those using new, domestic semi-automatic looms.

Next, as to the destination of the output produced, a great deal of Korea's cotton fabric output is for export. As there are strong government incentives to export, differences in market destination are associated with differences in prices paid and received (see below). Among the five technologies, the share of output (by volume) that is exportable, i.e., the share of those varieties that are exported, is by far the greatest on imported automatic looms. This is to be explained by the fact that indigenous looms are available in widths up to only 42 inches, whereas imported looms can be
as wide as 54 inches, and much of the export award is for the wider varieties of cloth. On the other hand, exportable varieties are produced employing indigenous looms as well. Cloth quality is largely determined by the strand count (i.e., fineness) of the warp used to produce it; on average, there are not great differences among the qualities of cloth produced using the separate technologies, though those produced on European looms are somewhat higher owing in part to the greater share of exportable output on these. Nonetheless, aside from the difference in maximum width, there does not appear to be much truth in the once conventional wisdom which held that indigenous machines are technically incapable of producing an output of exportable quality, at least in this case. The reasons why indigenous looms produce less exportable output are thus to be found in the factors lying behind producers' decisions, and not in the technical characteristics of the looms per se.

Not all of the exportable output is actually exported, since these varieties command a premium in the domestic market. For reasons that will become apparent further below, where the operation of the system of export incentives is described, most of the surveyed firms were unwilling to divulge how much of their exportable output was indeed exported. From those firms that were willing to discuss this, and from aggregate data, it appears that on average roughly two-thirds of the exportable output is sold abroad. We have thus applied this ratio in all cases.

We next turn to the characteristics of the technologies, as shown by averages taken over the models within each. Most of the looms in the sample were produced in the mid- to late 1960s, the major exception being
that the second-hand, imported semi-automatic looms were originally purchased in the early 1950s. Our simulations to obtain the private benefit-cost ratio associated with each model (see section 5) provide estimates of the date at which it would be scrapped, which is that date beyond which the present value of the income stream (net of operating expenses) from employing the loom is just equal to its value sold as scrap. In turn, these yield estimates of the economic lifetimes, from date of purchase (most recent purchase in the second-hand case), for each model. It is to be noted that there are substantial differences in average lifetimes among technologies, the longest being 26 years for new, domestic semi-automatic looms and the shortest being 8 years for second-hand, imported semi-automatic looms. The lifetime of a new, imported automatic loom is considerably less on average than that of an indigenous loom, largely due to the higher cost of scheduled maintenance for the former.

As one might expect, less labor is required to operate the automatic looms than is needed to run the semi-automatic looms. Thus, the average number of new, imported automatic looms tended by one operator is three times as great as the number of new, domestic semi-automatic looms per operator. Labor requirements using indigenous automatic looms fall between those characteristic of these technologies, while the second-hand, imported semi-automatic technology is the most labor intensive on this score. In addition to saving labor, the imported automatic technology saves raw materials, as indicated by its lower rate of yarn wastage.\footnote{Yarn wastage is measured by the percentage difference between the weight of the just woven fabric and the weight of the yarn used to manufacture it. Wastage results from the breakage of the weft yarn that is carried by the shuttle.} However, this
technology requires considerably more scheduled maintenance, not even
than the second-hand technologies. Likewise, it requires far more electrical
power, more even than the indigenous automatic technology. Semi-automatic looms
require the least power since a single motor can drive a number of them, while
individual motors are required in the case of automatic looms.

What about the prices paid for labor and capital? Again there
are substantial differences among firms using different technologies. First,
wages: the highest average wage, that associated with the use of new,
imported automatic looms, is 85 percent above the lowest, which is associated
with the use of second-hand, imported semi-automatic looms. We shall have
much more to say about this difference in the following section. Here we
need only add that, as one might expect, wage differentials are associate
with the location and size of plants.

Large differences are also observed among the real rates of
interest paid to finance purchase of looms. (The average purchase price of
a loom under each technology is shown in Table 4, in section 5.) Nearly all
imports of automatic looms were financed under foreign suppliers' credits,
which carried an interest rate only slightly greater than the average rate of
inflation between the date of purchase and the end of 1972. The purchase of
most of the semi-automatic looms, on the other hand, was financed by rolling
over short-term domestic credit on which an annual interest rate (nominal) of
24 percent was charged. Subsidized credit at an interest rate roughly half
way between that on foreign suppliers' credits and domestic short-term credit
was available to the purchasers of domestic automatic looms. The terms
shown in the last column will be discussed below in section 5.
Lastly we come to differences in tax treatment accorded firms employing the separate technologies. These differences are largely due to the share of output that is exported. There is no indirect tax on yarn used to produce for export, while a minimum tax rate of ten percent is charged on yarn going into production for sale on the domestic market. The business activity tax is a turnover tax, levied at a maximum rate of 0.5 percent of gross sales to the domestic market, and not levied at all on export sales, either direct or indirect (i.e., on inputs into production for export). The schedule of income tax rates is progressive, with lower rates on corporate income. More to the point, income derived from export sales is taxed at one-half the rate otherwise applicable. Furthermore, under the declining balance method, the depreciation rate allowed on assets used in export production is 30 percent while only 19 percent is permitted on assets used in production for domestic sale. Exporters received additional incentives as well, but these are better dealt with in section 6 below.

To summarize: there are obviously a number of differences associated with the use of different technologies. Many, if not most, of these are in the direction one would expect if producers were indeed motivated to maximize their firms' net worth. For example, the higher capital cost (see Table 4) of the automatic technologies is offset, though to state by precisely how much requires further analysis, by softer financing terms. Likewise, the use of automatic looms is associated with the payment of much higher wages, though here cause and effect cannot so clearly be separated. The evidence so far is thus not inconsistent with the notion that profit seeking under distinct economic environments has led different producers to choose alternative
technological. However, this needs to be recorded carefully. First, though, something more must be said about the work as to, we have employed.

3. Process Analysis of Technological Relationships

The classic empirical monograph on process analysis is that edited by Manner and Markowitz [1963]. Our approach differs from conventional process analysis, however, in employing statistical methods to estimate technological relationships rather than basing them on single observations. In that the estimated functions are predicated on engineering relationships, our approach is also similar to that of Chenery [1958]. However, Chenery used the calculus to derive the production function, defined in the conventional way to include only efficient input combinations, from the underlying physical "laws." By contrast, the relationships we have estimated are based on observations from operating plants and can at best only be inferred to pertain to the efficiency loci. Furthermore, as will become clear in the ensuing discussion of the influence of wage rates, under our approach it is necessary to test the significance of price variables in determining technological relationships, so that these cannot be described a priori as being strictly physical, choice elements may also intrude. On the other hand, there are obvious advantages to basing the benefit-cost ratio simulations on technological relationships as they are observed in the "real world."

