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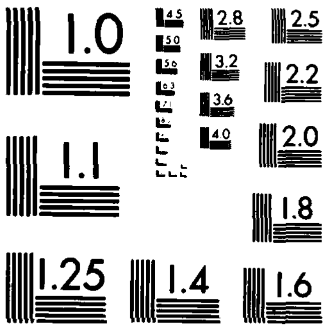

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FACTORS INFLUENCING PRODUCTIVITY CHANGE
IN THE FOREST PRODUCTS INDUSTRY

by

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with input from

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April, 1985

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per letter

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May 3, 1985

Mr. Peter J. Ince
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Dear Peter

Thanks for your letter of April 19, 1985, regarding the final version of the manuscript by Anne Strees. John Haygreen has asked me to respond for him as well as myself.

We will permit NTIS to duplicate the manuscript and to sell the manuscript as appropriate.

The earlier version of the manuscript, which is essentially the same as the present version, was reviewed by Fred Kaiser and Chris Risbrudt of the U.S. Forest Service, and by Professor Vernon Ruttan and Professor John Waelti of the Department of Agricultural and Applied Economics here at the University of Minnesota. Professor Dietmar Rose of the College of Forestry, University of Minnesota, also reviewed it.

If you need anything further from us, please do not hesitate to write or call.

Best regards.

Sincerely

Hans M. Gregersen
Professor

HMG/mah

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Chapter I

INTRODUCTION

Problem statement

Productivity growth is an important component of long term economic growth. It has been estimated that historically, productivity increases have accounted for as much as a third of the growth rate in the United States (Jorgenson, 1980). During the period 1950 to 1973, the U.S. economy grew at an average annual rate of 2.1 percent, dropping to an average annual rate of 0.3 percent for the period 1973 to 1977 (Denison, 1979). Current sluggish growth rates for the economy have been blamed almost entirely on the recent slowdown in the productivity growth rate. For the same periods, aggregate productivity growth rates were 2.1 percent and 0.4 percent, respectively (Fortune, 1979).

Part of the decline in the aggregate productivity growth rate has been attributed to significant changes in the composition of output. The rapid expansion of the services sector, which has traditionally exhibited low rates of productivity growth, is often cited as a major factor. However, declines in productivity growth are evident at the sectoral level as well. Productivity for U.S. manufacturing increased at an average annual rate of 2.7 percent between 1947 and 1973 compared with an average annual rate of 2.2 percent between 1973 and 1979 (American Productivity Center, 1980).

At the aggregate and sector level, productivity measures are used as indicators of the health of industry and the economy. Many believe that the recent sharp decline in the productivity growth rate is cause for alarm. However, a more optimistic viewpoint is that, as a welfare measure, productivity has been severely overstated in the past since many negative production externalities were not captured in productivity measures (Henderson, 1918). As many of these externalities are institutionalized through legal restrictions and financial penalties they show up in productivity measures. Adopting this view, Henderson argues that recent productivity declines can be largely attributed to the costs of worker health and safety, and environmental regulations and that these costs represent the social costs of pollution and endangered health.

This study explores the sources of productivity change in the U.S. forest products sector. Specifically the following questions were considered:

1. Since the forest-based sector is diverse in terms of products and manufacturing processes, are there differences in the sources of productivity change between the industries comprising the forest-based sector?

2, And, considering the regional nature of some forest products industries and the regional differences in the wood resource, do the sources of productivity change vary across geographical regions as well?

Study objectives

The objectives of the study are as follows:

1. analyze the potential sources of productivity change,

2. identify the important factors involved in productivity change in the forest-based sector,

3. and, assess the relative importance of these factors among industry groups and geographical regions.

Framework for analysis

The first of these objectives will be achieved through review of the literature on productivity and technological change. The identification of the factors involved in productivity change in the U.S. forest industries and their relative importance will be determined through an analysis of the results of a survey of the U.S. primary forest products sector.

Scope of the study

Productivity change in the primary forest products industries was examined by means of a nationwide survey. The sector was grouped into eight separate product categories: (1) softwood lumber, (2) hardwood lumber, (3) softwood plywood, (4) hardwood plywood and veneer, (5) particleboard, (6) structural particleboard, (7) pulp, paper and paperboard, and (8) fiberboard, hardboard and medium density fiberboard (MDF). These eight product groups roughly comprise the primary forest-based sector.

In chapter II the basic analytical framework used to examine the factors involved in productivity change is developed. Productivity change is examined using an economic production function approach; the mechanisms of productivity change are developed and the factors influencing productivity change are described with particular emphasis on those factors most likely to be important in the forest-based manufacturing sector. Chapter III provides an overview of the survey approach used to collect data. A discussion of the categorical data analysis technique used to analyze the survey results is presented in chapter IV. Survey results are presented in chapter V and summarized in chapter VI.

Chapter II

PRODUCTIVITY CHANGE IN THE FOREST PRODUCTS SECTOR

Definitions and concepts

Productivity is a production measure used to describe the relative efficiency of production over time. It is always expressed as the ratio of outputs to inputs, both being measured in real terms. The use of productivity as an efficiency measure has been criticized on the grounds that efficiency involves a comparison between actual production output and theoretical production output, given a specific technology (Fenske, 1965; Thorelli, 1960). However, the productivity measure is not linked to any specific technology but rather, production is compared over time against production in some base period. In theory, if productivity increases from one period to the next, it can be said that production is more efficient in the second time period relative to the first time period since a unit of output can be produced with fewer inputs in the second period.

The definition of productivity as the ratio of outputs to inputs gives rise to a family of productivity measures depending on the choice of inputs to be included. Kendrick (1961) has classified these measures into two categories--total factor productivity and partial productivity. Total factor productivity includes all factors of production in the input measure, therefore it is essentially a measure of the relative efficiency of the entire production process over time. Partial productivity measures include only one (or several) production inputs hence they are measures of the relative efficiency of that particular input in the production process over time. Some commonly used partial productivity measures include labor productivity, capital productivity, and more recently, energy productivity.

For most uses, total factor productivity is the desired measure. However, total factor productivity is, in many cases, an extremely difficult measure to calculate. Some production inputs pose serious measurement problems. For example, the capital input should be measured as the flow of capital services (market rental value) but these data are generally unavailable. For this reason, some partial productivity measures are used as proxies for total factor productivity. The most common of these partial productivity measures is labor productivity. Since labor is often the single largest production input, a labor productivity series should be strongly correlated with total factor productivity. However, as Stigler cautions:

> An approximate answer depends upon the closeness of the approximation and the question which is being asked. For a lame ant the statement that the height of a house and of the Eiffel tower are equal is a satisfactory approximation; a pilot might need a closer approximation. The uses of productivity data, however, are infinitely varied, and it does not seem possible to present any objective criterion of the minimum goodness of approximation that is generally required." (Stigler, 1961, p. 48)

In the most general context, production of output depends on both the relative amounts of the various input factors and the absolute level of those factors. Changes in the relative amounts of input factors are classified as factor substitutions and changes in the absolute levels of those factors are termed scale economies. The discrepancy between total factor productivity and partial productivity measures arises from factor substitution. For example, consider a production process utilizing only capital and labor. Labor savings may be achieved without any change in output through the substitution of capital for labor. In this case, labor productivity has increased. Note however that capital productivity has decreased. Total factor productivity, however, is unchanged since output has remained constant. When factor substitution is accompanied by a change in the level of output, the relationship between the two measures is more complicated. In this case, the effect on total factor productivity depends on the extent to which capital productivity changed relative to labor productivity (Kendrick, 1961).

<u>Theoretical foundations -- the production function</u>

The process of production is described in economic theory by a generalized production function which relates outputs (goods and services) to factor inputs as follows:

$$(Y_1, Y_2, ..., Y_n) = f(X_1, X_2, ... X_m)$$

where

$$(Y_1, Y_2 ...., Y_n) \quad 0$$

$$(X_1, X_2, ..., X_m) \quad 0$$

$(Y_1, Y_2, ... Y_n)$ is the vector of production outputs and $(X_1, X_2, ... X_m)$ is the vector of factor inputs. In practice the function is generally restricted to be single valued. That is,

$$Y = f(X_1, X_2, ... X_m) \quad \text{where } Y \quad 0 \quad \text{and } (X_1, X_2, ...X_m) \quad 0$$

Y represents total real output. Given factor input levels $(X_1, X_2, ... X_m)$, the production function yields the highest level of output which is currently technically feasible. The case of a single output produced with two variable factor inputs is shown in fig. 1a.

The curves y_0 and y_1 represent different combinations of factor input levels yielding constant levels of output y_0 and y_1 respectively.

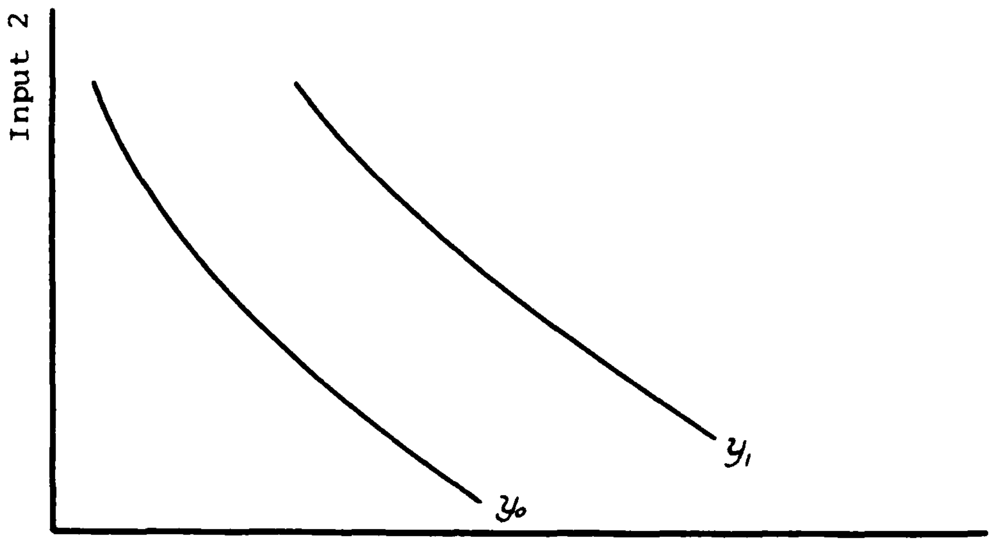


Fig. 1a. The production function.

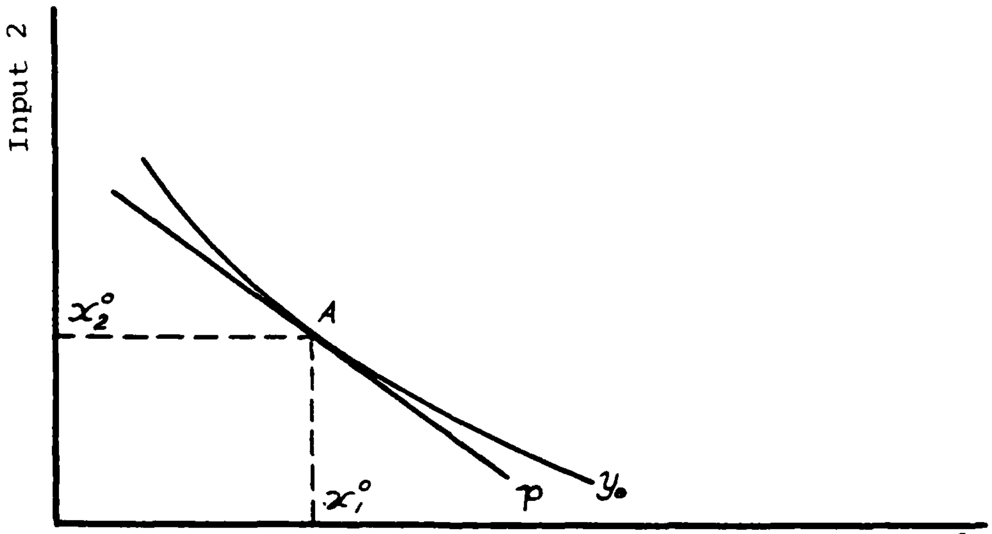


Fig. 1b. Cost-minimizing solution.

The level curves, or isoquants, y_0 and y_1 correspond to different levels of output with y_1 representing a higher level of output than y_0. The slope of the isoquant gives the rate at which the factor inputs can be substituted for one another at a constant output level. Given the relative price structure and output level, a producer selects the combination of factor inputs that minimizes the cost of production. The particular choice of factor inputs is shown in fig 1b. Given output level y_0 and the relative price structure described by the line p with slope $-p_2/p_1$ (where p_2, and p_1 are the prices of input factors x_2 and x_1 respectively), a producer will operate at a point A where the line p is just tangent to the isoquant y_0, producing output level y_0 with input factor combination (x_1^0, x_2^0).

A production function is described by two sets of parameters, the elasticity of factor substitution and returns to scale. Elasticity of factor substitution, the ratio of percentage change in one variable factor input needed to compensate for the percentage change in another variable factor while maintaining a constant level of output, is a measure of the degree to which input factors can be substituted or interchanged in the production process. Returns to scale indicates the relative efficiency of the production process for a given proportion of variable factor inputs over varying output levels (Stier, 1980). Using a translog cost function, Stier (1980), has estimated these production parameters for ten 3-digit SIC forest products industries and investigated the change in technology in these industries over time. For eight of the industries studied, Stier obtained estimates of the elasticity of factor substitution which were significantly less than one implying that the production process tends to be "rigid" with few opportunities for factor substitution. The remaining two industries, Miscellaneous wood products (SIC 249) and building paper and board products (SIC 266) exhibited elasticities of factor substitution close to one.

With regard to the diagrams in fig. 1a. and 1b., these findings would suggest that the isoquants for the forest products industries are likely to exhibit a far greater degree of curvature indicating a low degree of input factor substitution.

Choice of technology

Production functions are specified with regard to a specific set of structural conditions; the cultural, institutional and legal environment under which the firm operates. Therefore, a particular firm's choice of technology will depend on the configuration of structural conditions which exist at the time a decision is made. This choice process is a continuous and dynamic resource using activity (Binswanger and Ruttan, 1978). Changes in a firm's technical configuration over time can be generally classified as innovations. At any given point in time, an industry is composed of a set of individual firms with different technical configurations. In some cases a firm with several plants may have different technical configurations for each plant.

Since a commitment to a given technical configuration is essentially an investment decision, the costs and benefits must be ascertained and weighed accordingly. Projections of benefits must be developed under uncertain future market conditions. This is a difficult task at best. For example, there are problems in including as a benefit the anticipated competitive advantage achieved through innovation as this may only be a temporary short-term phenomenon. Gold (1980) lists four common errors in estimates of benefits:

"(1) underestimating the time needed to achieve effective functioning of the innovation.

(2) overestimating the average utilization rate as a basis for appraising benefits.

(3) underestimating the need to make adaptive adjustments in the preceding and subsequent operations...

(4) underestimating the costs of gaining labor acceptance of associated changes in tasks".

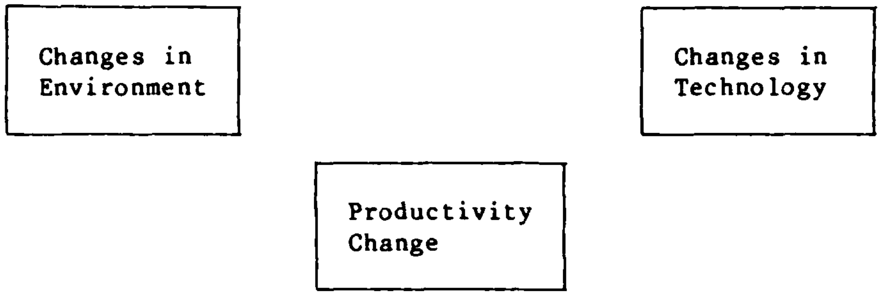
A "risk factor" must be added to the discount factor used in the analysis of benefits and costs. This risk factor can be separated into two components--the inherent risk of the innovation itself and in the case of a technical change, the risk of failing to innovate. There is always uncertainty surrounding any new product or process. But, if the firm fails to innovate while other competing firms change, it runs the risk of failure. These two components of risk work in opposite directions--the inherent risk is a negative component of total risk and the risk of failing is a positive component. Hill (1980) indicates that the risk of failing to innovate is relatively large in highly competitive industries. And, according to Gold (1980), many innovations are adopted "not in the hope of increasing profitability, but in order to minimize reductions in profitability threatened by competitive advances..."

Costs of evaluating an innovation must be considered in addition to the costs of "installing" the innovation. Gold (1980) indicates that these evaluation costs are exceedingly high so many possible innovations are never fully considered unless a strong need for change is indicated. This may be one reason why many opportunities go unrealized.

Changes in a firm's technical configuration over time largely determine its productivity growth. Productivity growth at the industry level is largely determined by the relative changes over time in the distribution of firms utilizing a given technology.

Sources of productivity change

The sources of productivity change can be broadly grouped into two categories--environmental factors and factors in technological change. The environment is broadly defined to include all cultural, legal and institutional, and economic factors which determine a firm's (and industry) structure and the conditions under which it functions. In the broadest context, technological change refers to the process by which the environment is changed or modified over time in response to needs or opportunities. The linkages between these two sources of productivity change are indicated below.



The distinction between the two categories, the environment and technological change, as described here is primarily temporal. Technological change is a continuous process involving the creation of new techniques and the subsequent adoption of those new techniques by industry. In some cases the new products and processes are adopted to replace existing ones. We take a static viewpoint with regard to the environment, and such a "snapshot" view of the environment presupposes a given state of technology. The two categories, technological change and the environment, are, of course, inexorably linked. The environment acts as a constraint on the integration of new technology. And the integration of new technology in turn results in changes in the environment (Binswanger and Ruttan, 1978).

The objective is to consider changes in the environment, whether exogenous (i.e. the changing quality of the timber resource as reflected in the change in average log diameter) or technologically induced (i.e. the changing quality of the labor resource as a result of the effect of new technology on worker attitudes and the work environment) and their effect on productivity. In the technological change category, the objective is to analyze how the process of technological change affects productivity.

Environmental Factors and their Impact on Productivity

Changes in the conditions, (i.e. the environment) under which a firm operates has a direct influence on productivity. Decisions regarding plant size, equipment, organization and other production matters are made given existing environmental conditions and expectations concerning future operating conditions. The ability to adapt to unexpected changes, both positive and negative, determine the degree to which productivity is effected. In theory, the degree to which productivity change occurs depends upon (1) the nature of the "environmental" change and (2) the specific characteristics of the firm's production technology. Production functions are specified with regard to a specific set of structural conditions; the cultural, institutional and legal environmental under which the firm operates. Changes in these structural conditions--new government regulations, for example--may directly affect a firm's ability to produce a previous output with the concomitant input requirements because, in the case of new government regulations, it may become necessary to divert otherwise productive resources to comply with the new regulations. In other cases, structural changes may be manifested in demand and supply changes in factor inputs and outputs. The degree to which firms can respond to these changes depends on the nature of the production technology, specifically the degree of possible input factor substitutions and the productive nature of the input itself. This can be illustrated in the context of economic production theory as follows. As discussed previously, in theory decisions regarding the composition of input factors and the level of production (scale) are made given available resources and the prevailing relative price structure (assuming a certain technical process). In the absence of any technical or technological change, a change in the relative price structure can result in changes in the marginal productivies of the factor inputs and total factor productivity. This process is shown graphically in fig. 2a. and 2b.

Given relative price structure p, the firm operates at A with input factor combination (x_1, x_2). If the relative price structure p changes to p' the firm would need to use the input factor combination (x_1, x_2) to maintain its current output level. The scale effects for input factor 1 are shown in fig. 2b. Given a constant level of input factor x_2, the level of input factor 1 can be described as a function of the level of output. Increasing the level of input factor x_2 shifts the function to the right as a result of input factor substitution possibilities. (Henderson and Quant, 1980). With regard to scale, the function can be logically separated into three stages of production. (Doll and Orazem, 1978). In stage I, the marginal physical product of input 1 (MPP_{x1}) is increasing, in stage II the MPP_{x1} is decreasing but positive and in stage III the MPP_{x1} is decreasing but negative. A rational producer will choose to operate at some level within stage II. (Doll and Orazem, 1978). In this example, if the producer operates with input factor combination (x_1, x_2) after the price change he will be operating outside of stage II with regard to input factor 1. In this case the producer would be better off reducing the scale of production and leaving some amount of input factor 2 idle. As an example of this phenomenon, Jorgenson (1980) in a study of sectoral productivity growth, found that declines in the rate of productivity growth after 1973 were the result of rapid increases in the relative price of energy forcing producers to cut back on their use of capital and substitute labor for energy.

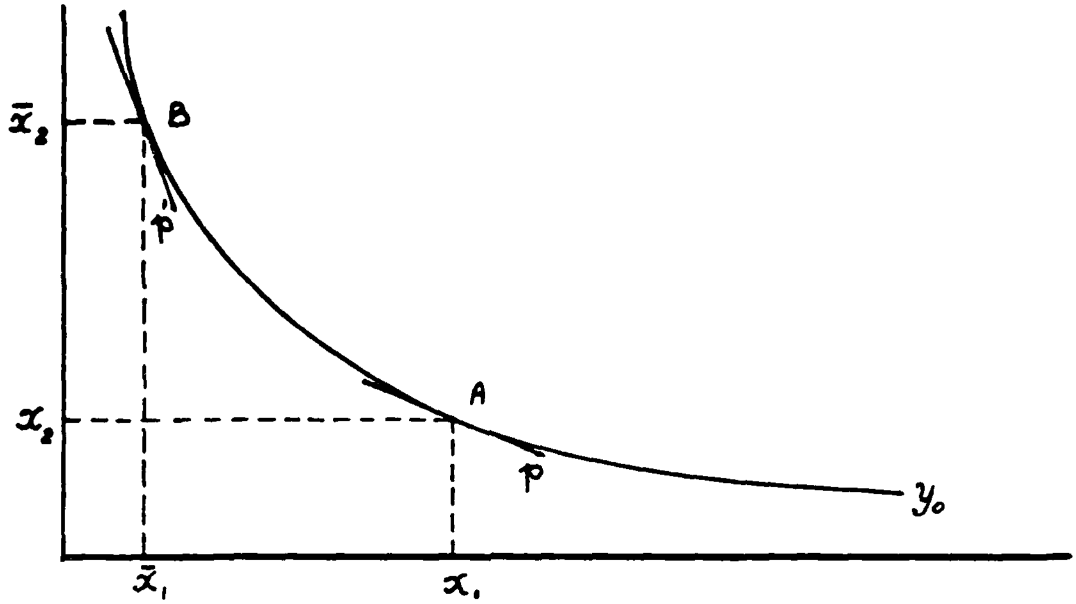


Fig. 2a. Change in input configuration in response to a relative price change.

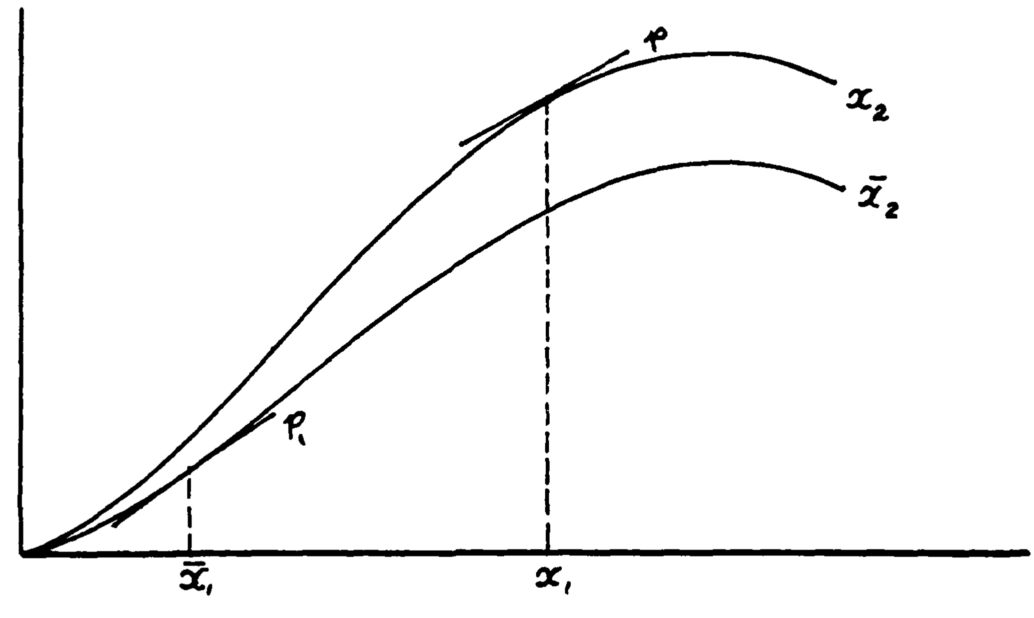


Fig. 2b. Change in output level in response to a relative price change.

The greater the ability of a firm to substitute input factors, the better the firm is able to respond to changes in input factor supplies with the result that productivity is affected to a lesser extent. At a more aggregate level, changes in the environment may lead to changes in the structure of the industry; the degree of competition, for example.

In theory, environmental changes such as those described above may lead to inefficiencies in the allocation of productive resources. An allocative inefficiency is an inefficiency in the sense that actual producer output deviates from theoretical producer output as a result of unanticipated changes in the price structure resulting in constrictions in the flow of production inputs. Under the theory of perfect competition, firms treat input factor prices and output prices as parameters in their production decisions and produce that level of output where the price level of factor inputs is equal to their respective marginal value products (Henderson and Quant, 1980). At this output level average unit costs are also equal to the price of output. Any environmental change resulting in deviations from this "ideal state" whether brought about by a firm's inability to adjust factor input levels through lack of substitution possibilities as a result of a relatively "rigid" production process or by deviations from perfect competition at the industry level result in efficiencies in the allocation of productive resources (Henderson and Quant, 1980).

In addition to problems concerning allocative efficiency, Leibenstein (1966) has identified another important source of potential inefficiency in production, which he terms "X-efficiency." X-efficiency arises from the "failure" of two important implicit assumptions in economic production theory and productivity measurement; in particular that

(1) all factor inputs are of a uniform quality, or that differing qualities or grades of factor inputs have no effect on the quantity of output produced and (2) that producers always operate "on their relevant production function" that is, all factor inputs are used to their highest technological potential. Given that assumption (1) holds, assumption (2) may fail as a result of different management techniques and work organization systems. As Leibenstein notes:

> "It is conceivable that in practice a situation would arise in which managers are exceedingly poor, that is, others are available who do not obtain management posts, and who would be very much superior. Managers determine not only their own productivity but the productivity of all cooperating units in the organization. It is therefore possible that the actual loss due to such a misallocation might be large. But the theory does not allow us to examine this matter because firms are presumed to exist as entities that make optimal input decisions, apart from the decisions of its managers." (p. 397)

The failure of assumption (1) is generally a "short-run" phenomenon since, in the long run, adjustments in the production process resulting from technological changes can compensate for most changes in factor input qualities. An exception, however, is the labor input. Leibenstein points out that:

> "People normally operate within the bounds of a great deal of intellectual slack. Unlike underutilized capital, this is an element that is very difficult to observe". (p. 405)

In Leibenstein's words, the production function relationships between output and factor inputs fails for four reasons:

> "(a) contracts for labor are incomplete, (b) not all factors of production are marketed, (c) the production function is not completely specified or known, and (d) interdependence and uncertainty lead competing firms to cooperate tacitly with each other in some respects, and to imitate each other with respect to technique, to some degree". (p. 407)

The key, according to Leibenstein, to utilizing the labor input to its fullest extent is motivation. This point is especially relevant in this decade where, changes in our social and cultural environment together with reluctance on the part of producers to adapt to these changes has brought worker motivation and worker attitudes to new levels (Rozen, 1982). Over the past decade there have been significant changes in the labor force, most notably the increasing average educational level of workers and the rapid influx of women into the labor force (Kerr, 1979). In addition, there has been a substantial increase in the demand for what Kerr terms, "good jobs;" jobs leading to personal self-fulfillment and political rights in the work place. As Kerr states:

> "The work ethic has not disappeared from the face of America, but the aesthetics of work has taken on a great new significance. This constitutes the central theme of the new evolution." (p. XI)

The manifestation of these demographic and cultural changes in the labor force may take three basic forms; skill deficiency, overvalued self-evaluation and job deficiency (Rozen, 1982). Rozen argues strongly that job deficiency is the major cause for lack of worker motivation noting that the "tell'em-what-to-do-and-see-that-they-do-it still seems to be the prevailing basis for work organization." (p. 736) Given the considerable social, demographic and cultural changes that have occurred, Rozen notes that:

> "...some or all of the following conditions obtain: effort is variable; workers build up considerable firm-specific human capital and define jobs; tasks are not rote; information about job duties and worker performance is incomplete; uncertainty, transactions costs, and attitudes towards risk may be important factors in shaping work arrangements; enforcement is difficult and costly; compliance cannot be taken for granted; and workers and firms are locked into explicit and implicit bargaining relationships. In such circumstances, the nature of the work contract and modes of work organization must allow for much more interaction between workers and their jobs." (p. 736)

Two basic approaches to these labor force motivation problems are apparent in the literature--modification of the work organization to explicitly include incentive systems, both monetary and politically, and refining the worker selection process in order to employ only those workers most likely to be satisfied with a given job. The motivation for group incentive systems derives from the public goods aspects of the work environment (Freemand and Medoff, 1978). The public goods aspects include safety conditions, lighting, heating speed of production, firm policies regarding layoffs, work sharing and formal grievance procedures. These factors affect all employees and exclusion from receiving the benefits of these factors is not possible. With public goods, the individual incentive to express preferences concerning the amount of factor desired is reduced so collective decision making is necessary to achieve optimum amounts of these factors (Freemand and Medoff, 1978).

Examples in Forestry

McCord (1975) in a study of financial incentive systems in the pulpwood industry of Georgia, tested three incentive systems for their effects on production. Of the incentive systems studied, Plan A, a guaranteed hourly wage plus a premium ties to actual production yielded the highest level of production. Plan C, a base rate plus a system of non-monetary compensation (coupons redeemable for merchandise) resulted in no increase in previous (under no incentive system) output levels. Plan B, a straight piece rate also resulted in increases in the level of output. Green and Podsakoff (1978), in a case study of the effects of removing a pay incentive system found that for the two large paper mills under study, the results in terms of output level and work satisfaction declined dramatically after eliminating a performance-contingent pay plan. With regard to specific firms, Reed-Forestville achieved increases in productivity by 60 percent after instituting a financial incentive system where bonuses were paid for production over set monthly quotas for timber harvesting (Anvik, 1977). Great Lakes Paper reported savings of $3/cord as a result of instituting a group performance incentive system for operators and mechanics in timber harvesting operations (Bartholomew, 1977).

An alternative approach to increasing labor productivity is through more careful selection of prospective employees. Cottell (1977), in a study of tree-sheer operators has found that productivity can be associated, to some degree, with personal traits such as depth perception, experience and manual dexterity--characteristics for which potential workers can be effectively screened. Forest and Boulard (1977) argue for the use of a psychological profile of forestry workers in Quebec as a screen for potential forestry workers and as an aid in the promotion and reclassification of workers.

The changing quality of raw materials can be a source of x-efficiency depending on the degree to which these quality changes are reflected in changes in the relationship between factor input and output levels as defined by the production function. In the forestry sector there has been a prevalent trend toward smaller average diameter logs. Tables 1 and 2 provide data on growing stock by diameter class and region for hardwoods and softwoods. Although the trend towards smaller logs is evident in both hardwoods and softwoods, the trend is considerably more pronounced for softwoods particularly in the northern region of the U.S.. Increasing costs in timber harvesting resulting from

Table 1. Percent of hardwood growing stock by diameter class and region of the United States, 1952 and 1977

Region	Diameter* Class	1952	1977
NORTH			
	Small	73.8	77.5
	Large	26.2	22.5
SOUTH			
	Small	66.8	69.7
	Large	33.2	30.3
PACIFIC COAST			
	Small	61.4	63.2
	Large	38.6	36.8
ROCKY MOUNTAIN			
	Small	80.3	85.7
	Large	19.7	14.3
TOTAL U.S.			
	Small	70.1	73.5
	Large	29.9	26.5

* Small = 5.0" - 14.9" DBH
Large = 15.0" + DBH

source: Impacts of the Changing Quality of Timber Resources, Poterfield, R. and Crist, J. Forest Products Research Society, Madison, WI. 1978

Table 2. Percent of softwood growing stock by diameter class and region of the United States, 1952 and 1977

Region	Diameter* Class	1952	1977
NORTH			
	Small	69.0	86.6
	Large	31.0	13.4
SOUTH			
	Small	80.0	77.0
	Large	20.0	23.0
PACIFIC COAST			
	Small	18.3	25.3
	Large	81.7	74.7
ROCKY MOUNTAIN			
	Small	50.5	57.8
	Large	49.5	42.2
TOTAL U.S.			
	Small	37.8	49.1
	Large	62.2	50.9

* Small = 5.0" - 14.9" DBH
Large = 15.0" + DBH

source: <u>Impacts of the Changing Quality of Timber Resources</u>, Poterfield, R. and Crist, J. Forest Products Research Society, Madison, WI. 1978 decreases in average log size have been documented (Erickson, 1978; Hypes, 1980). Both Erickson and Hypes found that mechanical harvesting systems, while more productive than manual harvesting systems in most cases, exhibited rapid declines in productivity in response to significant changes in log diameters.

In addition to changes in average log diameters, the use of intensive silvicultural practices on tree plantations have resulted, in some cases, in changes in wood composition. Table 3 provides a comparison of the specific gravity of some selected forest versus plantation grown conifers. In all cases the specific gravity of the plantation grown trees is less than the specific gravity of the forest grown trees. The importance of this quality change, however, depends primarily on the final wood product being produced. For some structural purposes this factor may be an important consideration.

Finally, government regulation has frequently been identified as a major source of inefficiency (Weidenbaum, 1979). To the extent that government regulations are a response to a market inefficiency--an external cost such as pollution for example--the cost of regulation in terms of lower levels of production can be justified on economic efficiency grounds. However, not all government regulations achieve their desired results. Further, the indirect costs of some regulations may exceed their benefits in terms of increased economic efficiency. Weidenbaum (1979) cites five major indirect or induced effects of regulation:

> "(1) The innovative product research and development that is not carried out because corporate R&D budgets increasingly are being devoted to what is termed 'defensive research'
> (2) The new investments in plant and equipment that are not made because the funds must be diverted to meeting government-mandated social requirements

Table 3. Specific gravity of plantation and forest grown conifers

Species	Plantation SG	Forest SG
European Larch	0.45	0.50
Jack Pine	0.43	0.46
Red Pine	0.39	0.51
Scotch Pine	0.44	0.49
Eastern White Pine	0.32	0.37
Norway Spruce	0.37	0.40

source: Impacts of the Changing Quality of Timber Resources, Poterfield, R. and Crist, J. Forest Products Research Society, Madison, WI. 1978

(3) The workers who are not hired because federal regulations have priced them out of the labor markets (i.e. minimum wage laws)
(4) The concentration of industry that results as smaller enterprises find that the burdens of government regulation fall on them disproportionately
(5) The immeasurable effects of government regulation on the basic entrepreneurial nature of the private enterprise system" (p. 38)

Worker safety regulations have been of particular concern to the lumber and wood products industries. Table 4 provides a breakdown of occupational injury and illness incident rates for the forest products sector. The lumber and wood products industries have experienced more than double the rates for the overall manufacturing sector.

The previous discussion can be summarized by the diagram in fig. 3. Cultural, institutional and legal factors together with resource quality requirements and economic factors determine the stock of available resources and conversely, the stock of resources influences cultural, institutional and legal arrangements. Exogenous changes in these factors result in dynamic allocation problems for a firm (or industry) and as previously discussed, the ability of firms to respond to these problems determines the extent to which productivity is influenced.

Technological Change and its Impact on Productivity Change

Research and study in the area of technological change has many dimensions. In the following brief discussion the interest is focused on only one aspect of technological change--its impact on productivity change. Within the context of technological change, productivity change is affected via the adoption of new technology.

Technological change can be more narrowly defined as "the process by which an idea or invention which fulfills a need is converted into the economy to create financial growth, exports and employment" (Cox,

Table 4. Occupational injury and illness incident rates

Year	Manufacturing	Lumber and Wood Products	Paper and Allied Products
----------------lost workdays per 100 full time workers--------------			
1972	62.6	145.2	76.4
1973	68.2	150.7	87.1
1974	72.7	156.5	85.8
1975	75.8	156.7	85.6
1976	79.5	167.3	94.8

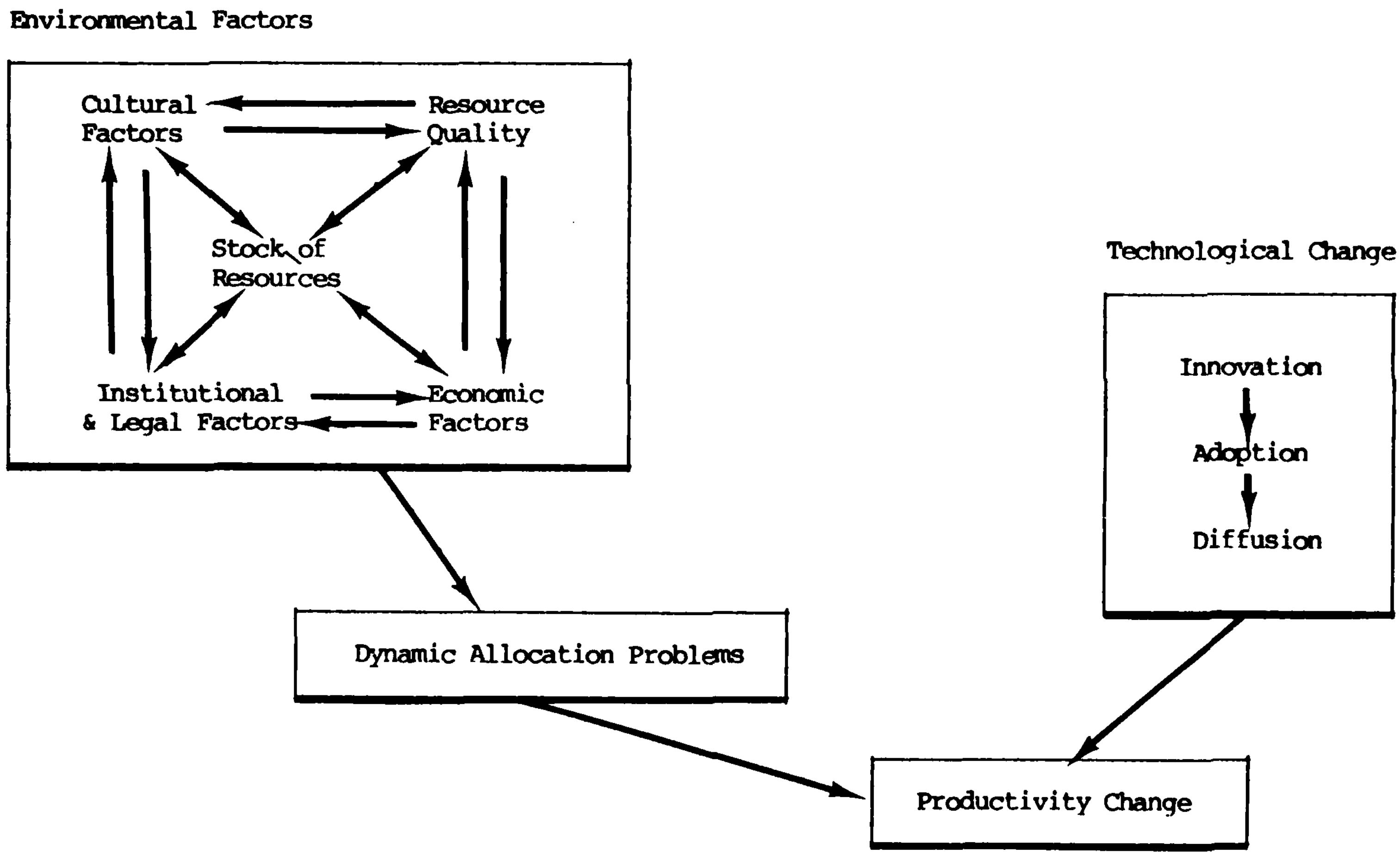


Fig. 3. Components of productivity change

1974). This process can generally be described as the process of innovation. The innovation process can be broken down into two components-the technical innovation process and the commercial innovation process. Technical innovation can be thought of as the process by which ideas are transformed into technically feasible products and production processes. Commercial innovation is the process by which technically feasible products and production processes are adapted and modified to become economically and institutionally feasible. The commercial innovation process draws heavily on the stock of existing technical innovations. As Mosteller (1981) points out, many successful commercial innovations were developed from existing technology. Commercial innovation can be conceptually separated into two broad categories--product innovations and process innovations. Product innovations include all new products-those that are substitutes for existing products and those that have entirely new uses. Process innovations involve changes in the production process itself, modifications to both existing manufacturing processes and entirely new manufacturing processes. Here, "manufacturing process" includes the entire scope of production including management, organization and marketing functions in addition to the mechanical process. Product innovations give rise to new industries. New industries are often characterized by the relatively rapid adoption of new processes (Hill and Utterback, 1980). And these process innovations contribute to productivity growth (Boretsky, 1980).

Within the context of economic production theory, productivity change occurs as producers manipulate technical configurations--technological change acts as a constraint on those changes. Technological change is represented in the context of economic production theory as a shift in the production function (see fig. 1a.). These shifts are either neutral or biased. A neutral change is consistent with a constant input factor ratio. Estimation of technological change, or total factor productivity generally takes two forms. As Sato (1970) points out,

> "There are a number of ways to approach the estimation of production functions and technical progress in economic growth, but from the standpoint of empirical analysis the following two seem most appropriate: (1) assume that the elasticity of substitution is constant and technical progress is neutral, and (2) assume that the production function has a variable elasticity of substitution together with nonneutral technical progress" (p.179)

Solow (1957) in a landmark study developed a method for estimating technological change (or total factor productivity). Many estimation procedures currently used are refinements of this basic approach. Intuitively, the estimation procedure can be described as one of estimating a production function for a base year and determining total factor productivity growth as the portion of observed output in a later period not accounted for by the estimated base year technology.

Assuming neutral shifts in the production function and that the function is twice continuously differentiable, production over time can be described by the equation:

$$y = A(t)\, f(X_1, X_2, \ldots, X_n)$$

where A(t) captures the cumulative shifts in the function over time. Totally differentiating with respect to time and dividing through by y yields:

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + A\left(\frac{\partial f}{\partial X_1}\frac{\dot{X}_1}{y} + \frac{\partial f}{\partial X_2}\frac{\dot{X}_2}{y} + \ldots + \frac{\partial f}{\partial X_n}\frac{\dot{X}_n}{y}\right) \qquad (I)$$

where $\dot{y}$, $\dot{A}$, $\dot{X}_1, \ldots, \dot{X}_n$ are time derivatives (i.e. y = dy/dt, etc.)

From the necessary conditions for producer equilibrium, the relative factor share of the ith factor input is equal to the output elasticity of that input. That is,

$$W_{xi} = \frac{\partial y}{\partial x_i} \frac{X_i}{y} = \sigma_{x_i} \qquad \text{(II)}$$

where $_{xi}$ is the putput elasticity and W_{xi} is the relative factor share value for the ith factor input. Noting that

$$\frac{\partial y}{\partial x_i} = A \frac{\partial f}{\partial x_i}$$

for the ith factor input, and together with (II), equation (I) can be rewritten as:

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + W_{x1} \frac{\dot{X}_1}{X_1} + W_{x2} \frac{\dot{X}_2}{X_2} + \ldots + W_{xn} \frac{\dot{X}_n}{X_n} \qquad \text{(III)}$$

or alternatively, the rate of productivity change over time can be expressed as:

$$\frac{\dot{A}}{A} = \frac{\dot{y}}{y} - W_{x1} \frac{\dot{X}_1}{X_1} - W_{x2} \frac{\dot{X}_2}{X_2} - \ldots - W_{xn} \frac{\dot{X}_n}{X_n}$$

which is simply the difference between the rate of growth of output and a weighted sum of the factor input growth rates. Then, an index of total factor productivity can be calculated as follows:

$$A(t+1) = A(t)\left(1 + \frac{\dot{A}(t)}{A(t)}\right) \qquad \text{(IV)}$$

Robinson (1975) applied this approach of measuring total factor productivity to the lumber and wood-products industry (SIC 24), obtaining an average annual rate of total factor productivity growth of 1.75 percent over the period 1949 to 1970. A significant limitation of the Solow approach to measuring total factor productivity is the implicit assumption of neutral technological change. In the case of the forest products industry, Robinson observed that over the period studied, the relative shares of the two factor inputs, labor and capital, were not constant but rather there has been a strong trend in the direction of the substitution of capital for labor suggesting the possibility of non-neutral technological change. Stier (1980) tested the hypothesis of non-neutral technical change in ten forest products industries and found that in eight of the industries, technological change has been labor-saving for the period 1958 - 1974 (implying that capital has been substituted for labor. This together with the findings of elasticities significantly less than one suggests that the substitution of labor for capital was achieved as a result of biased technological change (Stier, 1980).

More recently Greber and White (1982) analyzed and estimated biased technical changes in the lumber and wood products industry (SIC 24). They concluded that technological progress has been biased and the direction of the bias has been labor-saving throughout the period 1951 - 1973. Further, this biased technological progress is, in large part, responsible for the observed growth rate of industry output with the change in labor efficiency accounting for 122.0 percent and the change in capital efficiency accounting for 7.2 percent.

Risbrudt (1979) analyzed technological change four four forest products industries: logging (SIC 2411), sawmilling (SIC 2421), pulping (SIC 2611) and papermaking (SIC 2621) using three different estimating techniques. The average annual rate of total factor productivity change for the logging industry for the period 1958 - 1976 ranged from 3.4 to 3.8 percent. Increased mechanization (feller-buncher, wheeled skidders) allowing for the substitution of capital for labor and improved resource use (whole tree logging) were important factors contributing to the productivity growth rate (Risbrudt, 1979). The average annual rate of total factor productivity change for the sawmills and planing mills industry for the same period ranged from 0.9 to 1.8 percent. Capital improvements allowing for the substitution of capital for labor and compensation for a declining wood resource were important factors contributing to the productivity growth rate. The need to invest in pollution abatement equipment during the later part of the period may account for the relatively lower observed productivity growth rate (Risbrudt, 1979). The average annual rate of total factor productivity change for the pulping industry for the same time period ranged from 2.3 to 2.5 percent. The substitution of capital for labor resulting in part from the change in the product mix (shift to relatively more high quality paper) was an important factor contributing to the productivity growth rate. And, finally, the average annual rate of total factor productivity change for the paper industry for the same time period ranged from 0.7 to 2.4 percent. The introduction of new and faster industrial processes increasing output was an important factor contributing to the productivity growth rate.

Labor productivity growth

Labor productivity for U.S. manufacturing increased at an average annual rate of 2.7 percent between 1947 and 1973 compared with an average annual rate of 2.2 percent between 1973 and 1979 (Amercian Productivity Center, 1980). Productivity growth rates for the U.S. forest industries have followed a similar pattern. Changes in the labor productivity growth rates for some selected forest industries are shown in table 5. Productivity growth rates in all but the folding paperboard box industry were above the average for manufacturing during the period 1947 to 1973. Declines in productivity growth rates during the period 1973 to 1978 were, for the most part, more pronounced than the average for manufacturing. Wood household furnishing experienced the largest decline in productivity growth, falling 3.3 percent from 1947 - 1973 growth levels. Corrugated and solid fiber boxes recorded the lowest drop in productivity growth, falling 0.9 percent from 1947 - 1973 levels. While virtually all the forest products industries posted strong labor productivity growth rates for the period 1958 - 1973, the factors responsible for these observed productivity increases are varied. Technological changes in sawmills enabled firms to make significant factor substitutions of capital for labor. In addition, fluctuating levels of demand precipitated a drop in employment (Duke and Huffstutler, 1977). Increases in labor productivity in the folding paperboard box industry can be similarly characterized as resulting from factor substitution brought on by technological advances and declining employment levels in response to uneven levels of demand (York, 1980). However, weakening demand in this industry is the result of competitive pressures from packaging industries using synthetic materials, whereas uneven levels of demand in the sawmill industry are tied to the cyclical levels of demand in the housing market. The strong increases in labor productivity in the veneer and plywood industry are the result of a strong demand for softwood plywood and technological changes allowing for the use of lower grade materials (Farris, 1978).

Table 5. Average annual change in output per employee - hour.

Industry	1958 - 1973	1973 - 1978
	percent	
U.S. Manufacturing	2.7	2.2
Sawmills and Planing Mills	3.1	1.4
Paper, Paperboard and Pulpmills	4.0	2.1
Corrugated and Solid Fiber Boxes	3.5	2.6
Veneer and Plywood	5.0	2.7
Wood Household Furnishings	2.7	-0.6
Folding Paperboard Boxes	2.0	-0.1

source: Amercian Productivty Center, 1980, Productivity Prespectives (Amercian Productivity Center: Houston, Texas)
U.S. Department of Labor, Bureau of Labor Statistics, 1979, Productivity Indexes for Selected Industries Bulletin 2054, (U.S. Government Printing Office: Washington, D.C.)

Some important factors influencing technologically induced productivity change

The process of commercial innovation is critical since it is this process that can lead directly to increases in productivity. Commercial innovation occurs primarily as a response on the part of the firm to its operating environment (Hill and Utterback, 1988). One important source of environmental change is a changing relative price structure of input factors and outputs. Changing relative prices of outputs and inputs can adversely affect earnings and hence profits. The importance of changing relative prices in the commercial innovation process in agriculture has been documented by Binswanger and Ruttan (1978).

Competition within the sector and outside the sector is a source of relative price changes. Within the sector, the level of competition is often determined by both the number of producing firms and the ease of entry into the sector. Aggressive competition for materials inputs and output market shares results in relative price changes that often cannot be absorbed by profits. Outside the sector, competition from manufacturers of substitute products for market shares exerts pressure on prices. Competition for scarce material inputs from other industries can accelerate price increases. The adoption of new industrial processes to utilize wood residues as an energy source in the pulp and paper industry is an example of the response of an industry to changing relative prices of factor inputs. In this case the need was precipitated in an energy intensive industry by a rapid increase in the price of fossil fuels.

In addition to changes in economic conditions, the commercial innovation process can be initiated because of government intervention. Federal regulations may require the firms in an industry to modify some part of their production process. Pollution controls are one example of this type of legislation. Of course the effect of this type of control is a function of the extent to which the regulation is enforced. Changing technology in secondary markets can induce innovation in primary markets. The importance of this factor for the pulp and paper industry is summarized by Styan (1980).

> "Technological changes in press rooms and publishing houses and the need to stretch fiber resources will be the driving factors for innovation in North America's pulp and paper industry. This will result in a trend to high-quality, high-yield pulps and a reduced fiber usage per ton of pulp and paper produced." (p. 25)

Research, both basic and applied, is an important component of the innovation process. It has been argued that the level of research and development activity by firms has been too low (Nelson, 1959). And this low level of applied R&D has retarded commercial innovation. The output of R&D exhibits some characteristics of a public good--nonrival consumption. The incentive to invest in R&D is reduced since it may be difficult for the inventive firm to completely exclude other firms from the information output of the research activity. This point may be a relevant consideration for firms innovating to achieve a competitive advantage within the sector. However, firms reacting to economic pressures originating from outside the sector may have an incentive to cooperate.

Terleckyi (1980) has investigated the role of industrial research and development in the productivity growth of the manufacturing sector finding that privately financed industrial research and development had a significant effect, but that government financed R & D did not.