We will illustrate our approach by discussing in some detail the relationship estimated to "govern" the number of limes tended by a single operator. At the conclusion of this section we will briefly indicate the other technological relationships that need to be estimated in order to simulate benefit-cost ratios. The observations to which these equations have been estimated were obtained, as we have stated previously,
at the level of individual loom models. Observations (for a single period) pertaining to the production of identical cloth across individual looms in the same plant and falling under the same model were averaged (using equal weights) before the equations were estimated. The list of elements defining a particular model of loom, including its date of manufacture, is sufficiently detailed so that no two plants were found to employ precisely the same model of loom.

One would expect a relationship between inputs and outputs, or between inputs as in the case to be discussed, to depend upon a number of factors, including the characteristics of the product being produced, the machine being used, and the firm doing the production, as well as the skill levels of the labor being employed. In addition, one would expect productivity changes over time, due to learning-by-doing and/or physical deterioration of the machine. Engineering principles provide essential guidance in selecting the specific characteristics and functional form to be used in a particular relationship, as well as in indicating the relationships that are relevant. Nonetheless, we have found it necessary to test a number of alternative relationships and functional forms, including alternative choices of variables, to arrive at specifications that are both meaningful in engineering terms and statistically significant.

Table 2 presents the finally selected equations -- estimated using single equation regression techniques from pooled cross-section, times series observations -- for the number of looms per operator. (Note that the
Estimated Equations for the Log of the Number of Looms per Operator:

Cotton and Cotton-Blend Weaving

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Semi-Automatic</th>
<th>Automatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Characteristic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count per Stand of Yarn (log)</td>
<td>-.1650</td>
<td>.1680</td>
</tr>
<tr>
<td></td>
<td>(.0638)</td>
<td>(.0788)</td>
</tr>
<tr>
<td>Loom Characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Origin (import = 0, domestic = 1)</td>
<td>-.2962</td>
<td>-.7861</td>
</tr>
<tr>
<td></td>
<td>(.1113)</td>
<td>(.2965)</td>
</tr>
<tr>
<td>For Semi-Automatic:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shuttle Size</td>
<td>.00810</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.00032)</td>
<td></td>
</tr>
<tr>
<td>Feeler (no = 0, yes = 1)</td>
<td>.02792</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.0689)</td>
<td></td>
</tr>
<tr>
<td>For Automatic:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loom Width (log)</td>
<td>-.431</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.1547)</td>
<td></td>
</tr>
<tr>
<td>Cop Changing Mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Box Loader (no = 0, yes = 1)</td>
<td></td>
<td>.2115</td>
</tr>
<tr>
<td></td>
<td>(.1927)</td>
<td></td>
</tr>
<tr>
<td>Magazine (no = 0, yes = 1)</td>
<td></td>
<td>.3997</td>
</tr>
<tr>
<td></td>
<td>(.0784)</td>
<td></td>
</tr>
<tr>
<td>Firm Characteristic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office Type (0 = residential, 1 = non-residential)</td>
<td>.1591</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.0885)</td>
<td></td>
</tr>
<tr>
<td>Daily Wage of Loom Operator (log)</td>
<td>.2763</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.1176)</td>
<td></td>
</tr>
<tr>
<td>Productivity Change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reciprocal of Machine Age</td>
<td>.3625</td>
<td>-.2316</td>
</tr>
<tr>
<td></td>
<td>(.1678)</td>
<td>(.0856)</td>
</tr>
<tr>
<td>Calendar Year</td>
<td>.1135</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.0338)</td>
<td></td>
</tr>
<tr>
<td>Constant Term</td>
<td>-.31.4*27</td>
<td>-.35</td>
</tr>
<tr>
<td></td>
<td>(.1.63)</td>
<td>(.61.42)</td>
</tr>
</tbody>
</table>

- R = .776
- F Ratio = 47.0
- Number of Observations = 280

Note: Standard error given in parentheses below parameter estimate.
dependent variable is the log of the ratio of looms per operator.\textsuperscript{1} As in the case of all other estimated technological relationships, we have found the difference between the semi-automatic and automatic technologies to be sufficiently great to require separate regressions for each. However, within each set of technologies, the differences between imported and indigenous looms could be captured simply by the use of a dummy variable, and the differences among vintages — where significant — were adequately reflected using a continuous variable stating the model year. We now turn to a more detailed discussion of the variables appearing in the estimated equations.

**Product Characteristics**

The most important product characteristic in the case of both technologies is the fineness of the yarn being woven; higher counts indicate a finer yarn and, generally, a higher quality fabric. There is, however, a major difference between the semi-automatic and automatic technologies with respect to variations in the quality of fabric that is produced. The required labor input rises (i.e., the number of looms per operator falls) with a rise in the quality of output under the former whereas the required labor input falls under the latter. Other things being equal, the finer the yarn, the longer the length of yarn that can be carried on a shuttle, and

\textsuperscript{1} All logs are to the base e.
thus (given that the shuttle travels at approximately the same speed regardless of the yarn's fineness) the less often the shuttle needs to be changed. This alone reduces the required labor input, since a good deal of the loom operator's time is expended in activities associated with changing or reloading the shuttle(s). On the other hand, finer yarn is more apt to break, and repairing yarn breakages is another principal task of the loom operator. Data on brakeage rates (not discussed in detail here) corroborate that the latter effect dominates on semi-automatic looms while the former is more important on automatic looms.

\section*{Loom Characteristics}

For both technologies, whether the loom is imported or indigenous makes a significant difference in the technological relationships. In principal, this should be reflected in differences between the looms' technical specifications, although these differences may be captured only at the most minute level of detail. However, not having such detailed data, we represent these differences by a dummy variable which has a value of zero if the loom is imported and one if indigenous. The coefficients of the dummy variable in the relationships under discussion indicate that more operating labor is required when using domestic looms, with the difference being greater for the automatic technology. \textit{Vi. a vis} imported looms, and holding the values of the other independent variables constant, the operation of the same number of domestic looms requires 54 and 119 percent more labor under the semi-automatic
and automatic technologies respectively. The other loom characteristics that are significant in this technological relationship depend upon the technology, and so we discuss each in turn below.

**Semi-Automatic Technology:** Recall that the shuttle is changed manually under this technology. The size of the shuttle (length times width times height) determines how much yarn it can carry and thus how often it will need to be changed. One would thus expect a larger shuttle size to reduce the requirement for operating labor, and this is indeed the case. A "feeler" is a relatively simple device that indicates when the yarn in the shuttle is almost exhausted and thereby reduces the need for the operator manually to check the yarn supply in the shuttle to minimize the time the loom stands idle. With feelers, the number of looms that can be tended by a single operator is increased by roughly 10 percent.