The flow of information from research can sometimes be enhanced by government policy and regulations. Patent laws require detailed specifications of new products and processes to be published providing a source of information to other firms. However, the effect on innovation is uncertain. Silberston (1975), in a study of the British patent system found that while product innovations are influenced positively by the presence of patent laws, process innovations are largely unaffected. Silberston argues that this result is not surprising since product innovations can be copied more readily by competing firms. Thus, the incentive to innovate is reduced in the absence of a patent system since the inventive firm cannot maintain a competitive advantage.

In a sense, the firm generates a schedule of needs and opportunities for change based on the flow of information entering the firm. This schedule of needs and opportunities depends on the goals and objectives, stated or unstated, of the decision makers in the firm. The process of identifying needs and opportunities is a continuous and dynamic process over time. Goals and objectives may be closely tied to the stage of development and the current technology of the firm (Utterback and Abernathy, 1975). An innovation that is incompatible with current technology is less likely to be adopted by firms in the short term than one which is compatible.

The current technology of a firm and its stage of development are closely related. Utterback and Abernathy (1975) identify three stages of development for products and production processes. For production processes these are: uncoordinated, segmental and systemic phases, and for products these are: performance-maximizing, sales-maximizing and cost-minimizing. In the uncoordinated stage the production process is "loose" and unstructured. As the technology progresses from this stage to the segmental stage the production process becomes more specialized. The final systemic stage is characterized by an almost rigid, highly complex and relatively efficient production process. As the firm progresses through these stages of development, process innovations become increasingly costly and difficult to institute. Product innovations in the form of increasing product differentiation are frequent as a firm moves from the performance-maximizing to the sales-minimizing stage. In the cost-minimizing stage, the product becomes standardized with the emphasis on cost reduction. Product and process stages of development are necessarily related. For example, a highly developed complex production process is virtually impossible without a fairly standardized product. In a highly competitive sector this process of development is a continuous one with new firms entering the sector and other firms leaving (Hill and Utterback, 1980). With high barriers to entry the process of development tends to stagnate at the costminimizing and systemic stages.

Restrictive government regulations may act as constraints on the actions of firms. Environmental restrictions, for example, may effectively preclude some innovations from consideration.

The innovation itself is also an important factor related to cost. Two important characteristics are complexity and scale. Complexity is the extent to which an innovation can be understood and implemented. A more complex innovation involves a higher learning cost and is more difficult to implement. Scale is the size of an innovation which can be incrementally applied. The smaller scale an innovation is, the less disruptive it will be in terms of the total investment.

Once a preliminary decision to act has been made, the innovation must be "fit" into the production process. This involves thoroughly evaluating the technical innovation(s) involved and suggesting any necessary modifications to the innovations and current production operations. Communication between development teams. marketing and production units within the firm is critical during this phase. O'Keefe and Charkrabarti (1981) have found that the coordination between research and marketing operations is critical to successful commercial innovation. They suggest that "development of rather close personal relationships among members of several departments, mutual understanding of the duties and responsibilities of each department and discussions of the implications involved in the information to be transfered and shared" is the key to successful commercial innovation. Cox (1974) suggests the use of technical entrepreneurs or venture managers. The venture manager provides the linkages between the different organizational units. It is his job to effectively remove any communication barriers and coordinate the commercial innovation process.

The decision to accept and adopt an innovation may often be based on a comparison of the observed results with expected results. Overly optimistic evaluations may result in a substantial discrepency between expectations and actual results. It is possible that this could adversely affect the adoption of that innovation. Once the decision to accept and adopt is made to apply the innovation on a larger scale. Performance evaluations of an innovation after application may have considerable importance in terms of diffusion of the innovation.

Summary

Productivity change has been examined within the context of economic production theory. Within this framework, the mechanisms of productivity change were described and the underlying factors involved in the change were examined. Environmental factors influence productivity depending on the degree to which firms can compensate for different supplies of input configurations through input factor substitution. This depends primarily on the physical nature of the production process. Changes in environmental factors, however, are not always manifested in input factor supply changes. Changing quality of input factors, particularly the labor input has been identified as an important source of productivity change. Technological changes influence productivity change through their impact on the technical configuration of the production process.

Chapter III

SURVEY OVERVIEW

Given the nature of the questions to be considered and the available resources, a mail survey appeared to be the most practical approach to collecting the needed data. Although there are many shortcomings associated with mail surveys, the benefits associated with a survey of this nature appeared to outweigh the costs. One of the most frequently encountered problems with mail survey is the low response rate often achieved. Among the most frequently cited responsible factors are: (1) sponsorship of the survey, (2) length of the questionnaire, (3) attractiveness of the questionnaire format, (4) nature of the cover letter, (5) ease of returning the completed questionnaire, and (6) the nature of the respondents (Dillman, 1978). Since surveys directed at the business community frequently have the lowest response rates, attempts were made to compensate for this in both the questionnaire format design, sample size and survey procedure. The "total design method", an integrated survey procedure, was utilized (Dillman, 1978). The survey was sponsored by the University of Minnesota Agricultural Experiment Station.

Survey Design

The mail survey questionnaire used in this study was developed over the summer of 1982. The questionnaire, cover letter, follow-up postcard and second mailing cover letter are found in Appendix II.

As a consequence of the conceptual model developed in chapter II, the sources of productivity change can be divided into two major categories--productivity changes as a result of technological changes and productivity changes resulting from changes in environmental factors which include cultural, institutional, legal and resource quality factors. Within this broad categorization, specific examples of factors were developed which apply to the forest products industries. The lists of factors used in this survey in parts I, II, and III were developed from discussions with industry representatives and from a review of the research literature. The list of factors from part I of the survey--factors contributing to the decline in the rate of productivity growth can be considered in the framework of the conceptual model as follows:

Environmental Factors

Resource Quality Factors

-decreasing average log size

-increased proportion of inexperienced unskilled workers in the labor force

Institutional/Legal Factors

-adversary labor(unions)-management relations

-cost of complying with environmental regulations

-cost of complying with worker safety regulations (OSHA)

-tax laws

-government harvesting policies on publicly owned timber lands

-rapid increases in the price of fossil fuels

Market Factors

-plants operating at less than full capacity as a result of volatile product markets (cyclical markets)

Technological Change

-limited commercial availability of new technology and equipment

-cost of new equipment

-barriers to diffusion of new technology through the industry

-finance cost of capital

-inadequate expenditure on research and development

As discussed in chapter II, resource quality factors such as decreasing average log size and increases in the proportion of inexperienced unskilled workers in the labor force can result in productivity growth declines to the extent that firms are unable to compensate for these effects. Unskilled, inexperienced workers may not be able to handle complex production equipment as efficiently as their skilled counterparts. Likewise, productivity growth rate declines are probable where production equipment designed to handle limited ranges of log diameters is being utilized when average log size is declining and falling outside these ranges. Obviously the impact of these factors depends on the degree of flexibility in the production process, an industry specific characteristic.

Legal factors such as environmental and worker safety regulations have required firms to divert some otherwise productive resources in order to comply. Similarly, adversary labor-management relations can result in significant resource diversions as well (Clark, 1980). And these diversions of otherwise productive resources can decrease the potential for productivity growth.

Factors such as government harvesting policies on public lands, rapid increases in the price of fossil fuels and cyclical markets can result in supply disruptions and adversely affect productivity growth to the extent that production processes cannot accommodate these disruptions (i.e. input factors can only be substituted within the constraints of existing production technology).

The factors listed under the technological change category relate to possible sources of inefficiencies in the technological change process. Since many forms of technological change in the forest products industries are developed outside the industry and are manifested in the forest industries in new equipment, the factors listed under this category relate primarily to problems encountered in the transfer and adoption of new capital embodied technology.

The list of factors from part II of the survey--factors stimulating an increase in the rate of productivity growth generally relate to different aspects of the innovation process. The factors: developing and implementing specialized employee training programs, establishing financial incentives programs for employees, establishing company-wide productivity improvement programs and increased mechanization induced by an inadequate labor supply are all innovations addressing factor input quality problems--in this case labor quality problems. Incidence of labor quality problems and the successes of these programs to alleviate thes problems are well documented in the literature. (Anvik, 1979; Bartholomew, 1977; Basken, 1979; Berger and Schwab, 1980; Greene and Podsakoff, 1978; McCord, 1975; Pickering, 1977; Bryan, 1979; Carter, 1980; Denison, 1980). The role of industrial research in industry productivity growth has been discussed by Terleckyi (1980), Griliches (1980) and Hart (1980). Cooperative research and development programs between companies has been suggested as a potential solution designed to overcome scale problems associated with the production of research and the public goods problems associated with research results.

Part III addresses public policy and program changes needed to encourage increases in the rate of productivity growth. In addition to the factor lists for parts I, II, and III of the questionnaire, space was provided for respondents to list any additional factors they believed to be important. Respondents were asked to indicate the degree to which they believed each item to be important in the situation described in each part by checking one of the four listed "levels of importance"--very important, moderately important, slightly important or not important and to rank the five factors they believed to have had the greatest influence.

Pretest

The survey was sent to nine structural particleboard plants in September 1982. In addition to requesting respondents viewpoints, they were asked to include any comments regarding the content and style of the questionnaire. Responses for this sample were generally complete. At least half of the respondents provided additional factors under the open-ended "other" item although no respondents offered any suggestions for change in the questionnaire content and style.

Sample Design

The survey questionnaire was sent to plant and mill managers from eight industry product categories--softwood lumber, hardwood lumber, softwood plywood, hardwood plywood and veneer, particleboard, pulp, paper and paperboard, and fibreboard, hardboard and MDF. These eight product categories roughly comprise the primary forest-based manufacturing sector. Individual plants were chosen as the sampling unit since industry viewpoints at the production level were desired. It was felt that production managers would be the most familiar with daily operations and would be able to effectively judge the listed factors as sources of productivity change.

The sample was obtained from plant and mill listings from the 1982 Directory of Forest Products Industry and the 1982 Lockwood's Directory. These directories are representative of the population of plants and mills for all product categories except hardwood and softwood lumber. Most states publish exhaustive directories of sawmills. However, the directories are frequently dated. Since the industry is characterized by rapid turnover, the use of dated directories would likely result in lower response rates due to a higher proportion of closed mills. Sample sizes for each industry group were determined based on expected response rates and available resources (table 6). The fibreboard, hardboard, MDF, the structural particleboard and the particleboard product groups were sampled completely. The sample sizes for hardwood and softwood lumber were larger due to expected lower response rates. The industry group samples were stratified by geographical region--west, south and mideast. A breakdown of these regions is provided in Appendix 1. Since the cost of sampling is identical for all regions, the sample sizes for each region were allocated proportionally according to population sizes for each region and product group (Cochran, 1963). The final sample was chosen by assigning each plant in every product category and geographical region a number and then randomly selecting plants from the list.

Survey Procedure

All plants in the sample were sent a questionnaire, background information sheet, cover letter explaining the survey and requesting

Table 6. Sample sizes

Product Group	Region West	Region South	Region Mideast	Total	Number Plants	Sampling Rate
Hardwood Lumber	4	62	84	150	1525	0.10
Softwood Lumber	93	49	8	150	1222	0.12
Pulp, Paper, Paperboard	13	26	61	100	715	0.14
Softwood Plywood	60	38	2	100	178	0.56
Hardwood Plywood, Veneer	28	45	27	100	375	0.27
Fibreboard, Hardboard, MDF	16	24	18	58	58	1.00
Structural Particleboard	2	5	11	18	18	1.00
Particleboard	22	31	9	62	62	1.00

participation and a stamped addressed envelope for returning the completed questionnaire. Two to three weeks later a follow-up postcard was sent to all plants in the sample. And two to three weeks later another questionnaire and cover letter requesting participation and a stamped addressed envelope were sent to all non-respondents.

Returned questionnaires were checked for completeness and coded. Four hundred and fifty-one of the 738 questionnaires were returned for an overall response rate of 61 percent. Table 7 gives the response rates by industry group and geographical region. Response rates for hardwood and softwood lumber were considerably higher than expected and response rates for the pulp, paper and paperboard, the softwood plywood and the hardwood plywood and veneer were lower than expected a priori.

The effective overall response rate of 52 percent is low relative to other surveys using the total design method (Dillman, 1978).

Non-respondent Bias--A Sensitivity Analysis

A limitation of mail surveys is the possibility of biased results arising from a sample that is not representative of the underlying population in spite of a carefully chosen statistically sound sampling scheme. This bias can occur if the survey non-respondents (or respondents) as a group systematically exhibits a characteristic or set of characteristics to a greater degree than the underlying population. An obvious example is a situation where a canvasser samples households from a predetermined sample list in the afternoon. In this case the survey respondents as a group are likely to contain a much higher proportion of unemployed persons than the underlying population since in the afternoon it is unlikely that many employed persons would be home.

Table 7. Response rates

Product Group	Region						Total	
	West		South		Mideast			
	Number Returned	Response Rate	Number Returned	Response Rate	Number Returned	Response Rate	Number Returned	Sampling Rate
Hardwood Lumber	4	1.00	22	0.35	51	0.61	77	0.51
Softwood Lumber	51	0.55	26	0.53	7	0.88	84	0.56
Pulp, Paper, Paperboard	4	0.31	14	0.54	27	0.44	45	0.45
Softwood Plywood	27	0.45	14	0.37	2	1.00	43	0.43
Hardwood Plywood, Veneer	9	0.32	24	0.53	11	0.41	44	0.44
Fiberboard, Hardboard, MDF	12	0.75	14	0.58	13	0.72	39	0.67
Structural Particleboard	1	0.50	0	0.00	5	0.45	6	0.33
Particleboard	17	0.77	21	0.68	6	0.67	44	0.71
Totals	125	0.53	135	0.48	122	0.55	382	0.52

Table 8. Breakdown of Unusable Survey Responses

Reason	Number Returned
Out of Business	32
Insufficient Information	23
Refused to Participate	14
Total	69

In this case both the potential source of bias and the action for alleviating the bias are quite clear--sample at a different time! In many cases however, the nature of any potential bias cannot be directly observed and the procedures for eliminating the bias are unavailable to the researcher. However the importance of non-respondent bias decreases as the response rate increases.

A somewhat limited analysis of non-respondent bias and the possible effects of that bias on the productivity survey results was carried out for part I--factors contributing to the decline in the rate of productivity growth. Survey responses obtained after the first mailing and reminder postcard were identified as "the first mailing" and coded accordingly. Survey responses obtained after the second mailing were similarly identified and coded. Since the second mailing was sent only to those plants and mills that had not previously responded, the second mailing can be considered as a sample of non-respondents relative to the first mailing group. To determine the possible effects of non-respondent bias, both groups from the first and second mailing groups were pooled. Since the objective is to analyze any interactions between the importance level of factors with industry groups and geographical regions, two-way frequency tables of importance levels by geographical region and importance levels by industry group were constructed for the pooled group and the first mailing group. The level of significance of the chi-square test statistic for dependence is reported in tables 9 and 10 for each factor. Comparing the first mailing group results with the pooled group results show that for the importance level by product group interaction analysis there are some inconsistencies; however, the importance level by geographical region interaction analysis results are consistent.

Table 9. Significance Levels of Factors Contributing to the Decline in the Rate of Productivity Growth by Industry Group for the First and Pooled Mailing Groups

Factor	p-values Pooled Mailing	First Mailing
Decreasing Average Log Size	0.000*	0.000*
Rapid Price Increases in Fossil Fuels	0.002	0.228
Inexperienced, Unskilled Workers	0.056*	0.199*
Adversary Mgmt-Labor Relations	0.023	0.365
Cyclical Markets	0.159*	0.449*
Limited Availability of New Technology	0.082*	0.428*
Cost of New Equipment	0.320*	0.347*
Barriers to Diffusion of New Technology	0.251*	0.906*
Finance Cost of Capital	0.475*	0.782*
Low R&D Expenditures	0.034	0.451
Cost of Environmental Regulations	0.057	0.022
Cost of Worker Safety Regulations	0.005*	0.004*
Tax Laws	0.018	0.352
Government Harvesting Policies	0.001*	0.001*

* indicates consistent results (i.e. both are either significant or not significant) between the pooled group and the first mailing group.

Table 10. Significance Levels of Factors Contributing to the Decline in the Rate of Productivity Growth by Geographical Region for the First and Pooled Mailing Groups

Factor	p-values Pooled Mailing	p-values First Mailing
Decreasing Average Log Size	0.338*	0.390*
Rapid Price Increases in Fossil Fuels	0.658*	0.818*
Inexperienced, Unskilled Workers	0.007*	0.008*
Adversary Mgmt-Labor Relations	0.224*	0.466*
Cyclical Markets	0.840*	0.285*
Limited Availability of New Technology	0.057*	0.055*
Cost of New Equipment	0.054*	0.139*
Barriers to Diffusion of New Technology	0.702*	0.810*
Finance Cost of Capital	0.649*	0.567*
Low R&D Expenditures	0.739*	0.606*
Cost of Environmental Regulations	0.257*	0.105*
Cost of Worker Safety Regulations	0.442*	0.622*
Tax Laws	0.422*	0.098*
Government Harvesting Policies	0.000*	0.000*

* indicates consistent results (i.e. both are either significant or not significant) between the pooled group and the first mailing group.

Inconsistent results between the pooled group and the first mailing group could arise from (1) differences in the sample size and/or (2) differences in respondent characteristics. To examine differences in respondent characteristics for the first and second mailing groups, the proportion of industry groups and the regional distributions were tabulated. These data are presented in tables 11 and 12. With the exception of the softwood lumber industry group, the distribution of industry groups for the first and second mailing groups are very similar. The regional distribution of respondents for the first and second mailing groups are close as well. Relative rankings of the important factors were used as a rough indicator of differences in the characteristics of the first and second mailing groups. Characteristic differences between samples such as the relative composition of large and small plants and/or successful and unsuccessful plants in the two samples may be manifested in respondent differences in the relative rankings of the factors. Table 13 provides a breakdown of these relative rankings for the pooled and first mailing groups. At this level there are no apparent differences between the samples. However, if the relative rankings are considered at the industry level, some differences can be seen. Three industry groups, the hardwood lumber, the particleboard and the fibreboard, hardboard and MDF groups exhibit differences in their relative rankings between the first and second mailing groups. These differences are as follows:

-Hardwood lumber, three most important factors

first mailing group

(1) finance cost of capital

Table 11. Distribution of Industry Groups for the First and Second Mailing Groups

Product Group	First Mailing		Second Mailing	
	Number	Proportion	Number	Proportion
Hardwood Lumber	48	0.20	29	0.21
Softwood Lumber	46	0.19	38	0.27
Pulp, Paper, Paperboard	31	0.13	14	0.10
Softwood Plywood	28	0.11	15	0.11
Hardwood Plywood, Veneer	29	0.12	15	0.11
Fibreboard, Hardboard, MDF	26	0.11	13	0.09
Structural Particleboard	4	0.02	2	0.01
Particleboard	32	0.13	12	0.09
Total	244		138	

Table 12. Regional Distribution of Respondents for the First and Second Mailing Groups

Geographical Region	First Mailing		Second Mailing	
	Number	Proportion	Number	Proportion
West	84	0.34	41	0.30
South	82	0.34	53	0.38
Mideast	78	0.32	44	0.32
Total	244		138	

Table 13. Relative Rankings of the Important Factors Contributing to the Decline in the Rate of Productivity Growth for the First, Second and Pooled Mailing Groups

Factor	Relative Rank		
	Pooled Mailing	First Mailing	Second Mailing
Decreasing Average Log Size	7	7	5
Rapid Price Increases in Fossil Fuels	5	5	6
Inexperienced, Unskilled Workers	11	11	11
Adversary Mgmt-Labor Relations	6	6	7
Cyclical Markets	2	2	3
Limited Availability of New Technology	13	13	14
Cost of New Equipment	3	3	2
Barriers to Diffusion of New Technology	14	14	13
Finance Cost of Capital	1	1	1
Low R&D Expenditures	12	12	12
Cost of Environmental Regulations	4	4	4
Cost of Worker Safety Regulations	10	10	10
Tax Laws	9	9	9
Government Harvesting Policies	8	8	8

(2) cost of new equipment

(3) decreasing average log size

second mailing group

(1) cost of new equipment

(2) finance cost of capital

(3) tax laws

-Particleboard, three most important factors

first mailing group

(1) cyclical markets

(2) finance cost of capital

(3) cost of new equipment

second mailing group

(1) finance cost of capital

(2) cyclical markets

(3) cost of environmental regulations

-Fibreboard, Hardboard, MDF

first mailing group

(1) cyclical markets

(2) cost of environmental regulations

(3) finance cost of capital

second mailing group

(1) finance cost of capital

(2) rapid price increases in the price of fossil fuels

(3) cyclical markets

Based on the results listed in tables 9 and 10, these differences have a small impact. Out of fourteen factors only five have inconsistent results and only when cross classified by product group. With the exception of the factor: cost of environmental regulations, the factors yielding inconsistent results were not listed in the top five important factors contributing to the decline in the rate of productivity growth.

Chapter IV

CATEGORICAL DATA ANALYSIS -- THEORY

Introduction

Categorical data analysis is a set of statistical techniques used to investigate statistical relationships between multidimensional discrete cross-classified categorical variables. In the U.S. forest industries productivity growth survey there are three such variables -- industry group, geographical region and the level of importance assigned by questionnaire respondents for each listed factor in questionnaire parts I, II, and III. Each factor in questionnaire parts I, II, and III will be analyzed separately. Statistical relationships between the levels of importance for each factor, industry group and geographical region were analyzed using the following basic approach:

(1) three-dimensional contingency tables were set up for each factor with importance level cross-classified by industry group and geographical region. Each cell in the contingency table corresponds to the frequency counts for each level of importance given the industry group and geographical region. Since there are four levels of importance, eight industry group categories and three geographical regions, this 4x8x3 table has 96 cells.

(2) The three-dimensional contingency table of observed frequencies is then compared with a hypothetical table of expected frequencies determined by assuming an hypothesis concerning the statistical relationships between the categorical variables.

(3) A test statistic is then constructed based on the difference between the table of observed frequencies and the table of expected frequencies based on the proposed model in order to determine if the observed data are statistically consistent with the proposed model.

(4) Model components were then analyzed to ascertain the nature of the relationships among the variables.

Definitions, Concepts and Notation

The following discussion is adapted from Fienberg (1981), The Analysis of Cross-Classified Categorical Data. For each factor, a three-dimensional contingency table can be constructed with importance level cross-classified by industry group and geographic region. Of the three categorical variables, importance level, industry group and geographical region, industry group and geographical region can be thought of as explanatory variables and importance level as a response variable. The number of observations in both industry group and geographical region were fixed by experimental design. The three-dimensional table has the general form IxJxK where I refers to the importance level, J to the industry group and K to the geographical region. Specifically, we have a 4x8x3 contingency table with four levels of importance -- very important, moderately important, slightly important and not important -- eight industry groups -- softwood lumber, hardwood lumber, softwood plywood, hardwood plywood and veneer, particleboard, structural particleboard, pulp, paper and paperboard, and fibreboard, hardboard and MDF -- and three geographical regions -- west, south and mideast. The following notation will be used throughout the subsequent discussion:

x_{ijk}	refers to the frequency count of an arbitrary cell of importance level i, industry group j, and geographical region k.
$x_{+++} = \sum_i \sum_j \sum_k x_{ijk} = N$	sum of all cell frequencies.
$x_{i++} = \sum_{jk}\sum x_{ijk}$	4x1 vector of marginal cell frequencies.
$x_{+j+} = \sum_{ik}\sum x_{ijk}$	8x1 vector of marginal cell frequencies.
$x_{++k} = \sum_{ij}\sum x_{ijk}$	3x1 vector of marginal cell frequencies.
$x_{+jk} = \sum_i x_{ijk}$	8x3 matrix of marginal cell frequencies.
$x_{ij+} = \sum_j x_{ijk}$	4x8 matrix of marginal cell frequencies.
$x_{i+k} = \sum_k x_{ijk}$	4x3 matrix of marginal cell frequencies.
m_{ijk}	refers to the expected frequency count of an arbitrary cell of importance level i, industry group j, and geographical region k under some hypothesis concerning the statistical relationship between importance level, industry group and geographical region.
$\hat{m}_{ijk}$	refers to the maximum likelihood estimate (MLE) of the expected frequency count of an arbitrary cell of importance level i, industry group j and geographical region k.

And, m_{+++}, m_{i++}, m_{+j+}, m_{++k}, m_{ij+}, m_{i+k}, m_{+jk}, are defined analogously to x_{+++}, x_{i++}, x_{+j+}, x_{++k}, x_{ij+}, x_{i+k}, x_{+jk}. All models to be considered are special cases of the general loglinear model:

$$\log m_{ijk} = u + u_1(i) + u_2(j) + u_3(k) + u_{12}(ij) + u_{13}(ik) + u_{23}(jk) + u_{123}(ijk)$$

subject to the constraints:

$$\sum_i u_1(i) = \sum_j u_2(j) = \sum_k u_3(k) = 0$$

$$\sum_i u_{12}(ij) = \sum_j u_{12}(ij) = \sum_i u_{13}(ik) = \sum_k u_{13}(ik) = \sum_j u_{23}(jk) = \sum_k u_{23}(jk) = 0$$

$$\sum_i u_{123}(ijk) = \sum_d u_{123}(ijk) = \sum_k u_{123}(ijk) = 0$$

$u=(1/96) \sum\sum\sum_{ijk} \log m_{ijk}$ and represents the "grand mean"; the other u-terms represent deviations from this grand mean. In the general model above, subscript 1 refers to categorical variable importance level, subscript 2 refers to categorical variable industry group and subscript 3 refers to categorical variable region. Then,

$$u_1(i) = 1/24 \sum\sum_{ji} \log m_{ijk} - u$$

$$u_2(j) = 1/12 \sum\sum_{ik} \log m_{ijk} - u$$

$$u_3(k) = 1/32 \sum_{ij} \log m_{ijk} - u$$

$$u_{12}(ij) = 1/3 \sum_{k} \log m_{ijk} - u$$

$$u_{13}(ik) = 1/8 \sum_{j} \log m_{ijk} - u$$

$$u_{23}(jk) = 1/4 \sum_{i} \log m_{ijk} - u$$

$$u_{123}(ijk) = \log m_{ijk} - u$$

Since the number of observations in both industry group and geographical region were fixed by experimental design (i.e. the sample was exogenously determined based on survey cost), the relevant sampling model is product multinominal (Fienberg, 1981). For each factor, the level of importance can be thought of as a response variable and industry group and geographic region as explanatory variables. Under a product-multinominal sampling scheme, only models which include u-terms corresponding to the fixed variables are considered (Fienberg, 1981).

Models

Three model types will be considered. These are (1) independence of one variable from both of the two remaining variables, (2) independence of two variables, conditional on the third variable, and (3) no three-factor interaction. All models must include the $u_{23}(jk)$ term since these two variables, 2 (industry group) and 3 (geographical region) are fixed by experimental design.

Model Type 1 -- joint independence

The only model of this type to be considered is, independence of importance level with the industry group and geographical region jointly. This model corresponds to setting the terms $u_{13}(ik) = u_{12}(ij) = u_{123}(ijk) = 0$ in the general loglinear model. To determine the expected frequency count, m_{ijk}, form the following marginal totals:

$$m_{+++} = e^{u} \sum_{ijk} e^{u_1(i) + u_2(j) + u_3(k) + u_{23}(jk)} \qquad \text{(I)}$$

$$m_{i++} = e^{u + u_1(i)} \sum_{jk} e^{u_2(j) + u_3(k) + u_{23}(jk)} \qquad \text{(II)}$$

$$m_{+jk} = e^{u + u_2(j) + u_3(k) + u_{23}(jk)} \sum_{i} e^{u_1(i)} \qquad \text{(III)}$$

Recall that:

$$m_{ijk} = e^{u + u_1(i) + u_2(j) + u_3(k) + u_{23}(jk)}$$

under the assumptions of the model. Then, multiplying (I) and (II) and dividing the result by (III) yields:

$$m_{ijk} = \frac{m_{i++}\ m_{+jk}}{m_{+++}}$$

Since $\{x_{i++}\}$, $\{x_{+jk}\}$, and $\{x_{+++}\}$ are the complete minimal sufficient statistics for $\{m_{i++}\}$, $\{m_{+jk}\}$, and $\{m_{+++}\}$, the expected values can be expressed as:

$$m_{ijk} = \frac{x_{i++}\ x_{+jk}}{N}$$

Model Type 2 -- conditional independence

Two models of this type will be considered.

(a) given industry group, importance level is independent of region. This model corresponds to setting the terms $u_{13}(ik) = u_{123}(ijk) = 0$ in the general loglinear model. The expected frequency cell count under this model is:

$$m_{ijk} = \frac{m_{ij+}\, m_{+jk}}{m_{+j+}}$$

Since $\{x_{ij+}\}$, $\{x_{+jk}\}$, and $\{x_{+j+}\}$ are the complete minimal sufficient statistics for $\{m_{ij+}\}$, $\{m_{+jk}\}$, and $\{m_{+j+}\}$, the expected values can be expressed as:

$$m_{ijk} = \frac{x_{ij+}\, x_{+jk}}{x_{+j+}}$$

(b) given region, importance level is independent of industry group. This model corresponds to setting the terms $u_{12}(ij) = u_{123}(ijk) = 0$ in the general loglinear model. The expected frequency cell count under this model is:

$$m_{ijk} = \frac{m_{i+k}\, m_{+jk}}{m_{++k}}$$

Since $\{x_{i+k}\}$, $\{x_{+jk}\}$, and $\{x_{++k}\}$ are the complete minimal sufficient statistics for $\{m_{i+k}\}$, $\{m_{+jk}\}$, and $\{m_{++k}\}$, the expected values can be expressed as:

$$m_{ijk} = \frac{x_{i+k}\, x_{+jk}}{x_{++k}}$$

Model Type 3 -- no-three-factor interaction

The third model type involves the following set of pairwise relations between the variables:

-importance level and product group

-importance level and geographical region

-product group and geographical region

Each pair of interactions is independent of the excluded variable. Under this model the expected cell frequencies m_{ijk} can only be e)ressed as unspecified functions of the two dimensional marginal totals $\{x_{ij+}\}$, $\{x_{+jk}\}$ and $\{x_{i+k}\}$. (1) Expected cell frequencies are estimated using an iterative procedure.

Model Selection

If the model under consideration is correct then both of the statistics:

$$X^2 = \frac{\text{(observed cell freq. - expected cell freq.)}^2}{\text{expected cell freq.}}$$

$$G^2 = 2 \quad \text{(observed cell freq.)} \log \frac{\text{observed cell freq.}}{\text{expected cell freq.}}$$

are distributed chi-square with degrees of freedom (d.f.) equal to the difference between the total number of cells and the total number of fitted parameters (i.e. the u-terms in the model under consideration). In this case, the null hypothesis is that the proposed model is "true." That is,

H_0 : observed cell frequencies = expected cell frequencies

H_a : observed cell frequencies = expected cell frequencies

A "good fit", then, corresponds to a test statistic values consistent with accepting the null hypothesis at a 95 percent confidence level--

that is, test statistic values not in the upper 5 percent tail of the corresponding chi-square distribution.

In some cases more than one model may fit the data. When one (or more) of the acceptable models is a special case of another, i.e. model (1) $u_{13}(ik) = u_{123}(ijk) = 0$ is a subset of model (2) $u_{123}(ijk)$, a new test statistic, $G^2{}_2 - G^2{}_1$ can be constructed. This new statistic, $G^2{}_{21}$ is distributed chi-square with d.f.(2-1) = d.f.(2) - d.f.(1), under the null hypothesis that model (2) is correct and is used to test the following hypothesis:

$H_0 : u_{13}(ik) = 0$

$H_a : u_{13}(ik) \neq 0$

The difference between the models (1) and (2) is the inclusion, in model (1), of the interaction term $u_{13}(ik)$. Large values of $G^2{}_{12}$ (i.e. values in the upper 5 percent tail of the corresponding chi-square distribution) are consistent with rejecting H_0--that is choosing model (2). The following criteria were used to select a model (Everitt, 1977):

(1) only models with significant test statistic values for X^2 and G^2 were considered.

(2) the simplest (i.e. the model with the fewest estimated parameters) model that fits the data adequately will be selected.

(3) when more than one model yielded significant test statistics and some models under consideration were special cases of others, new test statistics were constructed and used to choose between the models.

(4) Operationally these criteria were translated into the following procedure. For example, suppose all the fitted models yielded significant test statistics. The four models form sets of hierarchial models:

(a) $u_{12}(ij) = u_{13}(ik) = u_{123}(ijk) = 0$

(b) $u_{12}(ij) = u_{123}(ijk) = 0$

and

(a) $u_{12}(ij) = u_{13}(ik) = u_{123}(ijk) = 0$

(b) $u_{13}(ik) = u_{123}(ijk) = 0$

Within each set of hierarchial models, model (a) is a subset of model (b). Using this information, a new "best" model can be choosen from each set of models by constructing new test statistics $G2_{ab} = G2_a - G2_b$ for each set of models. Starting with model (a), the test statistic $G2_{ab}$ is constructed. If this test statistic is consistent with choosing model (a), than (a) is the final choice. Otherwise check:

(b) $u_{12}(ij) = u_{123}(ijk) = 0$

(c) $u_{123}(ijk) = 0$

and

(b) $u_{13}(ik) = u_{123}(ijk) = 0$

(c) $u_{123}(ijk) = 0$

$G^2_{bc} = G^2_b - G^2_c$. If G^2_{bc} is consistent with choosing either model (b) then the appropriate conditional independence model will be chosen otherwise the no-three-factor interaction model, $u_{123}(ijk)=0$ will be selected.

Estimated interaction parameters can be examined to determine which effects are significant by checking their standardized values. A standardized

value is the ratio of the parameter estimate and its standard error. This value is distributed asymptomatically normal with the sign indicating the direction of the effect. A significant effect then, is an effect whose standardized value is greater than or equal to the $\pm$ 1.96--the 5% normal deviate.

Chapter V

SURVEY RESULTS

Introduction

Survey data for each factor in questionnaire parts I, II, and III were fitted to each of the four models described in chapter IV. Results from this fitting procedure are described in Appendix II. Of the fourteen factors listed in questionnaire part I, the joint independence model adequately described nine of those factors implying that for those nine factors there was no apparent statistical relationship between factor importance level, product group and geographical region. Of the nine factors listed in questionnaire part II, the joint independence model adequately described five of the factors and of the eight policies listed in questionnaire part III, the joint independence model adequately described four of the policies. Other factors for questionnaire parts I, II, and III were fit to either of the conditional independence models or the no-three-factor interaction model. The saturated three-way interaction model was not found to adequately describe the survey data results for any of the factors.

Questionnaire part I -- factors contributing to the decline in the rate of productivity growth

The factors: decreasing average log size, rapid increases in the price of fossil fuels and the cost of complying with environmental regulations were described best with the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$, where importance level is independent of geographical region controlling for product group effects. The product group effects can be examined by checking the estimated $u_{12}(ij)$ standardized values. These values are shown in table 14 for the factor: decreasing average log size. For the softwood and hardwood lumber product groups the standardized values corresponding to the "very important" category are positive and significant and the values corresponding to the "not important" category are negative and significant indicating that respondents in both of these product groups recognized this factor to be very important. The results are inconclusive for the softwood plywood, the hardwood plywood and veneer and the structural particleboard product groups. The negative and significant standardized value in the "not important" category under the softwood plywood product group suggests that this factor is important but none of the other positive importance level categories have corresponding significant values. None of the importance level categories show significant standardized values for both the hardwood plywood and veneer and the structural particleboard product groups providing no information concerning the relative importance of this factor for these groups. Positive and significant standardized values under the "not important" category for both the particleboard and the fibreboard, hardboard and MDF product groups indicate the lack of importance survey respondents in these groups associated with this factor. Finally, the strongly significant and positive standardized value under the category "slightly important" for the pulp, paper and paperboard product group indicated that survey respondents in this product group view this factor as having a low, but positive degree of importance. These results are to be expected as the general manufacturing processes in the softwood and hardwood lumber product groups utilize whole logs.

Table 14. Standarized values for the parameter, $u_{12}(ij)$, for the factor: decreasing average log size under the model $u_{13}(ik) = u_{123}(ijk) = 0$

	Product Group							
Importance Level	Softwood Lumber	Hardwood Lumber	Softwood Plywood	Hardwood Plywood, Veneer	Particle-board	Structural Particle-board	Pulp, Paper, Paperboard	Fibreboard Hardboard MDF
Very Important	2.423*	3.375*	1.009	1.267	-0.623	-0.088	-2.259*	-3.371*
Moderately Important	0.836	1.368	1.018	0.733	-1.379	-0.697	-1.502	-0.635
Slightly Important	-0.648	-1.824	0.138	-1.228	-1.220	-0.418	3.006*	1.161
Not Important	-2.425*	-2.329*	-2.069*	-1.105	2.471*	0.888	1.149	2.879*

* indicates a value in the 5% tails of the standard normal distribution

The estimated $u_{12}(ij)$ standardized values under the conditional independence model for the factor: rapid increases in the price of fossil fuels are shown in table 15. For both the pulp, paper and paperboard and the fibreboard, hardboard and MDF product groups, the positive and significant standardized values associated with the "very important" category indicate that survey respondents in these groups view this factor as important. Results for the remaining product groups are inconclusive. For the softwood lumber, the hardwood lumber, the softwood plywood, the hardwood plywood and veneer and the particleboard product groups, all the standardized values are insignificant. The negative and significant value corresponding to the "very important" category for the structural particleboard product group suggests that the survey respondents in this product group did not attach a high degree of importance to this factor. However, since the standardized values in the other three importance level categories are not significant, inferences regarding the importance or lack of importance of this factor cannot be made given these data.

The forest products industries can be generally characterized as energy intensive industries. There has, however, been a steady trend in the forest products industries of the substitution of wood residues as an energy source for conventional fossil fuels. Of all the industry groups, the pulp, paper and paperboard industry group is the most energy intensive therefore, it is not surprising that this group is positively related to importance level. The positive relation of the fibreboard, hardboard and MDF industry group with importance level may be related to the relatively larger number of older plants in this industry which have not yet converted to wood residue energy use.

Table 15. Standardized values for the parameter, $u_{12}(ij)$, for the factor: rapid increases in the price of fossil fuels under the model $u_{13}(ik) = u_{123}(ijk) = 0$

	Product Group							
Importance Level	Softwood Lumber	Hardwood Lumber	Softwood Plywood	Hardwood Plywood, Veneer	Particle-board	Structural Particle-board	Pulp, Paper, Paperboard	Fibreboard Hardboard MDF
Very Important	-1.455	0.431	-1.637	-0.756	-1.112	-2.388*	2.561*	2.725*
Moderately Important	-1.182	-0.264	-0.701	-0.407	1.526	-0.181	0.018	-0.483
Slightly Important	0.222	-0.742	0.874	-0.782	-0.886	0.708	-1.375	-0.931
Not Important	1.210	-0.278	0.541	-0.442	-0.073	-1.174	-1.027	-1.127

* indicates a value in the 5% tails of the standard normal distribution

The estimated $u_{12}(ij)$ standardized values under the conditional independence model for the factor: cost of complying with environmental regulations are shown in table 16. The positive and significant standardized value corresponding to the "very important" category for the hardwood lumber product group indicates that respondents in this group consider this factor to be very important. The positive and significant values associated with the "slightly important" category for the pulp, paper and paperboard product group suggest that this factor has some importance for this industry group as well. Results for the other six industry groups are inconclusive. None of the standardized values for the softwood lumber, the softwood plywood, the structural particleboard and the fibreboard, hardboard and MDF product groups are significant. The negative and significant standardized value under the "very important" category for the particleboard product group suggest that survey respondents in this industry group did not attach a high degree of importance to this factor. However, since the values in the other three importance level categories are not significant, inferences concerning the importance or lack of importance of this factor cannot be made given the data. Results for the hardwood plywood and veneer product group are ambiguous as well. Standardized values for all categories except "slightly important" are insignificant. A negative and significant value for this category would suggest that survey respondents don't regard this factor as mildly important but no conclusions regarding the importance or lack of importance can be made given these data.

The high degree of importance associated with the hardwood lumber industry group for this factor may be attributed to the lack of a high profit margin together with steady but not increasing demand providing

Table 16. Standardized values for the parameter, $u_{12}(ij)$, for the factor: cost of complying with environmental regulations under the model $u_{13}(ik) = u_{123}(ijk) = 0$

Importance Level	Product Group: Softwood Lumber	Hardwood Lumber	Softwood Plywood	Hardwood Plywood, Veneer	Particle-board	Structural Particle-board	Pulp, Paper, Paperboard	Fibreboard Hardboard MDF
Very Important	-1.379	-2.661*	0.280	0.670	-2.078*	-1.500	-1.418	-0.094
Moderately Important	-0.090	-0.453	-0.303	0.378	0.149	-0.150	-0.498	-0.660
Slightly Important	0.334	-2.246*	0.528	-2.600*	1.598	-1.925	2.219*	1.066
Not Important	-1.848	-0.796	-1.870	-0.622	0.525	0.315	-0.405	0.058

* indicates a value in the 5% tails of the standard normal distribution

few opportunities for adoption of new technology. Any factor then which could potentially increase production costs would be viewed with concern. The pulp, paper and paperboard industry has been faced with a similar situation but a strong and expanding demand and higher average profit margins provided an opportunity for technological advances in process technology. Increases in production cost brought on by the need to conform to environmental regulations has been offset to some degree by the lower production costs associated with the new technologies (Hart, 1980 and Tomlinson, 1979).

The no-three-factor interaction model, $u_{123}(ijk)=0$, was choosen as the best model for the factor: increased proportion of inexperienced, unskilled workers in the labor force. Estimated standardized values for both the $u_{12}(ij)$ and the $u_{13}(ik)$ terms can be used to examine the interactions between importance level, product group and geographical region. The standardized values for the $u_{12}(ij)$ terms in table 17 yield inconclusive results. The values across all levels of importance for all product groups except fibreboard, hardboard and MDF are not significant. The positive and significant value corresponding to the "slightly important" category for the fibreboard, hardboard and MDF industry group indicates that survey respondents in this group view this factor as being mildly important. The standardized values for the geographical region interaction terms, $u_{13}(ik)$ are shown in table 18. A significant and negative value under the "very important" category together with a significant and positive value associated with the "not important" category indicates that survey respondents in the west region considered this factor not to be important. A positive and significant standardized value corresponding to the "moderately important" category for the south region suggest that

Table 17. Standardized values for the parameter, $u_{12}(ij)$, for the factor: increased proportion of inexperienced unskilled workers in the labor force under the model $u_{123}(ijk) = 0$

Importance Level	Product Group Softwood Lumber	Hardwood Lumber	Softwood Plywood	Hardwood Plywood, Veneer	Particle-board	Structural Particle-board	Pulp, Paper, Paperboard	Fibreboard Hardboard MDF
Very Important	0.715	0.732	-0.556	0.039	-1.054	0.455	0.288	-0.287
Moderately Important	1.789	1.587	1.279	0.934	0.177	0.122	-1.257	-2.282*
Slightly Important	-1.668	-0.876	-0.086	-0.559	0.160	-0.429	0.499	2.569*
Not Important	-1.090	-1.388	-0.587	-0.950	1.152	-0.227	0.747	1.810

* indicates a value in the 5% tails of the standard normal distribution

Table 18. Standardized values for the parameter $u_{13(ik)}$, for the factor: increased proportion of unexperienced, unskilled workers in the labor force under the model $u_{123}(ijk) = 0$

Importance Level	Geographical Region		
	West	South	Mideast
Very Important	-2.015*	0.627	1.700
Moderately Important	-1.086	2.238*	-0.753
Slightly Important	0.970	-1.355	0.237
Not Important	2.960*	0.237	-1.280

* Indicates a value in the 5% tails of the standard normal distribution.

in this region survey respondents considered this factor to be somewhat important. Results for the mideast region are inconclusive. None of the values in any of the four importance level categories are significant for this region.

Survey data were fitted to the conditional independence model, $u_{12}(ij)=u_{123}(ijk)=0$ (where importance level is independent of product group controlling for geographical region) for the factor: government harvesting policies on publicly owned timber lands. The standardized values for the estimated geographical region interaction term, $u_{13}(ik)$ are shown in table 19. The significant and negative standardized value under the "very important" category together with a significant and positive value under the "not important" category indicates that the survey respondents in the south region considered this to be an unimportant factor. The positive and strongly significant value associated with the "very important" category indicates that respondents in the west region consider this factor to be strongly important. Results for the mideast region are inconclusive as the standardized values associated with all importance level categories are insignificant. These results are to be expected since the large proportion of public timber lands are in the west region.

<u>Other factors contributing to the decline in the rate of productivity growth</u>

In addition to the fourteen listed factors in part I of the questionnaire, space was provided for respondents to include any other factors they felt were important. Approximately 10 percent of the survey respondents provided additional factors. The following is a summary of these additional factors.

Table 19. Standardized values for the parameter, $u_{13}(ik)$, for the factor: government harvesting policies on publicly owned timber lands under the model $u_{12}(ij) = u_{123}(ijk) = 0$

Importance Level	Geographical Region		
	West	South	Mideast
Very Important	5.645*	-3.600*	-1.681
Moderately Important	1.557	-1.011	-0.568
Slightly Important	-1.688	0.740	1.176
Not Important	-3.608*	3.699*	0.898

* Indicates a value in the 5% tails of the standard normal distribution.

Management, labor problems

-management philosophy regarding profits and long-term planning

-poor employee attitudes

Raw materials

-shortage of economical sawmill waste

-poor log quality

-competition for raw materials

Market factors

-increased product complexity

-unstable interest rates, inflation

Government

-federal involvement in construction standards

-wilderness and related land set-asides

Relative rankings of factors contributing to the decline in the rate of productivity growth

Survey respondents were asked, to indicate the relative importance of the listed factors by ranking the five factors they felt had the greatest influence on the decline in the productivity growth rate. These rankings were tabulated by product group and geographical region. Overall rankings and rankings by product group and geographical region are provided in tables 20 and 21.

Among the eight product groups, there is a general consensus that the finance cost of capital, the cost of new equipment and plants operating at less than full capacity as a result of volatile product markets are among the most important factors contributing to the decline

Table 20. Relative rank of the factors contributing to the decline in the rate of productivity growth

Factor	Relative Rank	Frequency of Response
Finance cost of capital	1	285
Plants operating at less than full capacity as a result of volatile product markets (cyclical markets)	2	230
Cost of new equipment	3	225
Cost of complying with environmental regulations	4	145
Rapid increases in the price of fossil fuels	5	128
Adversary labor (unions)-management relations	6	119
Decreasing average log size	7	114
Government harvesting policies on publicly owned timber lands	8	99
Tax laws	9	78
Cost of complying with worker safety regulations	10	66
Increased proportion of inexperienced unskilled workers in the labor force	11	61
Inadequate expenditure on research and development	12	41
Limited commercial availability of new technology and equipment	13	22
Barriers to diffusion of new technology through the industry	14	16

Table 21. Relative factor ranks for questionnaire part I -- factors contributing to the decline in the rate of productivity growth

	Product Group								Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Finance cost of capital	1	1/2	2	3	2	1/2/3	1	2	1	1	1
Plants operating at less than full capacity as a result of volatile product markets (cyclical markets)	2	3	1	1	1	1/2/3	4	1	2	3	3
Cost of new equipment	3	1/2	4	2	3	1/2/3	2	4	5	2	2
Cost of complying with environmental regulations	6	7	5/6	8	4	5/6	5	3	4	10/11	10
Rapid increases in the price of fossil fuels	10	6	8	6	5		3	5	8	5	4
Adversary labor (unions)-management relations	7	10	3	5	7	4	6	6	6	6	7
Decreasing average log size	4	4	5/6	4	10/11	8/9/10	11/12	12	7	7/8	5
Government harvesting policies on publicly owned timber lands	5	9	7	12/13	6	7	11/12	7	3	10/11	12
Tax laws	8	5	12	10/11	10/11	5/6	9	9	10	7/8	9

Table 21. Relative factor ranks for questionnaire part I -- factors contributing to the decline in the rate of productivity growth, cont.

	Product Group								Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Cost of complying with worker safety regulations	9	8	9	7	13/14	8/9/10	13/14	10/11	9	10/11	10
Increased proportion of inexperienced unskilled workers in the labor force	11	11	10	9	9	8/9/10	8	10/11	11	9	8
Inadequate expenditure on research and development	14	12	11	10/11	8		7	8	12	12	11
Limited commercial availability of new technology and equipment	13	14	13	12/13	12		10	13/14	14	13	13
Barriers to diffusion of new technology through the industry	12	13	14	14	13/14		13/14	13/14	13	14	14

1. Product groups: SL = softwood lumber, HL = hardwood lumber, SP = softwood plywood, HP = hardwood plywood and veneer, PBD = particleboard, SPBD = structural particleboard, PP = pulp, paper and paperboard, FBR = fibreboard, hardboard and MDF

2. Geographical region: W = west, ME = mideast, SO = south

in the rate of productivity growth. Of these three, only the factor: the cost of new equipment exhibits any regional variation. However, apart from these three factors which are common across industries, there is evidence of some industry variation with regard to the important factors involved in the decline in productivity growth. For example, in the particleboard, the pulp, paper and paperboard and the fibreboard, hardboard and MDF product groups the factor: cost of complying with environmental regulations was identified as an important factor but this factor was considerably less important in the other product groups. Decreasing average log size was identified as an important factor by only the softwood and hardwood lumber and the hardwood plywood and veneer product groups. And, in the pulp, paper and paperboard product group, a particularly energy intensive industry, the factor: rapid increases in the price of fossil fuels was listed as an important factor.

Questionnaire part II -- factors stimulating an increase in the rate of productivity growth

The four factors not described by the joint independence model were fit to both conditional independence models. The factors: developing and implementing specialized employee training programs, cooperative research and development programs between companies and the availability of new (or better) processing equipment were fitted to the conditional independence model, $u_{12}(ij)=u_{123}(ijk)=0$ where importance level is independent of product group controlling for geographical region. The other factor, development of computer-based process control equipment was fitted to the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$ where importance level is independent of geographical region controlling for product group. Standardized values of the estimated interaction terms for these four factors are shown in tables 22, 23, 24, and 25. In general the results from the analysis are inconclusive. For the factor: developing and implementing specialized employee training programs, the only significant estimated geographical interaction term ($u_{13(ik)}$) value is a negative value for the south region under the "moderately important" category. This result implies that survey respondents did not feel that this factor was moderately important but yields no information regarding the relative importance that survey respondents in this product group attach to this factor.

Results for the factor: availability of new (or better) processing equipment are similar. A negative and very significant standardized value under the category "no important" for the west region suggests that this factor is important but no inferences regarding the degree of importance can be made. A negative and significant value associated with the "slightly important" category for the south region suggests that survey respondents felt that this factor was not mildly important but no inferences concerning the importance or lack of importance can be made. Negative and significant values under the categories "not important" and "moderately important" for the mideast region suggest that this factor is important but again, no inferences regarding the degree of importance can be made.

For the factor: cooperative research and development programs between companies, a positive and significant standardized value under the "slightly important" category suggest that survey respondents in the south region find this factor to be only mildly important. Results for the other two regions are not as informative. None of the values in the

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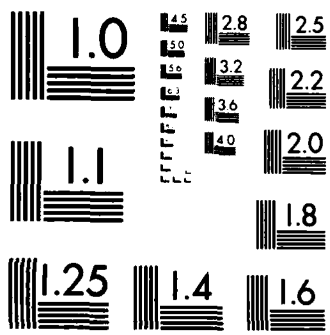

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Table 22. Standardized values for the parameter, $u_{13}(ik)$, for the factor: developing and implementing specialized employee training programs under the model $u_{12}(ij) = u_{123}(ijk) = 0$.

Importance Level	Geographical Region West	South	Mideast
Very Important	0.495	0.431	-0.861
Moderately Important	0.840	-2.404*	1.592
Slightly Important	-1.600	1.043	0.632
Not Important	0.273	0.575	-0.778

* Indicates a value in the 5% tails of the standard normal distribution.