**Automatic Technology:** The size of the shuttle is not significant under the automatic technology, where the width of the loom and the type of mechanism used to replace or reload the exhausted shuttle are the most important factors. A wider loom requires more time to be set-up to produce a particular variety of cloth and thus requires more operating labor. In turn, there are three types of mechanism for replacing or reloading the shuttle. In the first of these, the exhausted shuttle is simply replaced by another, fully loaded shuttle. The other two change not the shuttle but rather the "cop," which is the component of the shuttle that actually carries the yarn. The estimated equation indicates that changing the cop saves labor relative to

1/ Note that though the number of looms is the same, the total output need not be the same, since output per loom is dependent upon a number of other factors.
changing the entire shuttle, with a magazine-type mechanism being labor-saving relative to a box loader.

Firm Characteristics

Our data set includes four firm characteristics: size, location, type of ownership, and type of office. For those characteristics having sufficient variance among firms to test their significance in determining the number of looms per operator, no significant relationship is found under the automatic technology. However, firm characteristics do make a significant difference under the semi-automatic technology. While firm size and type of office are highly correlated among firms using this technology, the latter characteristic appears to be the more significant. Thus firms having a residential office require roughly 17 percent more labor to operate the same number of automatic looms. However, this is not sufficient evidence to conclude that these firms are inefficient, as their overhead expenses are less than those of firms having non-residential offices and they exhibit significantly lower material wastage rates. In fact, though we will not go into the details of the calculation, we may note that at shadow prices the benefit-cost ratio for a typical new, domestic semi-automatic loom is approximately 3 percent higher in a firm having a residential office than in one having a non-residential office.

1/ Recall that all firms employing the automatic technology are corporations.

2/ The regressions yielding these results are not reported here.
Wage Rate

We intended to obtain data on labor characteristics such as education and length of working experience so as to incorporate these into the relevant technological relationships. However, on going into the field it was discovered that the collection of such data would be too costly, and the effort was abandoned. But, on the assumption of perfect competition in the labor market (including costless migration), wage differentials within and across firms will reflect labor quality differentials, so that the wage rate may be used as a measure of labor quality. The discovery of a significantly positive elasticity for the number of looms per operator with respect to the wage of the operator would then be interpreted in terms of substitution among various labor skill categories rather than in terms of substitution between labor and other inputs. This interpretation would be all the more valid where labor is paid on a piece-rate system. Indeed, a significant, positive elasticity was found under the semi-automatic technology; the estimated elasticity under the automatic technology was not significantly different from zero, and so in this case the wage variable was dropped from the regression. This difference is itself consistent with the hypothesis that wage differentials reflect skill differences, for it is (independently) known that the rate of output under the semi-automatic technology is highly sensitive to the level of labor skill, whereas labor skill differentials are of little significance to productivity under the automatic technology. In turn, the labor employed

1/ See Hicks [1968] and Leontief [1964].

2/ Most firms in the sample paid fixed monthly wages. However, in nearly all such firms, each individual worker's wage was periodically revised on the basis of work performance, so that wage differentials within a particular category for a given firm are partially based on piece-rate standards.

3/ Indeed, the use of other wage data in the regression resulted in estimates that appeared to be significantly elevated in the period under consideration.
to operate the automatic technology is more highly skilled than that used with semi-automatic looms, which is clearly reflected in the fact that most automatic loom operators have previous experience operating semi-automatic looms. And, as we have observed in the previous section, automatic loom operators are more highly paid than semi-automatic loom operators.

The interpretation of the observed positive elasticity as being due to labor skill substitution is open to a serious objection however. Suppose that competition on the labor market had in fact equalized efficiency wages across skill levels. Then there should be no cost advantage to employing labor of a particular skill level. If it is further supposed that skill differentials affect only the number of looms that can be tended by an operator, then the elasticity in question should not be significantly different from 1.0. But, the estimated elasticity is significantly greater than 1.0, implying in particular that payment of a 10.0 percent higher wage would reduce the total wage bill of a firm using the semi-automatic technology by 2.8 percent. The question is thus immediately raised whether the estimated elasticity does not (perhaps, also) reflect the substitution of labor for other inputs. For example, when forced to pay a higher efficiency wage, it is conceivable that a producer might substitute raw materials for labor through experiencing a higher wastage rate upon having each operator tend a larger number of looms. However, tests of the significance of the wage rate variable in the technological relations for determining non-labor inputs failed to indicate any significant association. Unless the wage is acting in part as a proxy for some associated product, labor, or firm
characteristic, which we consider highly unlikely, we are thus left unable to explain fully the magnitude of the estimated elasticity. It may simply indicate the failure of the hypothesized model, which assumes perfect competition in the labor market and profit maximization by producers, to describe reality perfectly.

Productivity Change

Among the variables, and corresponding explanations, tested for their significance in determining rates of productivity change were the loom’s age -- to capture the loom’s physical deterioration with use and learning-by-doing effects at the loom level; the loom’s vintage -- embodied technological change; the firm’s age -- learning-by-doing at the firm level; and, simple calendar time -- disembodied technological change. For each variable, several functional forms were also tried, including some which yield asymptotic constancy of the technological relationship and some which yield continual change.

According to the specifications giving the best over-all fit, the log of the number of looms per operator varies with the reciprocal of the loom’s age under both technologies, as well as with calendar time under the semi-automatic technology. The number of looms per operator thus approaches $1/2$

Note should perhaps be made of the most interesting result from comparing rates of productivity change across broad types of textile. The rate of increase in the number of looms per operator is far more rapid in cotton and cotton-blend weaving, where product specifications are changed infrequently due to high volume orders, than in silk weaving, where low volume orders result in frequent product specification changes.
(from below) a constant, asymptotic value under the semi-automatic technology.Nearly 30 percent of the increase is realized within the first five years of the loom's operation. Under the semi-automatic technology, the age-dependent term asymptotically approaches (from above) one, while the age-dependent term yields a continued exponential increase in the number of looms per operator. A profile at a point in time across vintages indicates a pronounced vintage effect for the first few years of operation for a semi-automatic loom, as may be seen in the figure below.

<table>
<thead>
<tr>
<th>Loom Age</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>1.00</td>
<td>.93</td>
<td>.79</td>
<td>.76</td>
<td>.72</td>
<td>.71</td>
<td>.71</td>
<td>.71</td>
<td>.71</td>
</tr>
</tbody>
</table>

In turn, the simultaneous interaction of the vintage effect and the passage of time yields a fall in the number of looms per operator between the first and second years of operation, with the fourth year level being nearly constant in the third year. There is no doubt an observation caused by the functional form employed.