Table 23. Standardized values for the parameter, $u_{13}(ik)$, for the factor: cooperative research and development programs between companies under the model $u_{12}(ij) = u_{123}(ijk) = 0$.

Importance Level	Geographical Region		
	West	South	Mideast
Very Important	0.201	-1.155	1.055
Moderately Important	-0.840	0.806	0.040
Slightly Important	0.855	2.366*	-3.032*
Not Important	-0.224	-1.090	1.427

* Indicates a value in the 5% tails of the standard normal distribution.

Table 24. Standardized values for the parameter, $u_{13}(ik)$, for the factor: availability of new (or better) processing equipment under the model $u_{12}(ij) = u_{123}(ijk) = 0$.

Importance Level	Geographical Region West	South	Mideast
Very Important	-1.595	-0.604	-0.959
Moderately Important	-1.987	1.232	-2.224*
Slightly Important	0.379	-2.608*	-0.044
Not Important	-3.053*	-1.951	-2.673*

* Indicates a value in the 5% tails of the standard normal distribution.

Table 25. Standardized values for the parameter, $u_{12}(ij)$, for the factor: development of computer-based process control equipment under the model $u_{13}(ik) = u_{123}(ijk) = 0$

Importance Level	Product Group: Softwood Lumber	Hardwood Lumber	Softwood Plywood	Hardwood Plywood, Veneer	Particle-board	Structural Particle-board	Pulp, Paper, Paperboard	Fibreboard Hardboard MDF
Very Important	-0.142	-2.745*	1.402	-2.129*	0.783	-1.208	0.727	0.692
Moderately Important	-0.646	-1.473	-0.024	0.740	-0.915	-1.437	-0.622	1.356
Slightly Important	-0.940	0.899	-1.399	1.720	0.174	-1.164	-0.748	-2.440*
Not Important	-0.117	0.956	-1.547	-0.999	-1.698	0.455	-0.567	-1.742

* indicates a value in the 5% tails of the standard normal distribution

four importance level categories are significant for the west region and the negative and significant value associated with the "slightly important" category only indicates that survey respondents do not consider this factor to be slightly important.

Results for the factor: development of computer-based process control equipment are inconclusive as well. Negative and significant standardized values under the "very important" category for both the hardwood lumber and the hardwood plywood and veneer product groups indicate the respondents in these groups do not consider this factor to be strongly important. But information regarding the relative degrees of importance for these product groups cannot be determined with these data. A negative and significant value under the "slightly important" category for the fibreboard, hardboard and MDF product group suggests only that this factor was not considered by survey respondents in this group to be mildly important. No information regarding the degree of importance of this factor among the other five product groups is available as all the standardized values under all four importance level categories are insignificant.

<u>Other factors stimulating an increase in the rate of productivity growth</u>

The following is a summary of the additional factors provided by survey respondents:

Management, labor

-improve communication between management and labor

Market factors

-presence of market stability

Political, legal and institutional factors

-ease environmental restrictions

-assurance of long term timber supply

Relative rankings of factors stimulating an increase in the rate of productivity growth

Overall rankings and rankings by product group and geographical region are provided in tables 26 and 27. There is strong agreement across all product groups that the factors: availability of new (or better) processing equipment and establishing company-wide productivity improvement programs are among the most important factors stimulating an increase in the rate of productivity growth. Development of computer based process control equipment is an important factor for all product groups except hardwood plywood and veneer and hardwood lumber. This factor exhibits regional variation as well. Developing and implementing specialized employee training programs is an important factor for all groups except the softwood and hardwood lumber and the structural particleboard product groups. Establishing financial incentives programs is an important consideration for the softwood and hardwood lumber and the hardwood plywood and veneer product groups. In both the softwood and hardwood lumber groups the factor: increased mechanization induced by an inadequate labor supply is particularly important.

Questionnaire part III -- policies or program changes needed to encourage increases in the rate of productivtiy growth

The four policies not described by the joint independence model were fitted to both conditional independence models. The policy considerations: policies to accelerate the harvest of public timber, poli-

Table 26. Relative rank of the factors stimulating an increase in the rate of productivity growth

Factor	Relative Rank	Frequency of Response
Availability of new (or better) processing equipment	1	259
Establishing company-wide productivity improvement programs	2	256
Development of computer-based process control equipment	3	192
Developing and implementing specialized employee training programs	4	179
Increased mechanization induced by an inadequate labor supply	5	168
Establishing financial incentives programs for employees	6	141
Increased expenditures for research and development by private firms	7	141
Cooperative research and development programs between companies	8	105
Increased federal (state) expenditures for research	9	45

Table 27. Relative factor ranks for questionnaire part II -- factors stimulating an increase in the rate of productivity growth

	Product Group								Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Availability of new (or better) processing equipment	1	2/3	2	1/2	1/2	2/3	1	3	2	1/2	1
Establishing company-wide productivity improvement programs	5	2/3	1	1/2	1/2	1	2	1/2	1	1/2	2
Development of computer-based process control equipment	3/4	8	3	6	3	2/3	4/5	1/2	3	7/8	3
Developing and implementing specialized employee training programs	6	5	4	3	4	6/7/8	3	4/5	5	3	4
Increased mechanization induced by an inadequate labor supply	2	1	7	5	7/8	4	6	6	6	4	5
Establishing financial incentives programs for employees	3/4	4	5	4	6	5	7	7	4	6	6
Increased expenditures for research and development by private firms	7	6/7	6	8	5	6/7/8	4/5	4/5	7	5	7

Table 27. Relative factor ranks for questionnaire part II -- factors stimulating an increase in the rate of productivity growth, cont.

	Product Group								Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Cooperative research and development programs between companies	8	6/7	8	7	7/8	9	8	8	8	7/8	8
Increased federal (state) expenditures for research	9	9	9	9	9	6/7/8	9	9	9	9	9

1. Product groups: SL = softwood lumber, HL = hardwood lumber, SP = softwood plywood, HP = hardwood plywood and veneer, PBD = particleboard, SPBD = structural particleboard, PP = pulp, paper and paperboard, FBR = fibreboard, hardboard and MDF

2. Geographical region: W = west, ME = mideast, SO = south

cies to stimulate the housing sector and policies to reduce the cyclic boom to bust nature of the housing industry were fitted to the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$ where importance level is independent of geographical region controlling for product group and the policy consideration: policies to stimulate research by government agencies or universities was fit to the conditional independence model, $u_{12}(ij)=u_{123}(ijk)=0$, where importance level is independent of product group controlling for geographical region. Standardized values for the estimated interaction parameters are shown in tables 28, 29, 30, and 31. Results for this questionnaire part are mixed. For the policy consideration: policies to reduce the cyclic boom to bust nature of the housing industry, the negative and significant standardized values under the "very important" category for the structural particleboard and the pulp, paper and paperboard product groups indicate that survey respondents in these groups do not consider this policy to be an important one. However, the positive and significant value associated with the "slightly important" category for the pulp, paper and paperboard product group suggests that for this product group the policy is of mild concern. The negative and significant standardized value under the "not important" category indicates that respondents in the hardwood lumber product group consider this policy to be important but the degree of importance is uncertain as the other values associated with the other positive levels of importance categories are not significant. Results for the other five product groups are inconclusive. Standardized values under all importance level categories for the softwood plywood, the hardwood plywood and veneer, the particleboard and the fibreboard, hardboard and MDF product groups are insignificant. The negative and signi-

Table 28. Standardized values for the parameter, $u_{12}(ij)$, for the policy: policies to accelerate the harvest of public timber under the model $u_{13}(ik) = u_{123}(ijk) = 0$

Importance Level	Product Group							
	Softwood Lumber	Hardwood Lumber	Softwood Plywood	Hardwood Plywood, Veneer	Particle-board	Structural Particle-board	Pulp, Paper, Paperboard	Fibreboard Hardboard MDF
Very Important	-0.010	-0.039	1.170	0.516	-0.321	0.321	-1.473	-0.200
Moderately Important	0.267	2.446*	0.491	0.623	-1.229	0.340	-1.564	-0.807
Slightly Important	1.253	-0.605	-2.052*	-0.342	1.776	-0.306	1.994*	-0.418
Not Important	-1.101	-1.219	0.781	-0.611	-0.019	-0.244	1.472	1.351

* indicates a value in the 5% tails of the standard normal distribution

Table 29. Standardized values for the parameter, $u_{12}(ij)$, for the policy: policies to stimulate the housing sector under the model $u_{13}(ik) = u_{123}(ijk) = 0$

Importance Level	Product Group							
	Softwood Lumber	Hardwood Lumber	Softwood Plywood	Hardwood Plywood, Veneer	Particle-board	Structural Particle-board	Pulp, Paper, Paperboard	Fibreboard Hardboard MDF
Very Important	1.426	0.440	0.676	0.093	-0.076	-2.045*	-4.726*	0.514
Moderately Important	-1.199	0.855	-0.790	-0.350	-0.733	-1.370	1.010	-1.059
Slightly Important	-0.601	-1.337	-2.526*	-0.602	-0.159	-1.269	0.714	-0.264
Not Important	-1.032	-2.102*	-0.367	-1.221	-1.239	-0.540	0.179	-1.676

* *indicates a value in the 5% tails of the standard normal distribution*

Table 30. Standardized values for the parameter, $u_{12}(ij)$, for the policy: policies to reduce the cyclic boom to bust nature of the housing industry under the model $u_{13}(ik) = u_{123}(ijk) = 0$

	Product Group							
Importance Level	Softwood Lumber	Hardwood Lumber	Softwood Plywood	Hardwood Plywood, Veneer	Particle-board	Structural Particle-board	Pulp, Paper, Paperboard	Fibreboard Hardboard MDF
Very Important	1.281	-0.562	0.134	0.528	0.773	-2.264*	-3.742*	1.511
Moderately Important	1.557	0.779	-1.206	0.497	-0.852	-1.332	-0.857	-1.141
Slightly Important	-1.995	-0.434	-1.832	-1.603	-0.353	0.022	2.239*	-0.509
Not Important	-1.000	-2.914*	0.837	-0.558	-0.525	-0.594	0.071	-0.810

* indicates a value in the 5% tails of the standard normal distribution

Table 31. Standardized values for the parameter $u_{13}(ik)$, for the policy: policies to stimulate research by government agencies or universities under the model, $u_{12}(ij) = u_{123}(ijk) = 0$.

Importance Level	Geographical Region West	South	Mideast
Very Important	0.006	-0.115	0.107
Moderately Important	-1.564	-0.625	2.308*
Slightly Important	0.794	-0.371	-0.417
Not Important	0.855	1.077	-1.778

* Indicates a value in the 5% tails of the standard normal distribution.

ficant value under the "slightly important" category for the softwood lumber product group, while indicating that this policy is not mildly important for this product group, provides no insight to the degree of importance or lack of importance respondents assigned to this policy consideration.

For the policy consideration: policies to accelerate the harvest of public timber, positive and significant standardized values under the "moderately important" category for the hardwood lumber and veneer and under the "slightly important" category for the pulp, paper and paperboard indicate that survey respondents in these product groups attach some importance to this policy -- a relatively greater degree of importance for the hardwood lumber product group. Results for the other six product groups are inconclusive. Standardized values under all importance level categories for the softwood lumber, the hardwood plywood and veneer, the particleboard, the structural particleboard and the fibreboard, hardboard and MDF product groups are insignificant. The negative and significant value under the "slightly important" category for the softwood plywood product group indicates only that this policy is not considered to be mildly important to this product group -- inferences concerning the degree of importance or lack of importance of this policy cannot be determined given these data.

Results for the policy consideration: policies to stimulate the housing sector indicate that both the structural particleboard and the pulp, paper and paperboard product groups do not consider this policy to be very important -- both groups show negative and significant standardized values under the "very important" category. The negative and significant value associated with the "not important" category for the hardwood lumber product group indicates that this policy consideration is important for this group but the degree of importance cannot be determined since the standardized values associated with the positive importance level categories are not significant. Results for the other five product groups are inconclusive. Standardized values under all importance level categories for the softwood lumber, the hardwood plywood and veneer, the particleboard and the fibreboard, hardboard and MDF product groups are insignificant. The negative and significant value under the "slightly important" category for the softwood plywood product group indicates only that this policy consideration is not considered to be mildly important -- inferences concerning the degree of importance or lack of importance of this policy cannot be determined given these data.

The mideast region identified the policy consideration: policies to stimulate research by government agencies or universities as "moderately important" as evidenced by a positive and significant standardized value under this importance level category. Results for the other two regions are inconclusive as the values in all importance level categories are insignificant.

Relative rankings of the policies or program changes needed to encourage increases in the rate of productivity growth

Overall rankings and rankings by product group and geographical region are provided in tables 32 and 33. There is essentially no variation across industries or regions with regard to the highly ranked policy and program changes. These four policies are: tax changes to encourage investment, policies to reduce the cyclic boom to bust nature of the housing industry, policies to stimulate the housing sector and policies to promote market stability.

Table 32. Relative rank of the government policy or program changes needed to encourage increases in the rate of productivity growth

Factor	Relative Rank	Frequency of Response
Tax changes to encourage investment	1	285
Policies to reduce the cyclic boom to bust nature of the housing industry	2	272
Policies to stimulate the housing sector	3	268
Policies to promote market stability	4	268
Policies to stimulate research and development within private firms	5	151
Policies to accelerate harvest of public timber	6	145
Develop a national productivity improvement plan to encourage faster diffusion of knowledge	7	73
Policies and funds to stimulate research by government agencies or universities	8	66

Table 33. Relative factor ranks for questionnaire part III -- government policy or program changes needed to encourage increases in the rate of productivity growth

	Product Group								Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Tax changes to encourage investment	1/2	1	3/4	2/3/4	3/4	1/2/3	1	2	2	1	2
Policies to reduce the cyclic boom to bust nature of the housing industry	1/2	3/4	3/4	2/3/4	1/2	4	5	1	1	4	1
Policies to stimulate the housing sector	3	2	2	1	3/4	1/2/3	4	3	3/4	2	4
Policies to promote market stability	4	3/4	1	2/3/4	1/2	1/2/3	2	4	3/4	3	3
Policies to stimulate research and development within private firms	8	7	8	8	7/8	7/8	8	7	8	7/8	8
Policies to accelerate harvest of public timber	5	5	5	5	6	5/6	7	6	5	6	6

Table 33. Relative factor ranks for questionnaire part III -- government policy or program changes needed to encourage increases in the rate of productivity growth, cont.

	Product Group								Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Develop a national productivity improvement plan to encourage faster diffusion of knowledge	7	8	7	7	7/8	5/6	6	8	7	7/8	7
Policies and funds to stimulate research by government agencies or universities	6	6	6	6	5	7/8	3	5	6	5	5

1. Product groups: SL = softwood lumber, HL = hardwood lumber, SP = softwood plywood, HP = hardwood plywood and veneer, PBD = particleboard, SPBD = structural particleboard, PP = pulp, paper and paperboard, FBR = fibreboard, hardboard and MDF

2. Geographical region: W = west, ME = mideast, SO = south

Summary

Summarized results from the categorical data analysis appear on tables 34, 35, and 36. The symbol '?' indicates an inconclusive result and the symbols 'V', 'M', 'S' and 'N' indicate that standardized values associated with the importance levels represented by these symbols, V=very important, M=moderately important, S=slightly important, N=not important, were significant and positive. No entries for a factor indicates that the joint independence model was selected and that there is no apparent statistical relationship between importance level, product group and geographical region. Entries across product groups or geographical regions indicate that the appropriate conditional independence model ($u_{12}(ij)=u_{123}(ijk)=0$ or $u_{13}(ik)=u_{123}(ijk)=0$) was selected. Entries across both product groups and geographical regions indicate that the no-three-factor interaction model was selected. In some cases, inconclusive results may be reconciled by relative ranking results and some tentative conclusions developed.

Among the most important sources of the declines in the rate of productivity growth, both across industries and geographical regions, are the factors: the cost of new equipment, the finance cost of capital, and plants operating at less than full capacity as a result of volatile product markets. The key factor is the reduction in plant utilization rates as a result of cyclical product markets. Lower plant utilization rates must be taken into consideration when estimating the benefits from adopting and installing new technology and equipment, and these benefits must be weighted against the costs. A profitable innovation could conceivably become unprofitable under conditions of excess plant capacity. Increasing interest rates add unstableness to many of the forest

Table 34. Summary of survey analysis for questionnaire part I -- factors contributing to the decline in the rate of productivity growth

	Interaction Factors and Relationships										
	Product Group								Geographical Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Finance cost of capital											
Plants operating at less than full capacity as a result of volatile product markets (cyclical markets)											
Cost of new equipment											
Cost of complying with environmental regulations	?	V	?	?	?	?	S	?			
Rapid increases in the price of fossil fuels	?	?	?	?	?	?	V	V			
Adversary labor (unions)-management relations											
Decreasing average log size	V	V	?	?	N	?	S	N			
Government harvesting policies on publicly owned timber lands									V	?	N
Tax laws											

Table 34. Summary of survey analysis for questionnaire part I -- factors contributing to the decline in the rate of productivity growth, cont.

	Interaction Factors and Relationships										
	Product Group								Geographical Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Cost of complying with worker safety regulations											
Increased proportion of inexperienced unskilled workers in the labor force	?	?	?	?	?	?	?	M	N	?	M
Inadequate expenditure on research and development											
Limited commercial availability of new technology and equipment											
Barriers to diffusion of new technology through the industry											

1. Product groups: SL = softwood lumber, HL = hardwood lumber, SP = softwood plywood, HP = hardwood plywood and veneer, PBD = particleboard, SPBD = structural particleboard, PP = pulp, paper and paperboard, FBR = fibreboard, hardboard and MDF

2. Geographical region: W = west, ME = mideast, SO = south

3. Importance levels: V = very important, M = moderately important, S = slightly important, N = not important, ? = inconclusive

Table 35. Summary of survey analysis for questionnaire part II -- factors stimulating an increase in the rate of productivity growth

	Interaction Factors and Relationships										
	Product Group								Geographical Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Availability of new (or better) processing equipment									?	?	?
Establishing company-wide productivity improvement programs											
Development of computer-based process control equipment	?	?	?	?	?	?	?	?			
Developing and implementing specialized employee training programs									?	?	?
Increased mechanization induced by an inadequate labor supply											
Establishing financial incentives programs for employees											
Increased expenditures for research and development by private firms											

Table 35. Summary of survey analysis for questionnaire part II -- factors stimulating an increase in the rate of productivity growth, cont.

	Interaction Factors and Relationships										
	Product Group								Geographical Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Cooperative research and development programs between companies											
Increased federal (state) expenditures for research											

1. Product groups: SL = softwood lumber, HL = hardwood lumber, SP = softwood plywood, HP = hardwood plywood and veneer, PBD = particleboard, SPBD = structural particleboard, PP = pulp, paper and paperboard, FBR = fibreboard, hardboard and MDF

2. Geographical region: W = west, ME = mideast, SO = south

3. Importance levels: V = very important, M = moderately important, S = slightly important, N = not important, ? = inconclusive

Table 36. Summary of survey analysis for questionnaire part III -- government policy or program changes needed to encourage increases in the rate of productivity growth

	Interaction Factors and Relationships										
	Product Group								Geographical Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Tax changes to encourage investment											
Policies to reduce the cyclic boom to bust nature of the housing industry	?	?	?	?	?	?	S	?			
Policies to stimulate the housing sector	?	?	?	?	?	?	?	?			
Policies to promote market stability											
Policies to stimulate research and development within private firms											
Policies to accelerate harvest of public timber	?	?	?	?	?	?	S	?			S

Table 36. Summary of survey analysis for questionnaire part III -- government policy or program changes needed to encourage increases in the rate of productivity growth, cont.

	Interaction Factors and Relationships										
	Product Group								Geographical Region		
FACTORS	SL	HL	SP	HP	PBD	SPBD	PP	FBD	W	ME	SO
Develop a national productivity improvement plan to encourage faster diffusion of knowledge											
Policies and funds to stimulate research by government agencies or universities									?	M	?

1. Product groups: SL = softwood lumber, HL = hardwood lumber, SP = softwood plywood, HP = hardwood plywood and veneer, PBD = particleboard, SPBD = structural particleboard, PP = pulp, paper and paperboard, FBR = fibreboard, hardboard and MDF

2. Geographical region: W = west, ME = mideast, SO = south

3. Importance levels: V = very important, M = moderately important, S = slightly important, N = not important, ? = inconclusive

industry product markets in addition to increasing the opportunity cost of financial resources. Again, the result is an effective increase in the cost of new or replacement equipment.

Although there were few explicit factors concerning labor quality in questionnaire part I -- factors contributing to the decline in the rate of productivity growth, it is evident from both the additional factors listed by many survey participants and the results from the labor related factors listed in questionnaire part II -- factors stimulating an increase in the rate of productivity growth, that the apparent decline in labor quality is an important factor contributing to the decline in the rate of productivity growth for all industries sampled. Survey responses suggest that the declines in labor quality are not the result of an increased proportion of inexperienced, unskilled workers in the labor force, as this factor was listed as relatively unimportant by all sampled industry groups.

There is, however, considerable variation in industry views regarding the solutions to labor quality problems. Developing and implementing specialized employee training programs was cited as an important factor by the hardwood plywood and veneer, the particleboard, the softwood plywood and veneer, the pulp, paper, and paperboard and the fibreboard, hardboard and MDF product groups while the softwood and hardwood lumber product groups favor a substitution of capital for labor (as expressed in the high rankings for the factor: increased mechanization induced by an inadequate labor supply), and to a lesser degree, establishing financial incentives programs for employees. There are regional variations in these factors as well. Financial incentives programs are favored in the west region while specialized employee training programs are favored in the mideast and south regions.

In the softwood and hardwood lumber product groups the labor input has a relatively larger share of the total cost. Past productivity gains have occurred largely as a result of the substitution of capital for labor through biased technological change. It is not surprising, then, that firms in these product groups would advocate the continued substitution of capital for labor. The labor requirements for these product groups are generally of an unskilled nature. Therefore, financial incentives programs are likely to be more effective in generating productivity increases in these product groups than specialized employee training programs.

Decreasing average log size was cited as an important factor by the softwood and hardwood lumber and the hardwood plywood and veneer product groups. This factor exhibited no significant regional variation. Apparently the regional trends evident in tables 3 and 4 from chapter II were not perceived by survey respondents as resulting in differing regional impacts. Rapid increases in the price of fossil fuels is an important consideration in the pulp, paper and paperboard product group -- a particularly energy intensive industry.

Government harvesting policies on publicly owned timber lands were cited as important sources of declines in the rate of productivity growth in the west region. Environmental restrictions on timber harvesting practices on public lands, for example, restrictions on the maximum size of clear cuts and the placement of and methods of constructing logging roads, can add considerably to the cost of the wood resource. This factor is particularly important in the west region where much of the public timber land is concentrated.

Complying with water quality standards has been a problem for the pulp, paper and paperboard industries, eventually making large capital outlays necessary for the adoption of new waste reducing technology.

The cost of complying with worker safety regulations was not identified as an important factor contributing to the decline in the rate of productivity growth by either the softwood or hardwood lumber groups (or any other product groups) in spite of the relatively high incidence rates of work related injuries (chapter II, table 4).

Among the most highly ranked factors stimulating an increase in the rate of productivity growth is the factor: availability of new (or better) processing equipment. This factor, considered together with the important factors contributing to the decline in the rate of productivity growth: cost of new equipment and the finance cost of capital, tend to suggest that lack of new equipment and technology is not the limiting factor (in fact this factor was rated among the least important in questionnaire part I) but rather the availability of new economically feasible equipment and technology is critical to stimulating an increase in the rate of productivity growth. New technology may exist but economic conditions together with the characteristics of that technology (i.e. size of investment, complexity, etc.) may preclude adoption. This may also explain the lack of importance the survey respondents associated with increased research and development activity. Another possible explanation for the lack of interest concerning R & D activity is that technological change in many forest products industries comes as a result of the adoption of new technology developed outside the sector (i.e. from equipment manufacturers) rather than as a result of inventive activity -- research and development -- from within the sector (Bentley, 1970). Therefore, R & D may not be viewed by some forest products industries as an important component in their technological change process.

There is a general consensus among the forest products industries that policies and programs targeted at stablizing product markets and reducing the cost, to industry, of new and replacement equipment would be successful in stimulating an increase in the rate of productivity growth. Improving labor quality, a more insidious productivity problem, must ultimately be solved from within the private sector through changes and innovations in organizational structure and management techniques.

Chapter VI

SUMMARY AND CONCLUSIONS

The major findings of the study may be briefly summarized as follows. There is a strong consensus across all sampled forest products industries and geographical regions concerning the most important factors contributing to the decline in the rate of productivity growth. These factors are: the finance cost of capital, the cost of new equipment and plants operating at less than full capacity as a result of volatile product markets (cyclical markets). Some other important factors take on an industry group and regional significance. Rapid increases in the price of fossil fuels is an important factor in both the pulp, paper and paperboard and the fibreboard, hardboard and MDF product groups and decreasing average log size is an important factor in both the softwood and hardwood lumber product groups. Government harvesting policies on publicly owned timber lands is an important factor in the west region.

There is a strong consensus across all sampled forest products industries and geographical regions concerning the most important factors stimulating an increase in the rate of productivity growth. These two factors are: the availability of new (or better) processing equipment and establishing company-wide productivity improvement programs. The factor: establishing financial incentives programs for employees was also identified as an important factor although not uniformly across all product groups. The factor: developing and implementing specialized employee training programs is an important regional factor for the mideast. Development of computer-based process control equipment is an important factor in the softwood plywood, the particleboard, the structural particleboard and the fibreboard, hardboard and MDF industry groups. The factor: increased mechanization induced by an inadequate labor supply was identified by the ranking process in the survey as a particularly important factor for the softwood and hardwood lumber product groups -- a result which is inconsistent with the results from the categorical data analysis (where importance level was determined to be not statistically related to product group and geographical region for this factor).

In a sense, these survey results pose as many, if not more, questions than they answer. If this is so, one may ask then, of what value is the analysis? Is the study little more than an intellectual exercise? the answer is decidedly no. The study attempts to identify from the labyrinth of possible production factors only the most important factors and that objective is clearly satisfied. In the forest-based sector, sources of published data at both a specific industry and regional level are generally scarce. And results from sectoral studies may mask specific industry and regional effects. Certainly the forest-based sector (at the two-digit level) is not homogeneous. Problems associated with data collection include lack of adequate funds, lack of industry cooperation and often a lack of clear consensus concerning the relevance of a particular problem or issue. Often to study a broad issue like productivity change from a regional and industry perspective quantitatively requires an unrealistic level of funding if the necessary data are not readily available and must be collected. To focus on a small component of a broad issue like productivity change where data collection may be feasible is to risk taking the research effort in a possibly irrelevant direction. This study effectively bridges this gap. By identifying the factors contributing to the decline in the rate of productivity growth and the factors stimulating an increase in the rate of productivity growth, one can construct sets of different scenarios which may then be subjected to further analysis. The study answers some important broad general questions concerning productivity change in the forest-based sector and raises a different class of questions -- questions that are considerably narrower in scope. For example, the study indicated that both regional and product group effects are significant a~ should be considered. An unavoidable limitation of the analysis is the inability to investigate factor interrelationships within the methodological and statistical framework of this study. It is essentially this limitation that gives rise to many of the additional questions.

From the survey results, both parts I and II, the important sources of productivity change can be grouped into three categories -- those dealing with the capital input, those dealing with the labor input and those dealing with the resource input. With the exception of the factors concerning the capital input, the other categories of factors have considerable regional and product group variation. With regard to the capital input, the survey results tend to suggest that lack of new economically feasible equipment and technology is the limiting consideration. The results also tend to support that this is an economic phenomenon resulting from unstable demand brought on to some extent by high interest rates. Since this factor was identified as very important across all industry groups and regions, a quantitative sectoral study in this instance would be appropriate to determine the contribution of this factor to changes in the rate of productivity growth. Labor quality problems were identified as an important factor but the variety of potential solutions advocated by different industry groups and across geographical regions suggests that there may be certain inter-industry differences in the manufacturing process and work organizations that make one solution more viable than another. Cultural differences across regions may also influence this factor as well. These questions need to be considered more fully. Changes in the resource input (wood and energy) were important considerations for only a subset of the industry groups. However, this factor appears to have an institutional component with regional implications (i.e. the impact of government harvesting policies on federal lands). Again, this point needs to be investigated further. Also, the study made no attempt to quantify productivity changes and the contributions of these various factors to that change.

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Appendix I

MODEL SELECTION

Each factor from the questionnaire parts I, II and III was analyzed separately using categorical data analysis techniques described in chapter IV to investigate the relationships between importance level, product group and geographical region. The factors for each questionnaire part were then analyzed collectively in order to determine their relative importance in productivity change both by product group and geographical region.

Questionnaire Part I--Factors Contributing to the Decline in the Rate of Productivity Growth

Decreasing average log size

A summary of the questionnaire responses is provided in fig. A1. The data were fitted to each of the four log-linear models and the results are summarized in table A1. Using the criteria established in chapter IV, the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$ was selected. Under this model, importance level is independent of geographical region controlling for product group. The model asserts that when these "product group effects" are taken into consideration, any regional variation in the level of importance is random.

Rapid increases in the price of fossil fuels

A summary of the questionnaire responses is provided in fig. A2. The data were fitted to each of the four log-linear models and the results are summarized in table A2. Using the criteria established in chapter IV, the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$ was

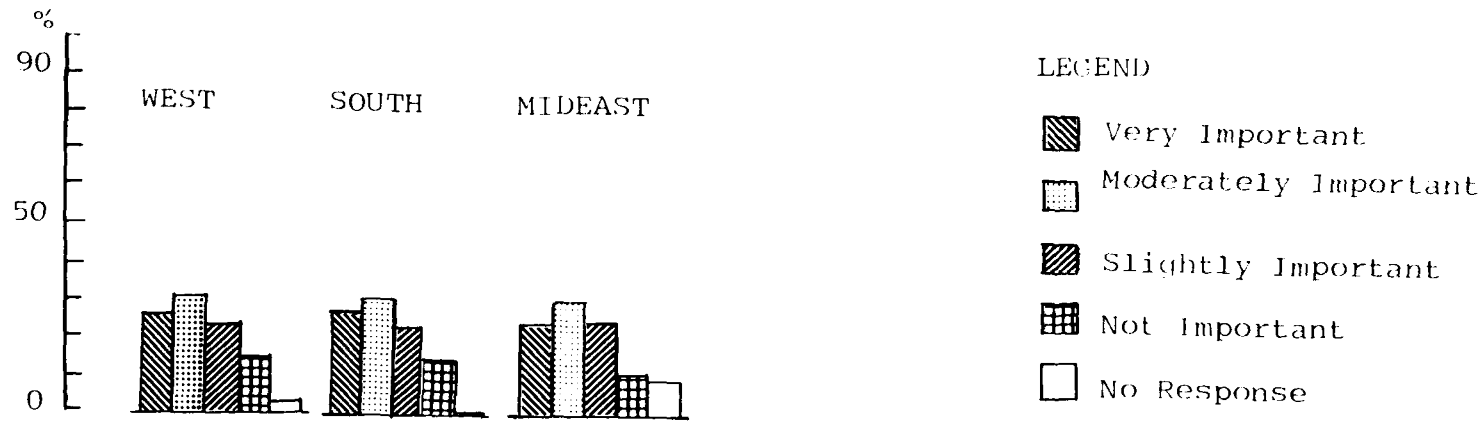

Fig. A1 (a) Percentage distribution of responses by geographical region for the factor: decreasing average log size

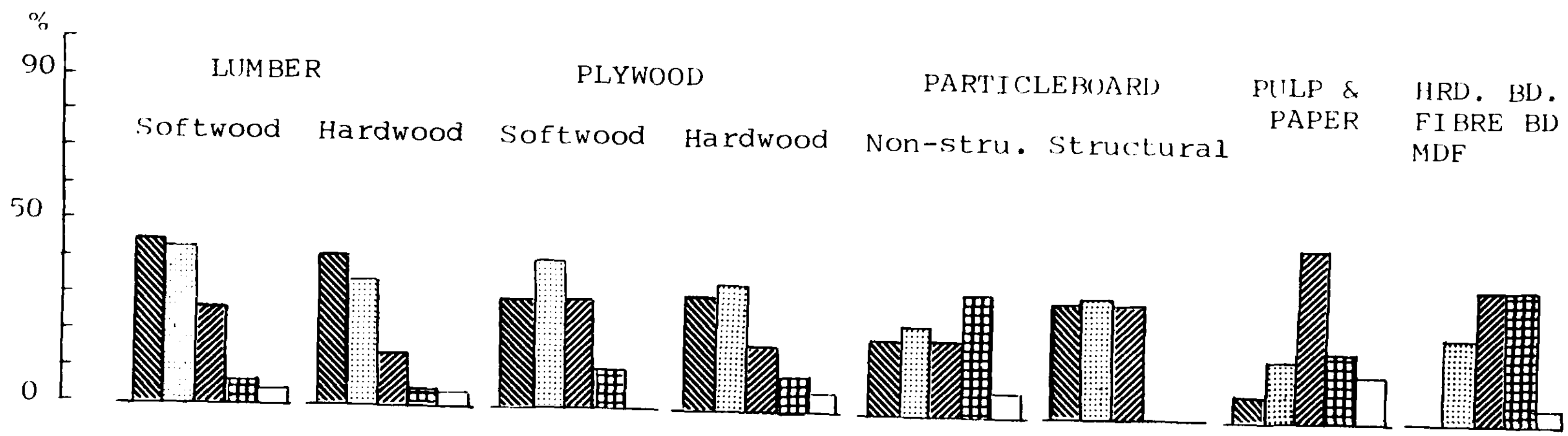

Fig. A1 (b) Percentage distribution of responses by product group for the factor: decreasing average log size

Table A1. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: decreasing average log size

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	30.33 (0.98)	30.97 (0.97)	48
$u_{12}(ij)=u_{123}(ijk)=0$	105.25* (0.00)	108.54* (0.00)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	108.57* (0.00)	109.75* (0.00)	69
$u_{123}(ijk)=0$	29.59 (0.92)	29.68 (0.92)	42

* statistic values in the upper 5% tail of the corresponding chi-square distribution with degrees-of-freedom as indicated.

() critical value

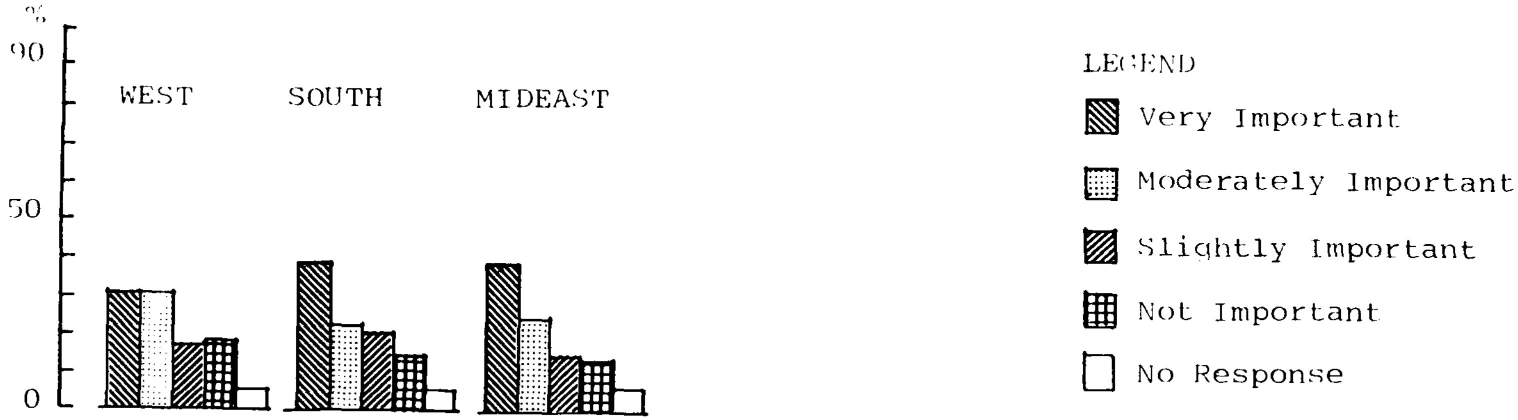

Fig. A2 (a) Percentage distribution of responses by geographical region for the factor: rapid increases in the price of fossil fuels

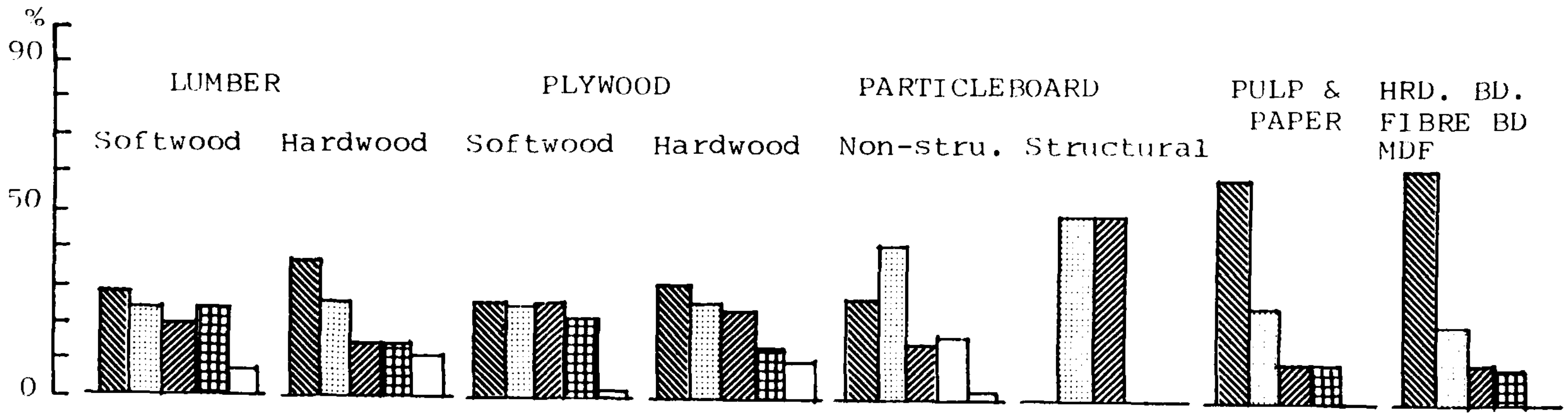

Fig. A2 (b) Percentage distribution of responses by product group for the factor: rapid increases in the price of fossil fuels

Table A2. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: rapid increases in the price of fossil fuels

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	39.06 (0.82)	37.36 (0.87)	48
$u_{12}(ij)=u_{123}(ijk)=0$	67.71 (0.32)	65.32 (0.40)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	72.23 (0.37)	70.45 (0.43)	69
$u_{123}(ijk)=0$	35.35 (0.76)	33.91 (0.81)	42

() critical value

selected. Under this model, importance level is independent of geographical region controlling for product group. The model asserts that when these "product group effects" are taken into consideration, any regional variation in the level of importance is random.

Increased proportion of inexperienced unskilled workers in the labor force

A summary of the questionnaire responses is provided in fig. A3. The data were fitted to each of the four log-linear models and the results are summarized in table A3. Using the criteria established in chapter IV, the no-three-factor interaction model, $u_{123}(ijk)=0$, was selected. (The three-way interaction model (saturated model) was examined and rejected.) Under this model there are two sets of pairwise relations between the variables: importance level and product group and importance level and geographical region.

Adversary labor(unions)-management relations

A summary of the questionnaire responses is provided in fig. A4. The data were fitted to each of the four log-linear models and the results are summarized in table A4. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of industry group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Fig. A3 (a) Percentage distribution of responses by geographical region for the factor: increased proportion of inexperienced workers in the labor force

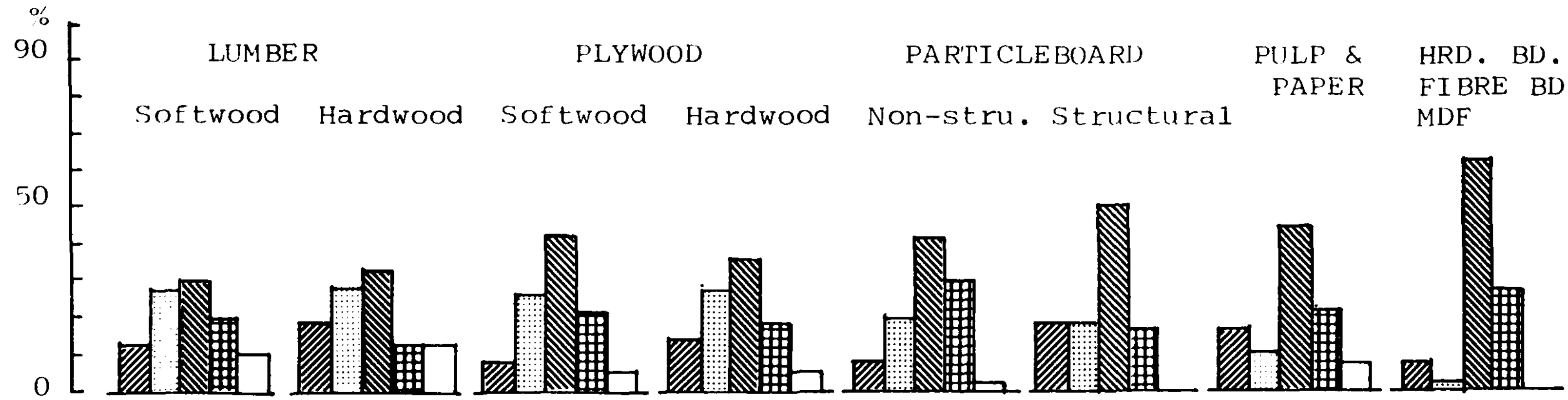

Fig. A3 (b) Percentage distribution of responses by product group for the factor: increased proportion of inexperienced workers in the labor force

Table A3. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: increased proportion of inexperienced unskilled workers in the labor force

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	44.72 (0.61)	45.48 (0.58)	48
$u_{12}(ij)=u_{123}(ijk)=0$	51.55 (0.85)	56.82 (0.69)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	70.35 (0.43)	74.14 (0.31)	69
$u_{123}(ijk)=0$	28.98 (0.94)	30.10 (0.91)	42

() critical value

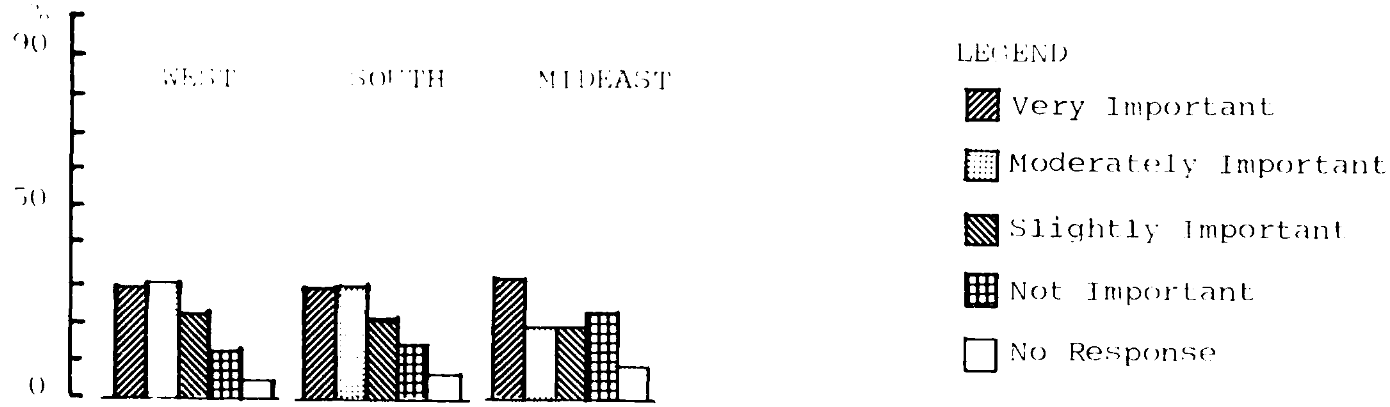

Fig.A4 (a) Percentage distribution of responses by geographical region for the factor: adversary labor (unions) - management relations

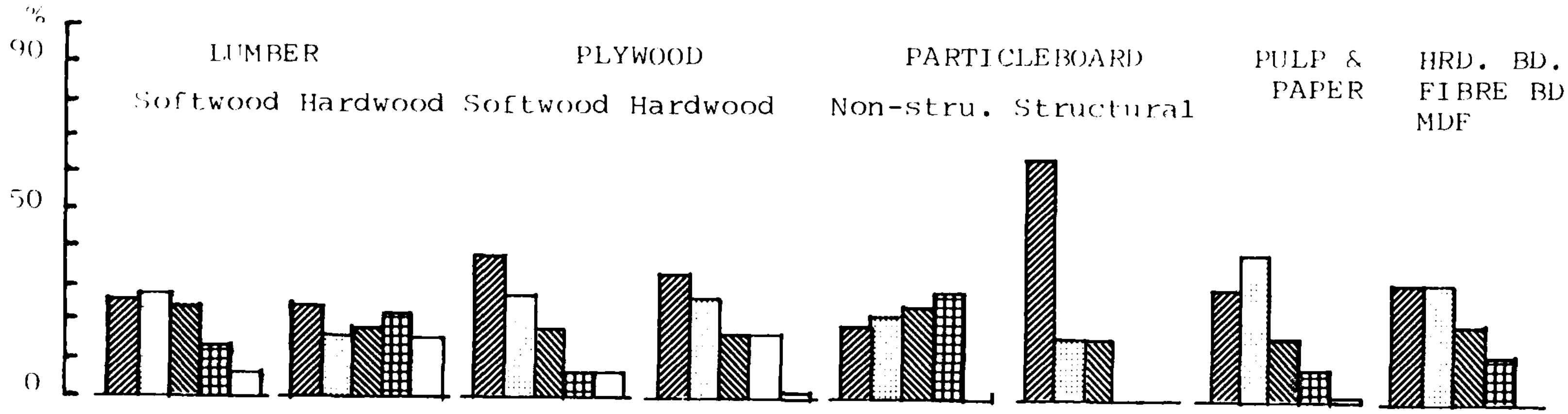

Fig A4 (b) Percentage distribution of responses by product group for the factor: adversary labor (unions) - management relations

Table A4. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: adversary labor(unions) management relations

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	35.85 (0.91)	35.53 (0.90)	48
$u_{12}(ij)=u_{123}(ijk)=0$	47.38 (0.92)	47.84 (0.92)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	55.90 (0.87)	56.01 (0.87)	69
$u_{123}(ijk)=0$	27.15 (0.96)	27.33 (0.96)	42

() critical value

Plants operating at less than full capacity as a result of volatile product markets (cyclical markets)

A summary of the questionnaire responses is provided in fig. A5. The data were fitted to each of the four log-linear models and the results are summarized in table A4. The joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Limited commercial availability of new technology and equipment

A summary of the questionnaire responses is provided in fig. A6. The data were fitted to each of the four log-linear models and the results are summarized in table A5. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Although the likelihood ratio statistic, $G_1 - G_2 = 12.44$ (with 6 degrees of freedom) was close to a 95% significance level, (where model 2 refers to the joint independence model and model 1 refers to the conditional independence model, $u_{12}(ij)=u_{123}(ijk)=0$) the joint independence model was selected after an examination of the standardized values for the $u_{13}(ik)$ term estimates under the conditional independence model indicated no values significantly different from zero. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

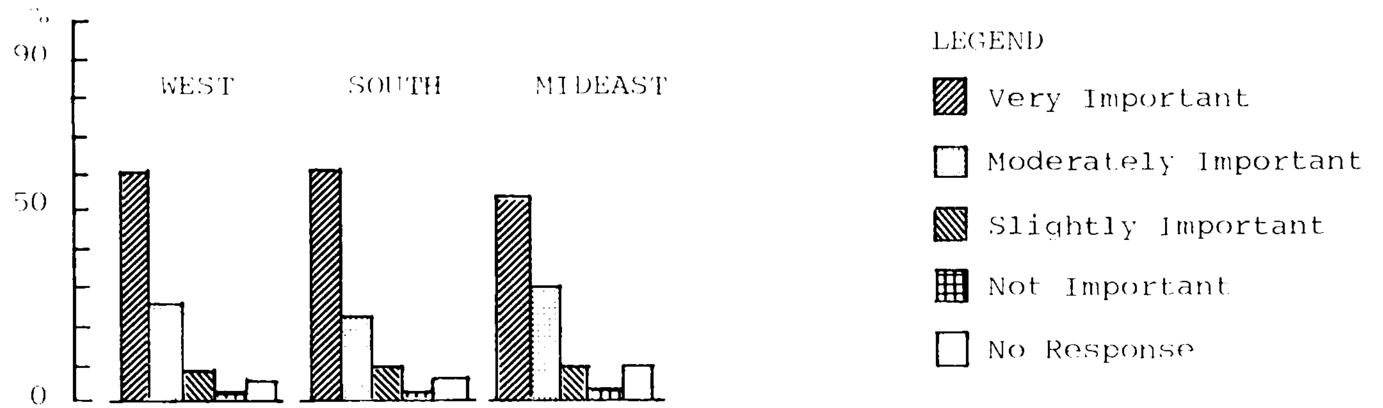

Fig.A5 (a) Percentage distribution of responses by geographical region for the factor: plants operating at less than full capacity as a result of volatile product markets (cyclical markets)

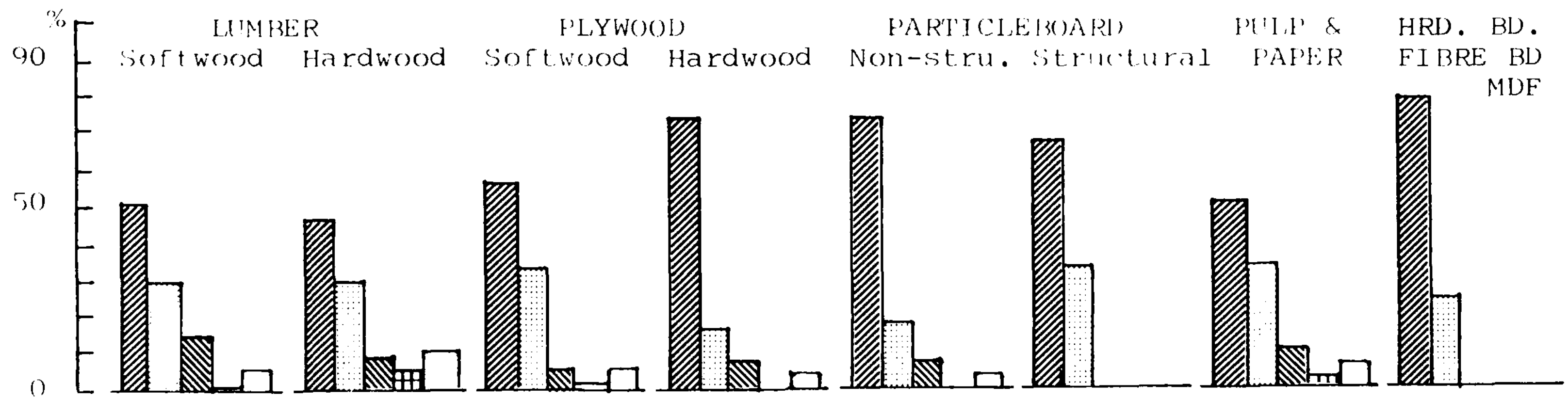

Fig. A5 (b) Percentage distribution of responses by product group for the factor: plants operating at less than full capacity as a result of volatile product markets (cyclical markets)

Table A5. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: plants operating at less than full capacity as a result of volatile product markets (cyclical markets)