While all of the evidence considered together indicates extremely rapid productivity change during the sample period, it is improbable to extrapolate this too far into the future. Textile engineers currently assume an upper bound to the number of looms per operator, beyond which it is physically impossible to go. Thus, in simulating benefit-cost ratios, we have superimposed estimates of upper bounds, related to each model of loom, provided by Korean textile engineers.
Other Technological Relationships

As stated previously, the technological relationship just discussed is but one of several required to simulate the benefit-cost ratio of a particular loom. Three additional categories of labor must be distinguished: cop suppliers, who assist the loom operator by refilling the exhausted cop; loom engineers, who are responsible for scheduled and unscheduled maintenance; and, assistant loom engineers. For each of these, a technological relationship governing the number of looms serviced by one laborer was estimated.

The gross yarn requirement to produce a given fabric is estimated using a separate technological relationship, as is the rate of fabric production on a single loom. These two relationships together, plus an engineering identity, determine the amount of yarn wastage (equivalently, the quantity of rejected product). The equations governing yarn inputs and fabric outputs include as explanatory variables the characteristics of the fabric being produced. For simplicity, it is assumed that an individual loom (i.e., one loom within a particular model) produces the same fabric throughout a year, which is the period employed where a length of time must be specified. Variations in capacity utilization are explicitly taken into account by distinguishing between the rate of output and the duration of loom operation.

Additional technological relationships are used to determine the amount of power consumption, the cost of maintenance materials, the cost of yarn preparation, and overhead cost.

1/ Down-time for unscheduled maintenance was taken to be exogenous, but was estimated for each loom from the sample data.
4. The Observed Structure of Prices

We next turn briefly to discuss the use of hedonic regressions to "filter" price observations obtained at the firm level. Hedonic regressions are estimated over individual specifications within a product group and express the price of a particular specification as a function of several of its characteristics. As noted in Section 1 above, hedonic regressions serve two purposes in this investigation. First, whether because prices for the same specification vary from transaction to transaction or because producers were either unable or unwilling to provide accurate price data, price observations at approximately the same points in time for the same specification exhibit wide variation within one sample. Because it exploits the available information more systematically, fitting hedonic regressions is superior to taking averages over observations for the same specification. This advantage relates to the second purpose served by hedonic regression estimation, which is to provide a concise description of the structure of prices across specifications in a manner that yields further insights into the determinants of the observed structure.

As a reduced form of the structural equations determining supply and demand prices, an hedonic regression includes determinants operating on both sides of the market. In turn, variations in a particular product characteristic will typically affect both the cost of production and the "utility" derived by the purchaser, so that it is generally not possible to distinguish between a characteristic's effect on supply and demand.

1' On the methodology of hedonic regressions, see Stahlecker (1971), particularly Chapters 1 and 2.
Table 1

Estimated Equations for Yarn and Cloth Prices:
Cotton and Cotton-Blend

<table>
<thead>
<tr>
<th>Variable</th>
<th>Yarn</th>
<th>Cloth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent (log)</td>
<td>Price per Pound</td>
<td>Mark-up of Price per Yard over Yarn Cost</td>
</tr>
<tr>
<td>Independent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Characteristics: Yarn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count per Strand of Yarn (log)</td>
<td>.2779 (.0476)</td>
<td></td>
</tr>
<tr>
<td>Number of Strands in Yarn</td>
<td>.0954 (.0413)</td>
<td></td>
</tr>
<tr>
<td>Blend (0 = blended; 1 = cotton)</td>
<td>-.1793 (.0409)</td>
<td></td>
</tr>
<tr>
<td>Product Characteristics: Cloth</td>
<td></td>
<td>.6759 (.3679)</td>
</tr>
<tr>
<td>Width after Weaving Times Weft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density/Yarn Cost per Yard (log)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Characteristic: Yarn</td>
<td></td>
<td>-.1219 (.0297)</td>
</tr>
<tr>
<td>Source (0 = domestic, 1 = import)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Characteristic: Cloth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination (0 = domestic, 1 = export)</td>
<td></td>
<td>-.8036 (.1037)</td>
</tr>
<tr>
<td>Strand Count (0 = less than 40S,</td>
<td></td>
<td>.7363 (1.2381)</td>
</tr>
<tr>
<td>l = 40S or more: only if sold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>domestically)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>3.9524 (.2975)</td>
<td>-3.0445 (1.3529)</td>
</tr>
<tr>
<td>R</td>
<td>.77</td>
<td>.29</td>
</tr>
<tr>
<td>F</td>
<td>38.57 (2.52)</td>
<td>2.52</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>110</td>
<td>87</td>
</tr>
</tbody>
</table>

Note: Standard error given in parentheses below parameter estimate.
priced. Engineering principles and a general knowledge of textile markets provide guidance as to the characteristics to be included as independent variables. However, we again found it necessary to experiment with various characteristics and alternative functional forms to obtain the most satisfactory specification. Table 3 gives the finally selected bivariate regressions for spun and cloth prices estimated from cross-sectional observations for 1972. Our discussion of the specification of product characteristics will focus on the latter regression.

Yarn cost exercised an obvious influence on the fabric's supply price. This is reflected by using the log of the markup of the fabric's price over the cost of the yarn required in its production as the dependent variable. Yarn cost may also serve as a proxy for various determinants of the fabric's quality in the eyes of the purchaser, which is also included in the description of an independent variable composed from several process characteristics. Audacity in the specification of this composite variable is the width and weight density of the cloth. On the supply side, both of these variables were found to be significant in the technological relationships determining the gross yarn requirement to produce a given fabric and the rate of output from a single loom; increases in width and weight density raise the gross yarn requirement per linear yard of cloth and reduce the volume of roll cotton measured in linear yards. On the demand side, uniform cloth is generally preferred while higher roll density is unusually associated with higher fabric quality. Higher strand count would yield uniform.
superior quality. However, the dichotomous variable distinguishing between strand counts above and below 40S is listed as a market characteristic for reasons that will soon become apparent.

Of major interest are the coefficients of the dummy variables representing market characteristics. As an indicator of the implicit tariff on yarn due to protective measures (in this case, import restrictions), the coefficient of the source of supply dummy variable in the yarn regression may be biased due to quality differences between domestic and imported yarn that are not captured by the product characteristic variables employed in the regression. Indeed, an estimated technological relationship not discussed in detail here shows significantly higher yarn breakage rates when indigenous yarn is used in weaving. Thus, the regression results, which imply that the price of domestically produced yarn is on average about 13 percent greater than that of "comparable" imported yarn, place a lower bound on the price effects of protective measures favoring domestic yarn producers.