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	30.35 (0.98)	27.74 (0.99)	48
$u_{12}(ij)=u_{123}(ijk)=0$	50.07 (0.88)	44.71 (0.96)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	51.35 (0.94)	46.79 (0.98)	69
$u_{123}(ijk)=0$	27.77 (0.95)	25.98 (0.97)	42

() critical value

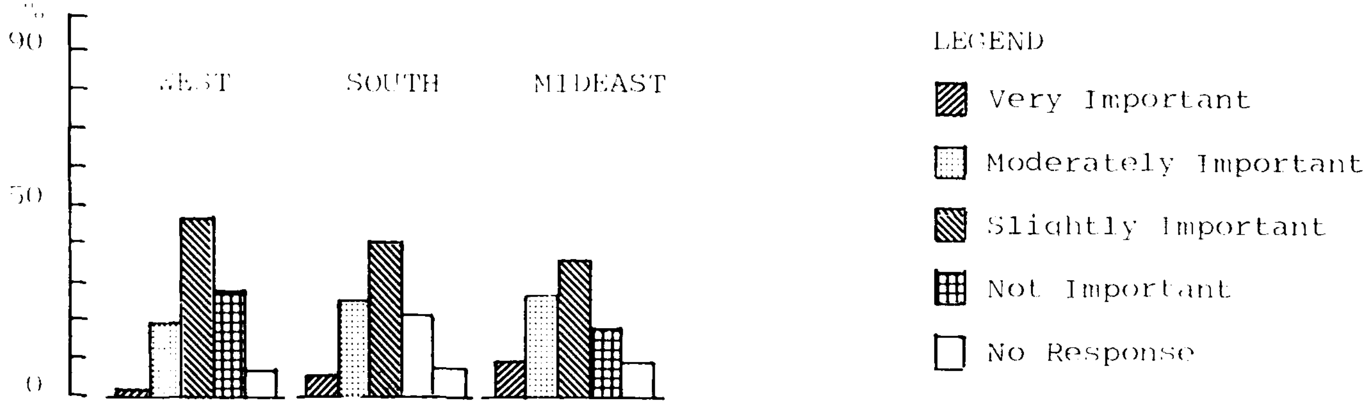

Fig. A6 (a) Percentage distribution of responses by geographical region for the factor: limited commercial availability of new technology and equipment

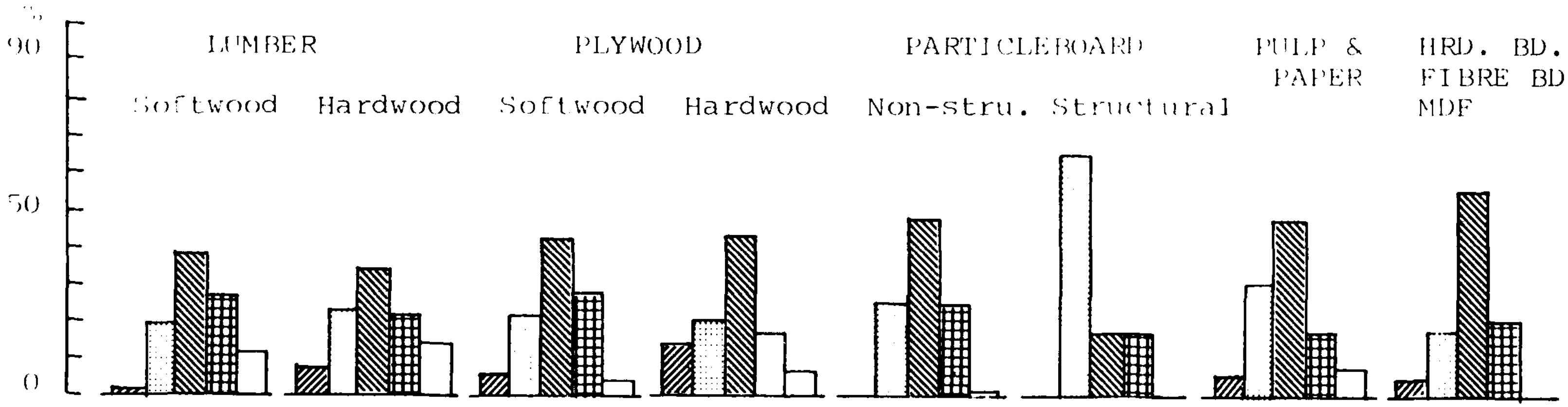

Fig. A6 (b) Percentage distribution of responses by product group for the factor: limited commercial availability of new technology and equipment

Table A6. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: limited commercial availability of new technology and equipment

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	35.22 (0.91)	34.31 (0.93)	48
$u_{12}(ij)=u_{123}(ijk)=0$	42.32 (0.98)	42.02 (0.98)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	52.90 (0.90)	54.46 (0.92)	69
$u_{123}(ijk)=0$	27.24 (0.96)	27.98 (0.95)	42

() critical value

Cost of new equipment

A summary of the questionnaire responses is provided in fig. A7. The data were fitted to each of the four log-linear models and the results are summarized in table A7. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$ was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Barriers to diffusion of new technology through the industry

A summary of the questionnaire responses is provided in fig. A8. The data were fitted to each of the four log-linear models and the results are summarized in table A8. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Finance cost of capital

A summary of the questionnaire responses is provided in fig. A9. The data were fitted to each of the four log-linear models and the results are summarized in table A9. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)= u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

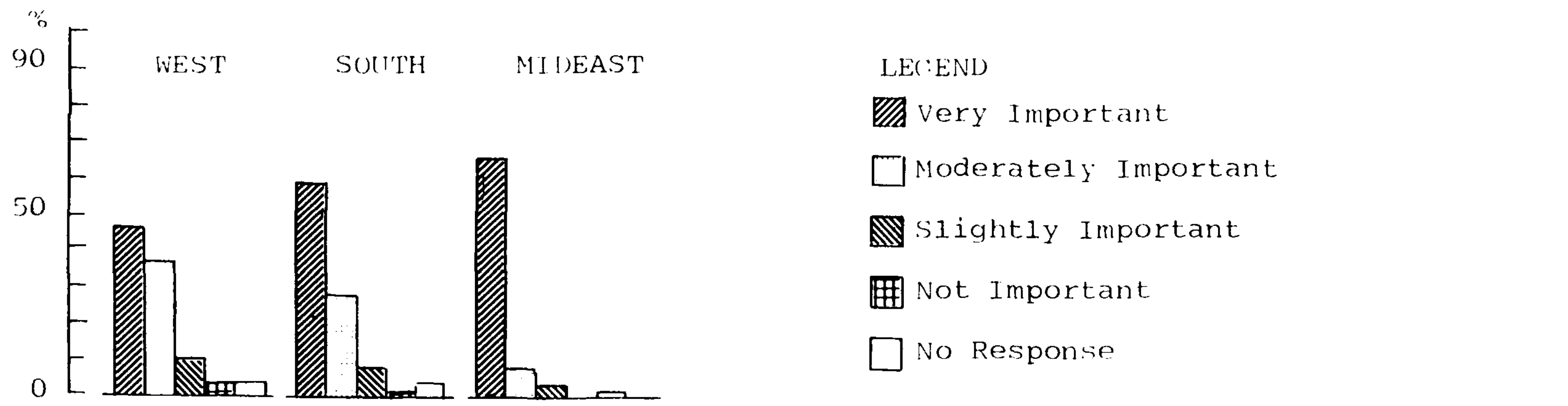

Fig.A7 (a) Percentage distribution of responses by geographical region for the factor: cost of new equipment

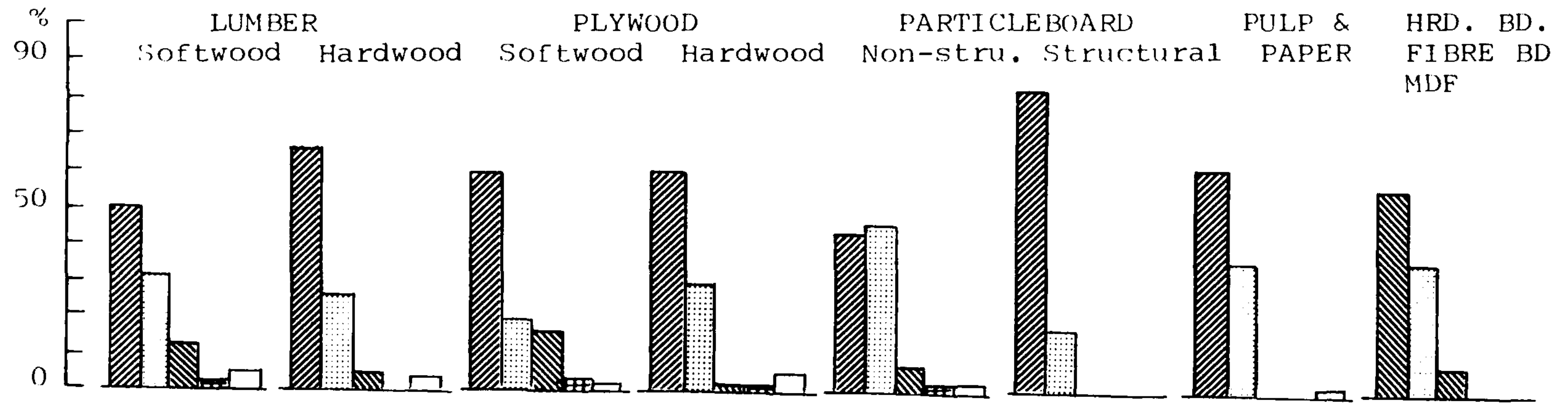

Fig. A7 (b) Percentage distribution of responses by product group for the factor: cost of new equipment

Table A7. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: cost of new equipment

Model	X^2	G^2	Degrees of Freedom
$u_{13(ik)}=u_{123(ijk)}=0$	26.48 (0.99)	26.81 (0.99)	48
$u_{12(ij)}=u_{123(ijk)}=0$	40.55 (0.99)	39.45 (0.99)	63
$u_{12(ij)}=u_{13(ik)}=u_{123(ijk)}=0$	48.27 (0.97)	48.63 (0.97)	69
$u_{123(ijk)}=0$	20.30 (0.99)	20.61 (0.99)	42

() critical value

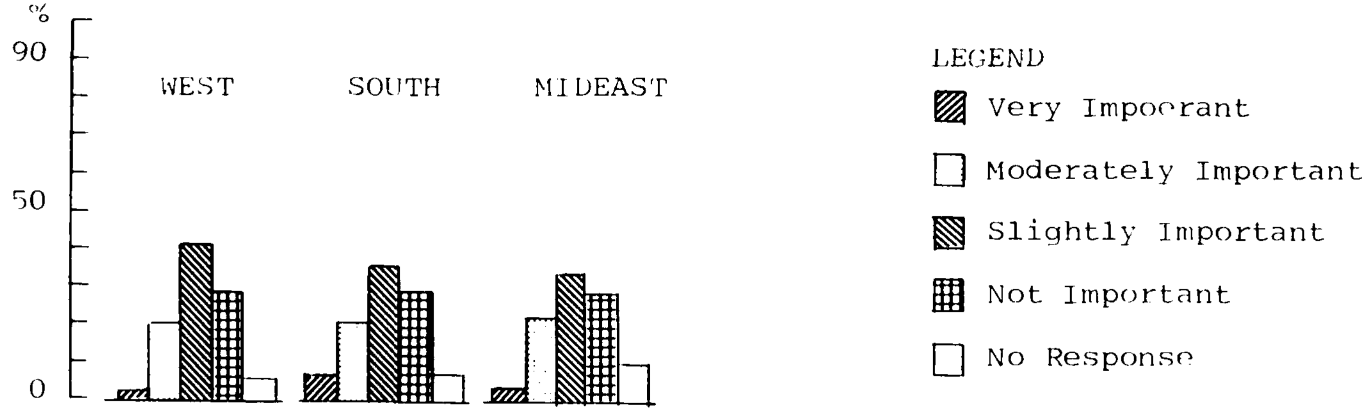

Fig. A8 (a) Percentage distribution of responses by geographical region for the factor: barriers to diffusion of new technology through the industry

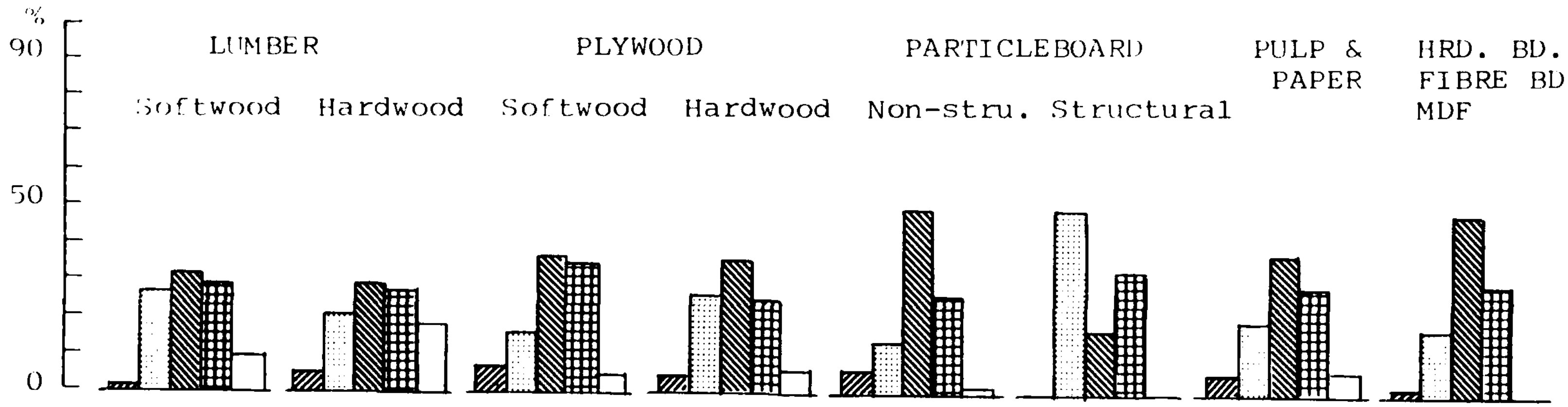

Fig. A8 (b) Percentage distribution of responses by product group for the factor: barriers to diffusion of new technology through the industry

Table A8. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: barriers to diffusion of new technology through the industry

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	36.47 (0.89)	38.20 (0.84)	48
$u_{12}(ij)=u_{123}(ijk)=0$	46.61 (0.94)	48.95 (0.90)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	49.24 (0.96)	50.55 (0.95)	69
$u_{123}(ijk)=0$	34.78 (0.78)	36.63 (0.70)	42

() critical value

Fig. A9 (a) Percentage distribution of responses by geographical region for the factor: finance cost of capital

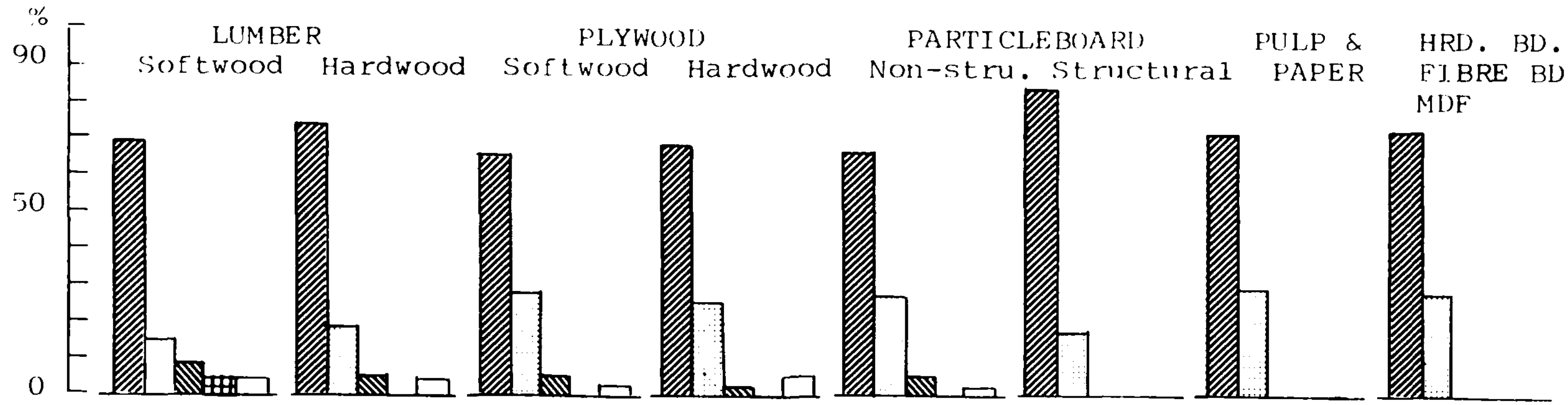

Fig. A9 (b) Percentage distribution of responses by product group for the factor: finance cost of capital

Table A9. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: finance cost of capital

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	32.29 (0.96)	31.45 (0.97)	48
$u_{12}(ij)=u_{123}(ijk)=0$	43.57 (0.97)	40.44 (0.99)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	45.98 (0.98)	43.90 (0.99)	69
$u_{123}(ijk)=0$	29.12 (0.93)	28.41 (0.95)	42

() critical value

Inadequate expenditure on research and development

A summary of the questionnaire responses is provided in fig. A10. The data were fitted to each of the four log-linear models and the results are summarized in table A10. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Cost of complying with environmental regulations

A summary of the questionnaire responses is provided in fig. A11. The data were fitted to each of the four log-linear models and the results are summarized in table A11. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Cost of complying with worker safety regulations

A summary of the questionnaire responses is provided in fig. A12. The data were fitted to each of the four log-linear models and the results are summarized in table A12. Using the criteria established in chapter IV, the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of geographical region controlling for product group. The model asserts that when these "product group effects" are taken into consideration, any regional variation in the level of importance is random.

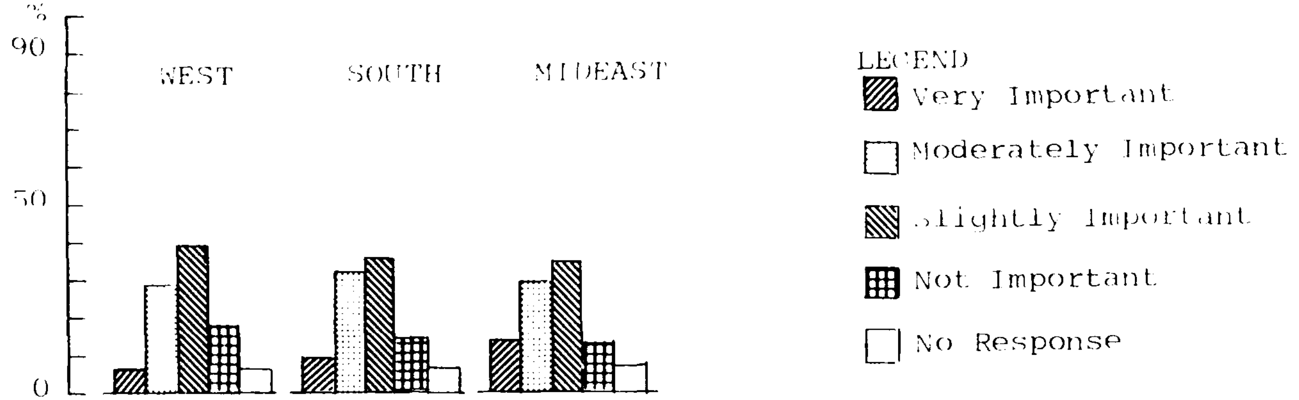

Fig. A10 (a) Percentage distribution of responses by geographical region for the factor: inadequate expenditure on research and development

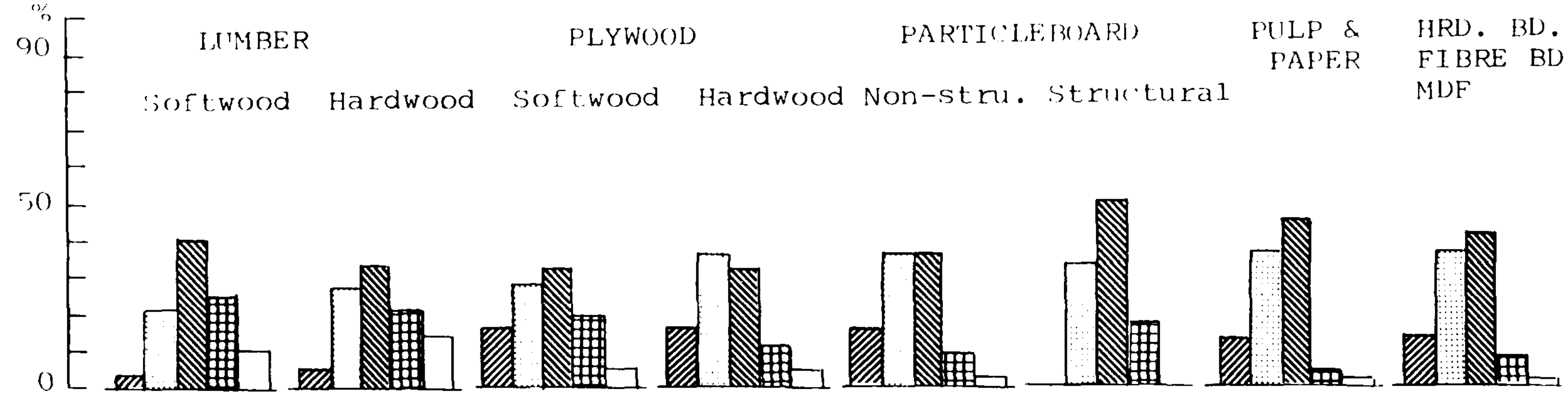

Fig. A10 (b) Percentage distribution of responses by product group for the factor: inadequate expenditure on research and development

Table A10. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: inadequate expenditure on research and development

Model	X^2	G^2	Degrees of Freedom
$u_{13(ik)}=u_{123(ijk)}=0$	25.74 (0.99)	27.29 (0.99)	48
$u_{12(ij)}=u_{123(ijk)}=0$	47.50 (0.87)	50.41 (0.93)	63
$u_{12(ij)}=u_{13(ik)}=u_{123(ijk)}=0$	51.56 (0.94)	54.01 (0.91)	69
$u_{123(ijk)}=0$	21.84 (0.99)	23.03 (0.99)	42

() critical value

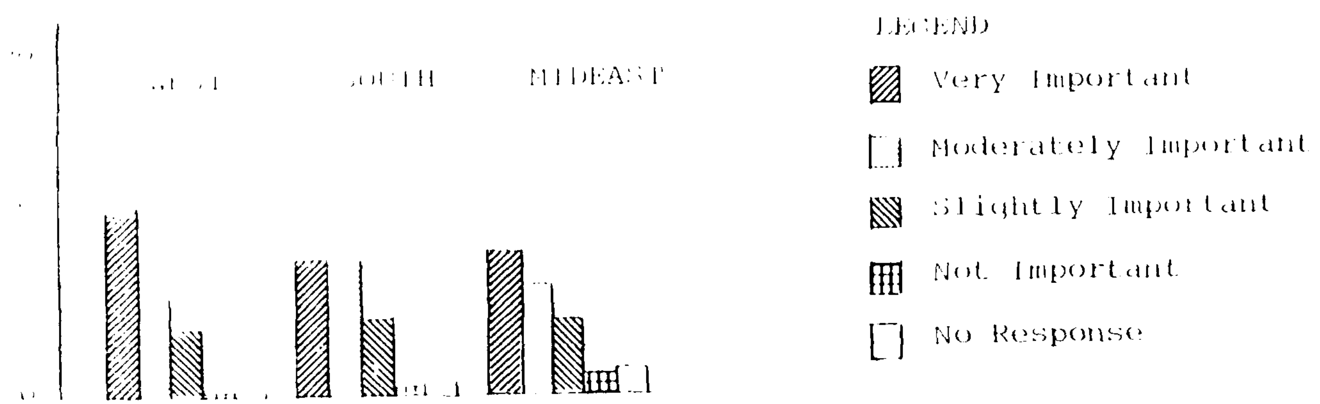

Fig. A11 (a) Percentage distribution of responses by geographical region for the factor: cost of complying with environmental regulations

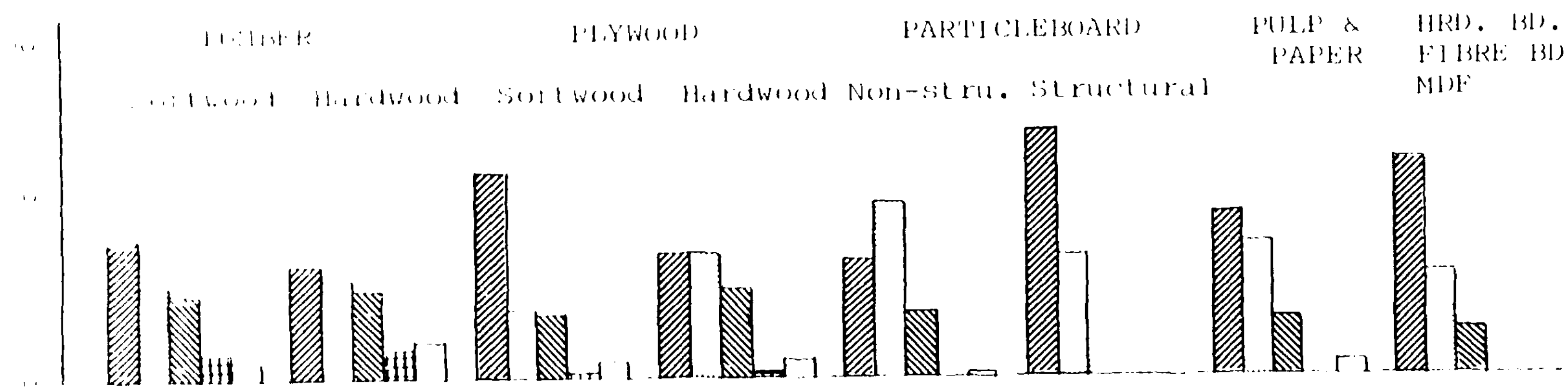

Fig. A11 (b) Percentage distribution of responses by product group for the factor: cost of complying with environmental regulations

Table A11. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: cost of complying with environmental regulations