So far as we could determine, there are no unaccounted for quality differences between domestically sold and exported fabrics for which the specification of the product characteristic appearing in the cloth regression is the same. There is thus more precision in the esti-

---

1/ Imports are valued at the domestic currency equivalent of their c.i.f. price, at the market exchange rate; indigenous yarn is valued at its ex-factory, producer's price. In neither case is the indirect tax on yarn included.

2/ This is on the assumption there is no "irrational" preference for imported yarn. On estimating implicit tariffs for differentiated products, see Balassa [1971b].
muted difference between the proportional mark-ups on the domestic and export markets. The former is on average more than 110 percent of the latter. This difference does not necessarily imply discriminatory pricing in relation to production cost, for it must be remembered that various incentives reduce the cost of inputs into export sales below what is paid for inputs into domestic sales. Whether or not there is discriminatory pricing can thus not be determined without further analysis, which we defer to section 6.

As was noted previously in section 2, an indirect tax is levied on yarn used in production for the domestic market; there is no indirect tax on fabric. To tax the consumption of "luxury" products at a higher rate, the government has set the ad valorem tax rate at 10 and 21 percent respectively on yarn of less than (or equal to) and greater than a 403 strand count. Since the yarn cost with respect to which the mark-up of the fabric price is defined does not include the indirect yarn tax, one would expect the mark-up to be greater for "superior" fabric (i.e., that containing yarn of more than a 403 strand count). Additionally, there is substantial evidence, discussed at the end of section 6, that the supply of superior fabric is cartelized while there is active competition among the suppliers of inferior fabric. The coefficient of the strand count dummy variable in the cloth regression indicates that the proportional mark-up in the domestic market on superior cloth averages nearly 110 percent above that on inferior cloth. Whether or not this difference more than compensates for the higher tax on superior cloth
cannot be determined without further analysis, for it depends upon the share of yarn in total cost and there are other differences as well in the cost of producing superior versus inferior cloth. Furthermore, very little confidence can be placed on the estimated coefficient, due to its relatively high standard error. As before, we postpone further analysis of this question to section 6.

5. Private and Social Benefit-Cost Ratios

Having sketched the underlying methodology, we may now turn to the simulated benefit-cost ratios. For each model of loom within our sample, several benefit-cost ratios were simulated, one for each principal variety of fabric produced using that loom. The number of looms under each technology and the number of loom/fabric combinations for which benefit-cost ratios were simulated are shown in Table 4, where the results of the simulations are summarized.

We will first discuss the simulated "private" benefit-cost ratios, which are based on the prices actually paid and received by the producers. The benefit associated with a loom is the present value of the profit stream realized by its use, where profits are after taxes but inclusive of depreciation allowances. The cost of a loom is simply the price that was paid for it; in the case of second-hand looms, benefit-cost ratios are simulated with respect to the most recent purchase. The following assumptions have been made:
for a particular loom/fabric combination, the same fabric is produced throughout the economic life (defined in section 2) of the loom;

- except for maintenance down-time, which varies by loom model, looms are operated continuously on a single-shift basis;

- for a variety of fabric that is exportable, one third of the output is sold on the domestic market; in turn, for each loom, the fabric varieties chosen for simulation yield roughly the same composition of output as that actually observed between exportable and non-exportable varieties;

- yarn and fabric prices are based on hedonic regression estimates, according to the observed source and destination respectively;

- wages and electricity rates are equal to their observed values for 1970 through 1972; prior to 1970 and after 1972, real wages and electricity rates increase at five percent per annum, in line with trends observed between these two years;

- the exchange rate is equal to its observed value through 1972 and remains constant thereafter;

- all prices, including loom purchase prices, are converted to a 1970 base by using the consumer price index; real wages and electricity rates and the real exchange rate (the latter only through 1972) are time dependent;

- benefits and costs are discounted to the date of the loom's purchase at the real rate of interest paid to finance the purchase of the loom; and,

- government policy variables, excepting the exchange rate, remain constant at the values observed in 1970 through 1972.

It bears emphasis that these simulations reflect all of the differences in circumstances associated with the purchase and use of different looms (see section 2), including those due to government incentive policies and in particular the differential treatment accorded production for the domestic and export markets. Furthermore, based on the estimated
technological relationships, they incorporate productivity changes from the date of the loom's purchase through the date of its being sold for scrap.

The averages shown in Table 4 are simple averages over the loom/fabric combinations under each technology. While the average of the simulated benefit-cost ratios is not the same for each technology, the differences among these averages are not statistically significant. Thus, assuming that producers' expectations at the time of loom purchase were not greatly different from the basis on which benefits have been simulated, our results are consistent with the assumption that producers maximize the net worth of their firms. That is, our results support the hypothesis that it is differences in the prices paid and received as well as in the varieties made by different producers that lead to the choice of different technologies. This does not mean that there may not be some producers who choose among technologies on other grounds, for example on the basis of an irrational preference for imported and/or automated technologies. However, until there is evidence to the contrary, we may conclude that such producers are atypical and few in number within our sample.

We now turn to evaluate the technologies in shadow prices. Our purpose in shadow pricing is to remove distortions caused by government policy. Thus we have stopped somewhat short of the conventional

\[\text{See Wells [1972] and Pickett, et. al. [1974].}\]
Table 4

Private and Social Benefits-Cost Comparisons
Cotton and Cotton-Blend Weaving

<table>
<thead>
<tr>
<th>Item</th>
<th>Automatic Loan</th>
<th>Semi-Automatic Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(AI)</td>
<td>(AI)</td>
</tr>
<tr>
<td></td>
<td>Domestic</td>
<td></td>
</tr>
<tr>
<td>Sample Sizes: Number of</td>
<td>3</td>
<td>32</td>
</tr>
<tr>
<td>Stock Models</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loom/Fabric Combinations</td>
<td>3</td>
<td>73</td>
</tr>
</tbody>
</table>

Average Private Values:
- Benefit per Loan: 1,000.3, 2,346.3, 718.8, 594.4, 123.4
- Cost of a Loan: 300.3, 369.4, 203.0, 129.9, 92.5
- Benefit-Cost Ratio: 3.00, 1.57, 3.60, 4.02, 2.57
- Standard Deviation: 1.33, 1.32, 3.54, 5.32, 2.27

Average Social Values:
- Benefit per Loan: 523.4, 907.4, 623.8, 614.6, 128.6
- Cost of a Loan: 306.3, 369.4, 203.0, 129.9, 92.5
- Benefit-Cost Ratio: 2.00, 1.57, 3.60, 4.02, 2.57
- Standard Deviation: 1.33, 1.32, 3.54, 5.32, 2.27

Average subsidy rates (%):
- Total: 82.0, 57.5, 41.5, 41.6, 21.6
- Interest Subsidy: 1.4, 13.6, 15.4, 16.5, 17.5
- Tax Subsidy: 8.5, 18.3, 23.5, 26.4, 29.2
- Price Subsidy: 7.0, 8.3, 10.4, 12.2, 14.0
- Loom Purchase Subsidy: 0.0, 19.2, 0.0, 0.0, 0.0

Notes: See discussion in text for method of estimation, definitions.


2/ Benefits and costs in 1967 won at 1970 prices. The nominal exchange rate in 1970 was 303 won to the U.S. dollar.
procedures for estimating shadow prices in project appraisal. In particular, labor is not shadow priced and the shadow discount rate is taken to be the weighted average of the real interest rates paid to finance loom purchases within our sample. On the other hand, most observers of the Korean economy would probably agree that market wages are not very different from shadow wages, so that it principally in the under-estimation of the discount rate that our shadow prices are markedly different from those that would be used in project appraisal.

The procedure followed to simulate "social" benefit-cost ratios is the same, as are the loom/fabric combinations for which benefit-cost ratios are simulated. However, we introduce the following changes in the assumptions on which the benefit-cost ratios are based:

- whether on the domestic or world market, yarn is purchased and fabric sold at the domestic currency equivalent of its border price, which is based on hedonic regression estimates;

- a shadow exchange rate is used; it is calculated to maintain real purchasing power parity at the level observed at the end of 1964; for 1972, the shadow exchange rate exceeds the market exchange rate by 14.5 percent of the latter;1/ unless imported by the purchaser, the purchase price of a loom is the same as that actually paid; if imported, the shadow exchange rate is applied to the c.i.f. import price;

- benefits and costs are discounted at a real interest rate of eight percent per annum, which is the weighted average of the real interest rates paid to finance loom purchases within the sample; and,

1/ The shadow exchange rate used here is consistent with the free trade exchange rate estimated for 1968 by Westphal and Kim [1974]; it is also consistent with the analysis in Frank, Kim, and Westphal [1975], Chapters 8 and 9.
It therefore seems safe to conclude that few if any indigenous automatic looms would have been purchased in the absence of preferential government policy. A similar conclusion would follow with respect to imported automatic looms were it not for the fact that these are capable of producing and are employed to produce fabrics of greater widths than is possible with indigenous looms.

With the same qualification, it appears warranted to conclude that the socially optimal choice of technology is the indigenous semi-automatic technology. Here it is relevant to cite the results of our simulations in regard to the volume of employment associated with the same amount of investment under each technology. Over the same period of time, use of the indigenous semi-automatic technology would generate more than ten times the volume of employment associated with use of the imported automatic technology, and more than twice that associated with use of the indigenous automatic technology. In addition, lesser skills are required to operate indigenous semi-automatic looms, while their economic life is nearly twice that of automatic looms from either source.

Subsidy Rates by Type of Policy

By simulating benefit-cost ratios under alternative sets of assumptions, it is possible to decompose the difference between the private and social benefit-cost ratios for a particular loom/fabric combination into components attributable to different policy elements. As with any such decomposition, there is a certain degree of arbitrariness involved
in the calculations, but the results are similar in substantive. We shall distinguish between four subsidy elements: (a) one that due to the difference in interest rates paid to finance home purchases; second, that due to differences among direct and indirect tax rates; third, that due to differences between domestic and border prices for yarn and fabric; and, fourth, the implicit subsidy to the purchase of imported items due to the over-valuation of the exchange rate and the exemption from tariffs.

The magnitude of the interest subsidy (which we denote by $T$) is equal to the difference between the present value of the stream of after-tax profits (inclusive of depreciation allowances) calculated in the private case less that calculated on the same assumptions except that a real interest rate of eight percent is substituted for that actually paid. A negative subsidy, i.e., an implicit tax, is obtained if the interest rate actually paid exceeds eight percent. The magnitude of the tax subsidy ($P$) is calculated endogenously, while the magnitude of the price subsidy ($P$) due to protection is obtained as a residual. Each of these subsidies is expressed as a rate in proportion to the present value of the stream of after-tax profits in the social case. Lastly, the magnitude of the border purchase subsidy ($B$) is simply equal to the difference between the domestic currency equivalent of its border price at the shadow exchange rate and the price actually paid. (The border subsidy rate is taken to be the shadow elasticity of the border price.) This subsidy is expressed as a rate in proportion to the social cost of the item. The relationship between subsidy rates and profit/cost ratios is expressed in the following equation:

$$
\frac{1}{\bar{p}} = \frac{\bar{p}}{\bar{p}} \left[ \frac{1 - (1/B)}{1 - (1/\bar{p})} \right] \frac{(P/B)}{(P/\bar{p})} - 2 \bar{p} \right] \frac{\bar{p}}{\bar{p}} ;
$$
where benefits are denoted by $B$ in the social case and $b$ in the private case, and the loom purchase price by $C$ and $c$ respectively. The term in square brackets is the total subsidy rate.

Expressed as percentages, the average subsidy rates under each technology are presented as the last set of figures in Table 4. All producers benefit from protection in the domestic market, while only those using the automatic technology benefit from preferential interest and tax rates. Acting in combination, the government's incentive policies serve implicitly to tax the use of domestic semi-automatic looms and provide a very generous subsidy to the use of automatic looms. However, as one would conclude on the basis of the discussion in section 2, not all of these subsidies are tied explicitly to the purchase of technology. Nonetheless, in the case of imported automatic looms, those that are tied to the technology's purchase, i.e., access to preferential credit and the over-valued exchange rate, are sufficient on average to double the technology's benefit-cost ratio.

Tax and price subsidies are not tied to particular technologies but rather are realized through producers' choices regarding the fabric varieties to produce and the markets in which to sell them. Before investigating producers' choices further, however, we will briefly summarize the principal conclusions of various sensitivity analyses that were conducted in part to confirm the robustness of the foregoing simulation results.

**Sensitivity Analysis**

Here we will focus on the sensitivity analyses performed on the social benefit-cost evaluation of the different technologies. Our general conclusion is that the new, domestic semi-automatic technology retains its superiority over the automatic technologies over a wide range of parameter values.
though changes in some parameters of concern were the determining factors in the technological benefit-cost ratios. Thus, the semi-automatic technology resulted in superior output rates up to 15 to 20 times higher than those being paid within the sample. Similarly, though the difference between benefit-cost ratios is reduced under multiple-shift operation, that for the semi-automatic technology remains substantially higher. In turn, so long as the width of the fabric permits use of the semi-automatic technology, it yields the highest benefit-cost ratio even for high quality products, though the automatic technologies have a comparative advantage in producing fabrics of greater density using yarns of higher strand counts. Lastly, we should note that working capital requirements are not reflected in the figures presented in Table 1. Adding interest charges on working capital to operating costs does not, however, change the ranking of technologies by social benefit-cost ratios. It does though result in a substantial reduction in benefit-cost ratios; assuming that production costs are incurred continuously throughout the year while the resulting output is all sold at the end of the year, the inclusion of working capital charges (at eight percent) reduces benefit-cost ratios by 40 to 50 percent. Because of offsetting differences in wage and raw material costs, there is only a very small difference between the reductions for the semi-automatic and automatic technologies.

Perhaps the most interesting sensitivity analysis pertains to the effect of shuttle enlargement and feeder installation under the semi-automatic technology. By enlarging the shuttle and installing feeders, a number of Korean producers using this technology have achieved substantial savings in labor costs. Simulations to estimate the maximum benefit-cost ratio utilized the same technical assumptions in the design of a semi-automatic loom. The results obtained, however, vary widely depending upon the specific alternatives made. Furthermore, if the case of weaving well seen, the adoption of the semi-automatic technology will present the same over-all. It will retain its social superiority.

1/ Recall the discussion of loom characteristics in section 3.
6. The Simulated Structure of Prices under Competition

Just as one can simulate benefit-cost ratios given the prices of the fabrics, so too can one simulate fabric prices given the benefit-cost ratio to be realized. Here we shall compare the prices actually observed with prices simulated to correspond to those that would be observed under competition. This will permit us to determine whether there is discriminatory pricing in relation to production cost.

Since our interest is in relative rather than absolute prices, we must simulate the prices of (at least) two fabric varieties. Those chosen are duck and poplin. The former is considered to be a low quality product; among the firms in our sample, it is predominantly produced by small producers using the indigenous non-automatic technology, and the output is almost entirely sold on the domestic market. The latter ranks as a luxury product; it is predominantly produced by large and medium scale producers using the imported automatic technology, and most of the output is exported. The following discussion of price simulations for these varieties is based on the estimates presented in Table 5.

The first step in our analysis is to compare the simulated price of duck with that observed on the domestic market. The assumptions made to obtain the simulated price are analogous to those made in calculating private benefit-cost ratios, except that a discount rate of eight percent and a benefit-cost ratio of 2.0 have been arbitrarily assumed to compute the competitive supply price. Also, rather than use averages over the
looms within each technology, here we have used a single "synthetic" model of loom to represent a particular technology. The specification of each characteristic for the synthetic loom is the average value of the specification over the looms within the sample.

The technology on which the competitive price is based should be that which yields the lowest supply price. Over the five technologies, the lowest supply price for duck is obtained using the new, domestic semi-automatic technology, which is the technology predominantly used by duck producers. The simulated price is further based on the average of the actual values of government policy variables observed in the production and sale of duck. These policy variables include the interest rate paid to finance the purchase of looms, as well as direct and indirect tax rates (including the depreciation rate allowed to calculate before tax net income). As the yarn used to produce duck was not imported, and there were no imports of duck, tariff rates are not relevant. However, observed yarn and duck prices were maintained above the domestic currency equivalent of their border prices at the market exchange rate as a result of import prohibitions. The protection to domestic producers of yarn is reflected in the simulated price of duck. For convenience in the discussion that follows, we shall denote the interest rate, tax rates, and implicit tariff on yarn observed in the production of duck as the "neutral" rates.

In the upper part of Table 5, one can see that the simulated price of duck under the neutral, i.e., observed, value of the government policy variables and the optimal, which is the same as the observed, coincide in
Table 5

Decomposition of Distortion in the Price of Poplin Cloth

<table>
<thead>
<tr>
<th>Computation of Normalization Ratio Using Prices of Duck Cloth</th>
<th>Price ( \frac{PO}{PS} )</th>
<th>Distortion Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price Observed on the Domestic Market (PO)</td>
<td>7.77</td>
<td></td>
</tr>
<tr>
<td>Simulated Price under Observed = Neutral Policy, Observed = Optimal Technique (PS)</td>
<td>7.89</td>
<td></td>
</tr>
<tr>
<td>Normalization Ratio Equals 0.985 (PO/PS)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Poplin Price: Distortion Due to Government Policy, Technique Choice

| Simulated Price under Observed Policy, Observed Technique (P1) | 8.88            |
| Simulated Price under Neutral Policy, Observed Technique (P2)  | 10.70           |
| Distortion due to Government Policy (GDI = \( \frac{P1}{P2} \))  | 0.83            |
| Simulated Price under Neutral Policy, Optimal Technique (P3)   | 9.31            |
| Distortion due to Technique Choice (TDI = \( \frac{P2}{P3} \))  | 1.15            |

Poplin Price: Distortion due to Market Structure

<table>
<thead>
<tr>
<th>Domestic Market</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Price (Pd)</td>
<td>15.26</td>
</tr>
<tr>
<td>Simulated Price under Observed Policy, Observed Technique (P1 above)</td>
<td>8.88</td>
</tr>
<tr>
<td>Distortion due to Market Structure (MDI = ( \frac{Pd}{P1} )/NR)</td>
<td></td>
</tr>
<tr>
<td>Total Price Distortion (PDI = GDI x TDI x MDI)</td>
<td>1.74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Export Market</th>
<th></th>
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<tbody>
<tr>
<td>Observed Price (Pe)</td>
<td>6.70</td>
</tr>
<tr>
<td>Simulated Price under Observed Policy, Observed Technique (P1 above)</td>
<td>8.88</td>
</tr>
<tr>
<td>Distortion due to Market Structure (MDI = ( \frac{Pe}{P1} )/NR)</td>
<td></td>
</tr>
<tr>
<td>Total Price Distortion (PDI = GDI x TDI x MDI)</td>
<td>0.77</td>
</tr>
</tbody>
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Notes: See discussion in text for explanation.

1/ \( 10^{-2} \) won per square inch.
slightly higher than the actual price. The deviation from 1.0 of the ratio of the observed to the simulated price of duck is due to differences between the "actual" and assumed benefit-cost ratios and discount rates. It is not possible separately to estimate the benefit-cost ratio actually realized by and the discount rate actually used by the producers of duck; thus, we will use the ratio of the observed to the simulated price of duck to adjust the simulated price of poplin when the latter is compared to the market price of poplin. This is essentially a normalization to insure that the profit rates implied by the simulated prices of duck and poplin are the same.

As with any two prices, the market price of poplin relative to that of duck depends upon differences in production costs and in the degree of monopoly power exercised by their producers. In turn, differences in production cost can be traced to differences (if any) in government incentive policies, to the choice (if relevant) of an inappropriate production technique, and to those factors which would remain under competitive supply price determination and a non-discriminatory, or neutral, set of government incentive policies. The second part of Table 5 indicates the effect on poplin prices of discriminatory government policy and the use of an inappropriate technology. Taking the former first, the simulated supply price (i.e., production cost with "normal" profits) of poplin using the observed technology (imported automatic looms) is 8.86 under the observed values of the government policy variables affecting poplin producers; it is 10.76 under a neutral policy, i.e., when the values of the government policy variables observed
for duck producers are assumed. Government policy discrimination thus reduces the supply price of poplin by 17 percent. On the other hand, the producers' choice of the imported automatic technology rather than the minimum cost indigenous semi-automatic technology increases the supply price by 15 percent under a neutral policy.

Comparing the observed price of poplin with that simulated under the observed policy and observed technique and adjusted by the normalization ratio yields an index of the monopoly power exercised by poplin producers relative to that wielded by duck producers. On the domestic market, the greater monopoly power exerted by the producers of poplin increases the price of poplin by 74 percent; because they are counterbalanced by the use of an inefficient technology, government subsidies to poplin producers offset very little of the resulting distortion in relative prices. On the other hand, poplin producers have no monopoly power on the export market, and in fact export at a price below production cost.

The simulated supply price of poplin under the observed policy and observed technique is in fact a weighted average of the supply prices using the observed technique for exports and for domestic sale, since the basis for tax policy discrimination is the destination of the output. The share of domestic sales in output is one third. Multiplying the observed domestic sales price by one third and the observed export sales price by two thirds yields an average sales price of 9.55. Comparing this figure with the simulated supply price of 8.88 gives an indication of the relatively
high profits enjoyed by poplin producers due to their monopoly in the domestic market. Alternatively, one can compare the observed domestic sales price of poplin, which is 15.25, with the domestic sales price that would yield an average sales price of 8.80 when one third of the output is sold domestically; the latter price is 13.24. However, even at this price, domestic purchasers would still be subsidizing the export of poplin, since its supply price based on the observed technique and the tax rates levied on sales for domestic production is approximately 10.70 (i.e., its simulated supply price under a neutral policy and the observed technique).

Here, then, is the evidence that there is discriminatory pricing in the sale of poplin, involving cross-subsidization between the domestic and export markets.

It remains to explain how poplin producers are able to maintain a monopoly position on the domestic market. The explanation is quite simple: as large producers who also make the yarn required to produce poplin, they control the supply of the critical raw material. Of course, it is possible to import yarn, but this is prohibited unless used in production for export. The allocation of export targets among producers on the basis of negotiations between the government and an association of exporters which appears to act as a cartel serves to control the access of other producers to imports of

1/ Recall that the neutral policy is that observed for duck sold in the domestic market. Using it yields an approximate value for the tax inclusive cost of supplying poplin to the domestic market, first because poplin producers are observed to pay lower indirect and income tax rates for reasons not associated with exporting, and second because the indirect tax rate on yarn used in poplin is greater than that on yarn used in duck.
yarn. Furthermore, the government's participation in export target setting seems not only to give sanction to but also to actively support the operation of the cartel.

Those familiar with Korean export incentive policies, and who also know that export targets are generally exceeded, will undoubtedly raise an objection to this line of argument, based on the fact that it neglects the wastage allowance on imported yarn. To explain: the amount of yarn that can be imported is stated in terms of so many pounds of yarn per pound of resulting exports. The excess of this ratio over one is the wastage allowance, which exceeds actual wastage in production by a generous margin. Thus, the wastage allowance on imported yarn is 14 percent, compared to observed wastage rates in production which rarely exceed 3.5 percent (Table 1 gives averages for each technology). But, to answer the objection, even with a low wastage rate in production of 2.0 percent, the share of the output produced with imported yarn that can be sold on the domestic market is only 11 percent. Even assuming production using the efficient technology, this low a share of sales on the lucrative domestic market would be insufficient to yield the producer a profit rate equal to that made selling duck.

7. Conclusion

The conclusions reached on the basis of comparing poplin and duck are qualitatively the same as those reached comparing any high quality fabric

1/ We should note that the wastage allowance is incorporated in our simulations.
with any low quality fabric. Though there are exceptions, it is a safe generalization to say that large producers have specialized the production of luxury fabrics where high profits are to be made through export subsidies and discriminatory pricing on the protected domestic market. One might wonder why these producers export at all, but exporting is the price paid to do business in Korea except in newly established lines of import substitution (where the holiday from exporting, furthermore, tends to be short). In turn, large scale producers tend to be inefficient, because of their reliance on imported automatic technology. The only clear exception to this is in the production of wide cloth. But the inefficiency of large scale producers appears not to result from any failure to maximize profits on their part, it is rather due to government policies which have favored capital imports.

The obverse of the generalizations above also typically hold true. Thus, there appears to be a great deal of competition among smaller producers, who are predominantly engaged in producing lower quality fabrics, for which protection policies as a consequence have comparatively little impact. Where profitable, these producers also export, but generally without the benefit of cross subsidization between markets. In turn, the smaller producers appear to be more efficient. This is in part because they have chosen socially appropriate technologies in the face of the prices they pay and receive, but it also stems from their employment of relatively greater numbers of less skilled labor and their lower overhead expenses and material wastage rates.
A complex tangle of government policies thus appears to have introduced a number of distortions into Korea's textile sector. We do not know whether the implicit discrimination against smaller producers is an intended or unforeseen consequence. Among the other questions which we must also leave open are two of methodological importance. Without data on labor characteristics such as the amount of formal education and previous work experience, we have not been able to go very far in distinguishing labor skill substitution from the substitution of labor for other inputs. In turn, without estimates of demand functions for differentiated fabrics, we have not been able to analyze the quantities of various fabric varieties that would be produced under different circumstances, which would be necessary to close the circle between product demand and technology choice.

Postscript

Since we have used the present tense in describing and analyzing observations pertaining to 1970 through 1972, we need to indicate clearly that Korean government policy has changed since the period of our survey. In particular, imports of capital goods are no longer favored through access to credit on softer terms, while there are now tariffs and, in some cases, even import restrictions on competing imports of equipment. Income derived from exporting is no longer taxed at a preferential rate, and wastage allowances have been substantially reduced. Finally, it appears that export prices for most fabrics are now equal to or higher than domestic prices, when allowance is made for the remaining export subsidies. Many of the discriminatory policies have thus been removed. Additionally, looms having a width in excess of 60 inches are now produced locally in large numbers, recently having accounted for some 70 percent of indigenousloom production.