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	36.16 (0.89)	38.48 (0.83)	48
$u_{12}(ij)=u_{123}(ijk)=0$	51.87 (0.84)	54.08 (0.78)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	57.87 (0.83)	60.27 (0.76)	69
$u_{123}(ijk)=0$	31.78 (0.87)	33.87 (0.81)	42

() critical value

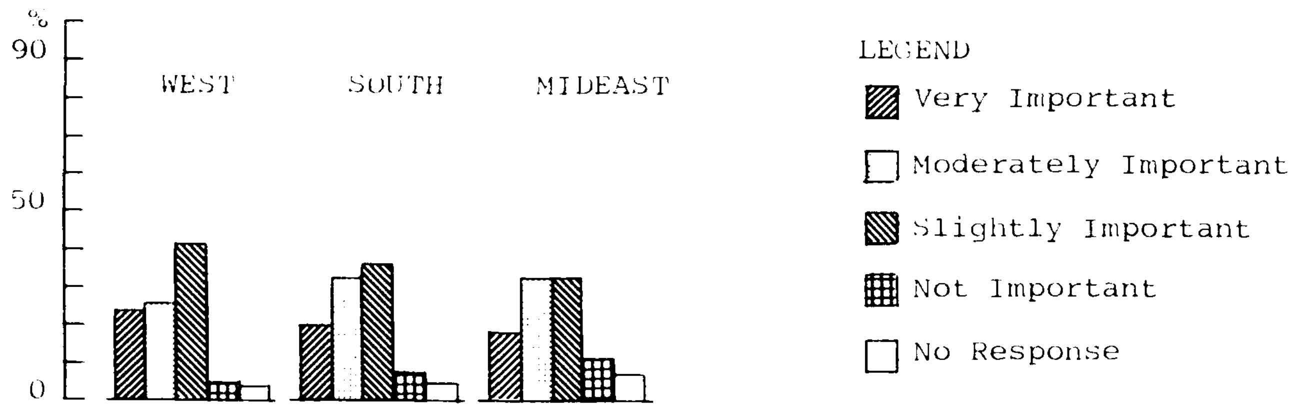

Fig. A1.(a) Percentage distribution of responses by geographical region for the factor: cost of complying with worker safety regulations (OSHA)

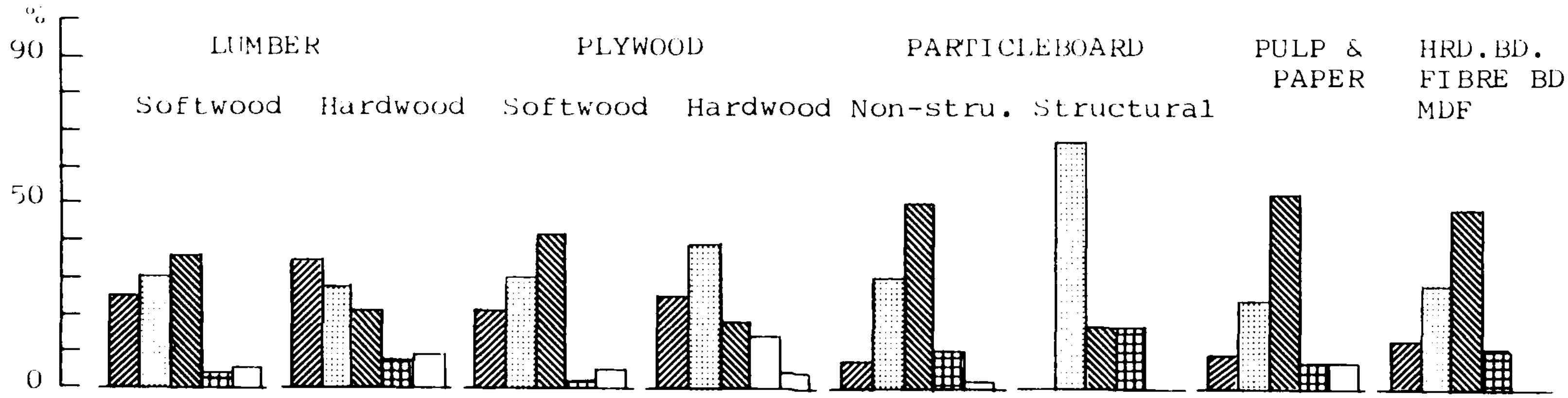

Fig. A1.(b) Percentage distribution of responses by product group for the factor: cost of complying with worker safety regulations (OSHA)

Table A12. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: cost of complying with worker safety regulations (OSHA)

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	36.26 (0.89)	37.25 (0.87)	48
$u_{12}(ij)=u_{123}(ijk)=0$	68.79 (0.29)	71.45 (0.22)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	7[illegible]32 ([illegible].28)	77.06 (0.24)	69
$u_{123}(ijk)=0$	31.12 (0.89)	31.60 (0.88)	42

() critical value

Tax laws

A summary of the questionnaire responses is provided in fig. A13. The data were fitted to each of the four log-linear models and the results are summarized in table A13. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$ was selected. Under this model, importance level is independent of product group and geographical region jointly--that is there is no apparent statistical relationship between importance level, product group and geographical region.

Government harvesting policies on publicly owned timber lands

A summary of the questionnaire responses is provided in fig. A14. The data were fitted to each of the four log-linear models and the results are summarized in table A14. Using the criteria established in chapter IV, the conditional independence model, $u_{12}(ij)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group controlling for geographical region. The model asserts that when these "regional effects" are taken into consideration, any variation in the level of importance between product groups is random.

Questionnaire part II--factors stimulating an increase in the rate of productivity growth

Increased federal (state) expenditures for research

A summary of the questionnaire responses is provided in fig. A15. The data were fitted to each of the four log-linear models and the results are summarized in table A15. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of pro-

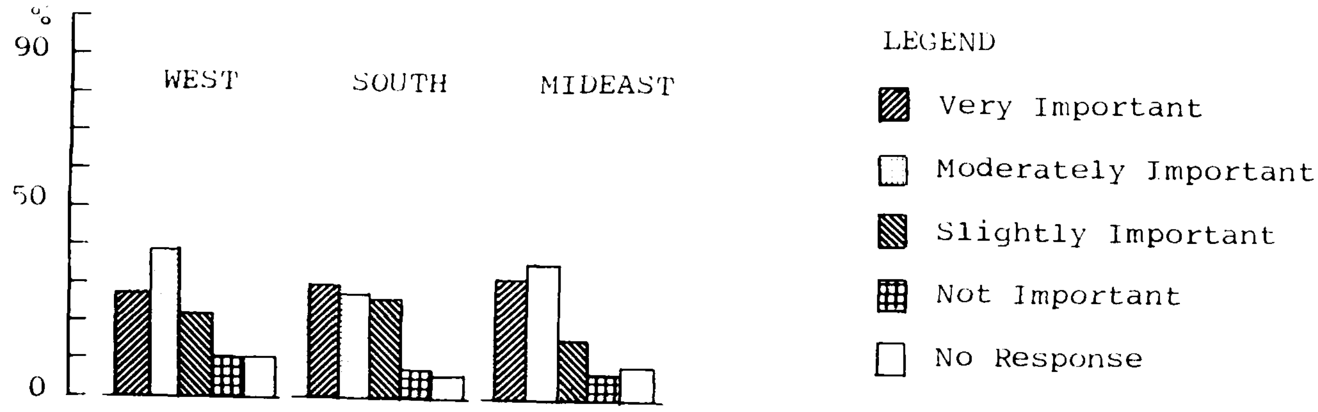

Fig. A13 (a) Percentage distribution of responses by geographical region for the factor: tax laws

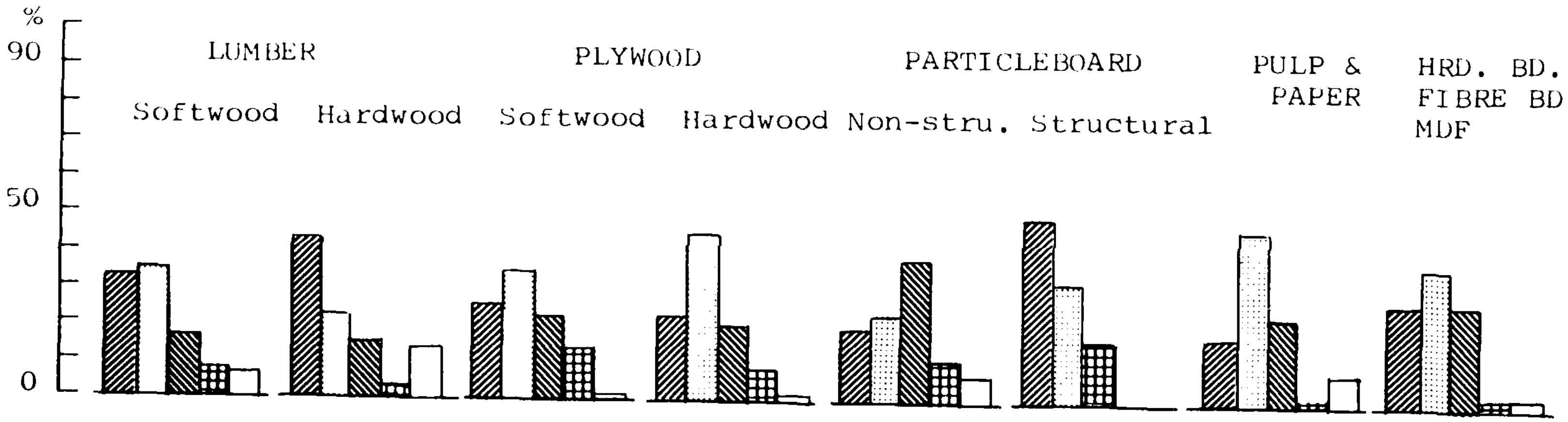

Fig. A13 (b) Percentage distribution of responses by product group for the factor: tax laws

Table A13. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: tax laws

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	50.30 (0.38)	48.63 (0.45)	48
$u_{12}(ij)=u_{123}(ijk)=0$	73.03 (0.18)	71.10 (0.23)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	79.01 (0.19)	76.69 (0.24)	69
$u_{123}(ijk)=0$	45.26 (0.34)	43.77 (0.40)	42

() critical value

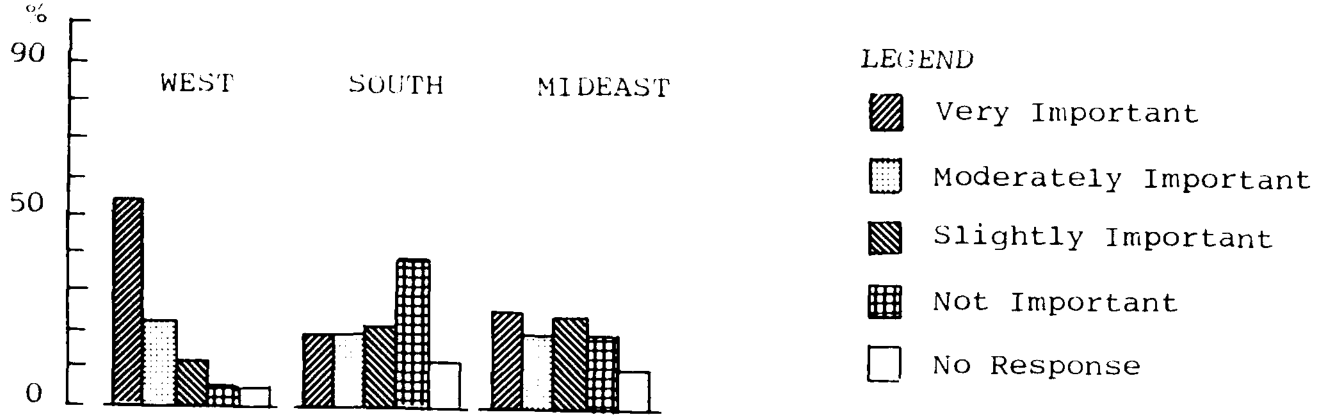

Fig. A14 (a) Percentage distribution of responses by geographical region for the factor: government harvesting policies on publicly owned timber lands

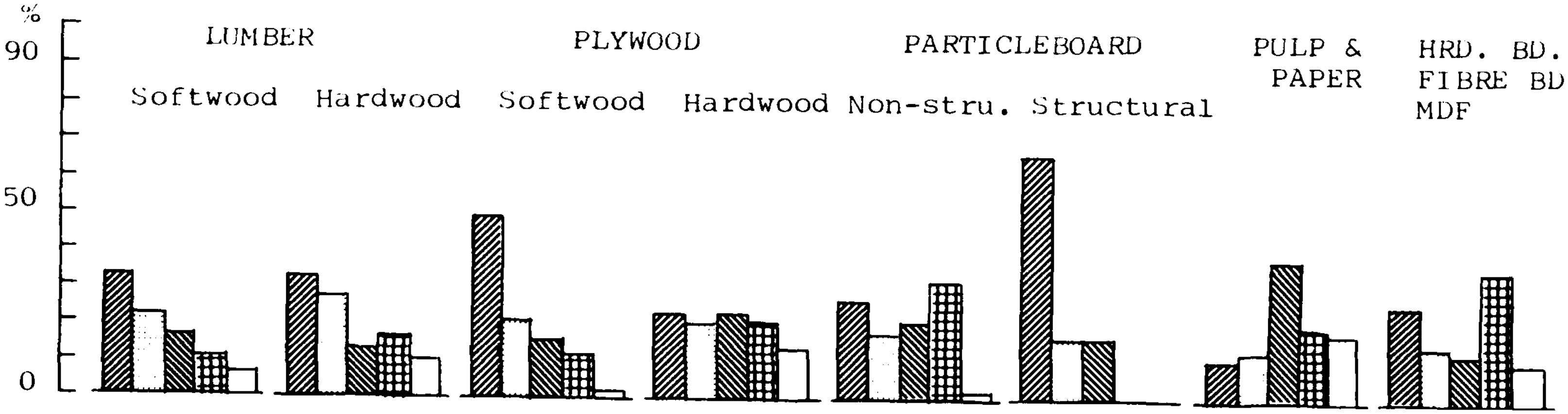

Fig. A14 (b) Percentage distribution of responses by product group for the factor: government harvesting policies on publicly owned timber lands

Table A14. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: government harvesting policies on publicly owned timber lands

Model	X^2	G^2	Degrees of Freedom
$u_{13(ik)}=u_{123(ijk)}=0$	78.98* (0.00)	84.27* (0.00)	48
$u_{12(ij)}=u_{123(ijk)}=0$	77.63 (0.10)	76.93 (0.11)	63
$u_{12(ij)}=u_{13(ik)}=u_{123(ijk)}=0$	113.84* (0.00)	122.94* (0.00)	69
$u_{123(ijk)}=0$	45.14 (0.34)	46.88 (0.28)	42

* statistic values in the upper 5% tail of the corresponding chi-square distribution with degrees-of-freedom as indicated.

() critical value

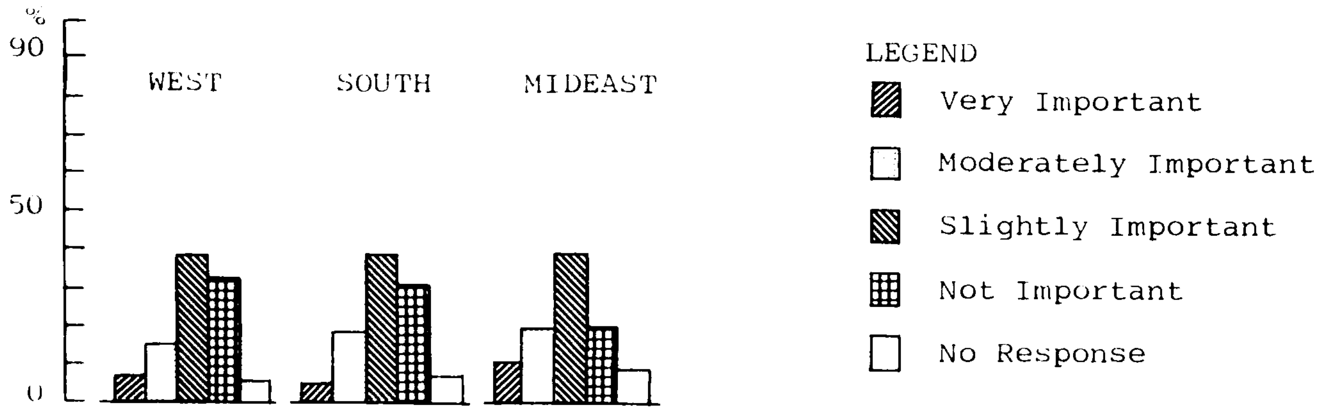

Fig. A15 (a) Percentage distribution of responses by geographical region for the factor: increased federal (state) expenditures for research

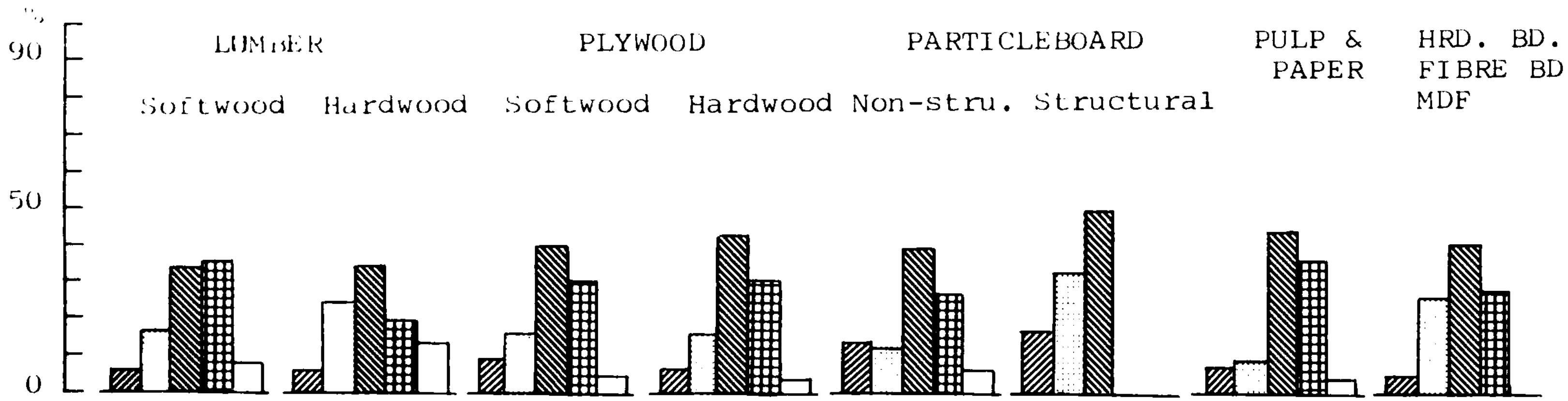

Fig. A15 (b) Percentage distribution of responses by product group for the factor: increased federal (state) expenditures for research

Table A15. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: increased federal (state) expenditures for research

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	36.51 (0.89)	36.53 (0.89)	48
$u_{12}(ij)=u_{123}(ijk)=0$	44.93 (0.96)	45.58 (0.95)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	49.66 (0.96)	51.43 (0.94)	69
$u_{123}(ijk)=0$	30.85 (0.90)	31.36 (0.88)	42

() critical value

duct group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Increased expenditures for research and development by private firms

A summary of the questionnaire responses is provided in fig. A16. The data were fitted to each of the four log-linear models and the results are summarized in table A16. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Developing and implementing specialized employee training programs

A summary of the questionnaire responses is provided in fig. A17. The data were fitted to each of the four log-linear models and the results are summarized in table A17. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Establishing financial incentives programs for employees

A summary of the questionnaire responses is provided in fig. A18. The data were fitted to each of the four log-linear models and the results are summarized in table A18. Using the criteria established in

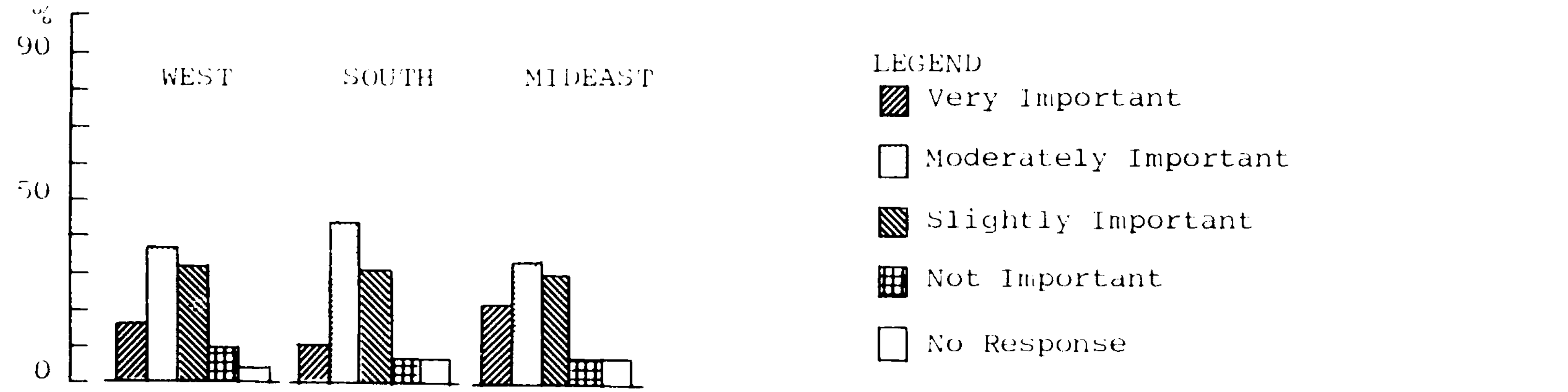

Fig. A16 (a) Percentage distribution of responses by geographical region for the factor: increased expenditures for research and development by private firms

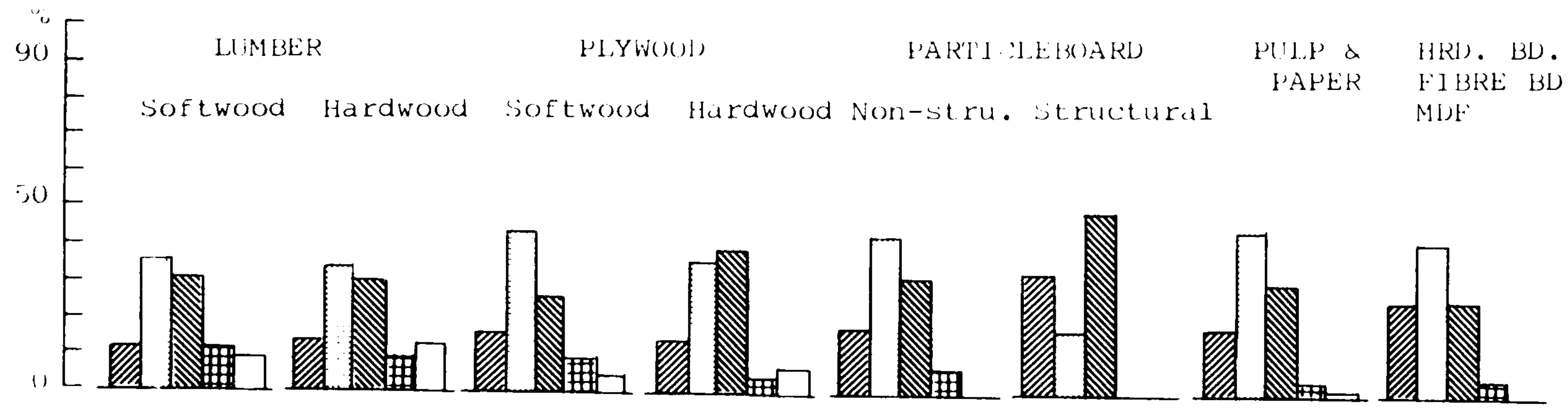

Fig. A16 (b) Percentage distribution of responses by product group for the factor: increased expenditures for research and development by private firms

Table A16. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: increased expenditures for research and development by private firms

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	29.57 (0.98)	29.58 (0.98)	48
$u_{12}(ij)=u_{123}(ijk)=0$	31.57 (0.99)	32.07 (0.99)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	39.02 (0.99)	39.07 (0.99)	69
$u_{123}(ijk)=0$	23.06 (0.99)	23.33 (0.99)	42

() critical value

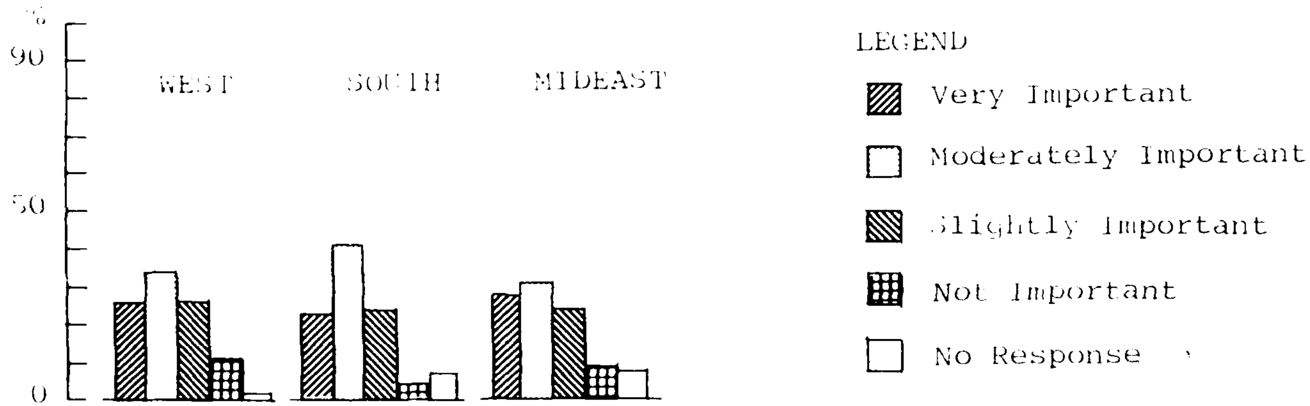

Fig. A17 (a) Percentage distribution of responses by geographical region for the factor: developing and implementing specialized employee training programs

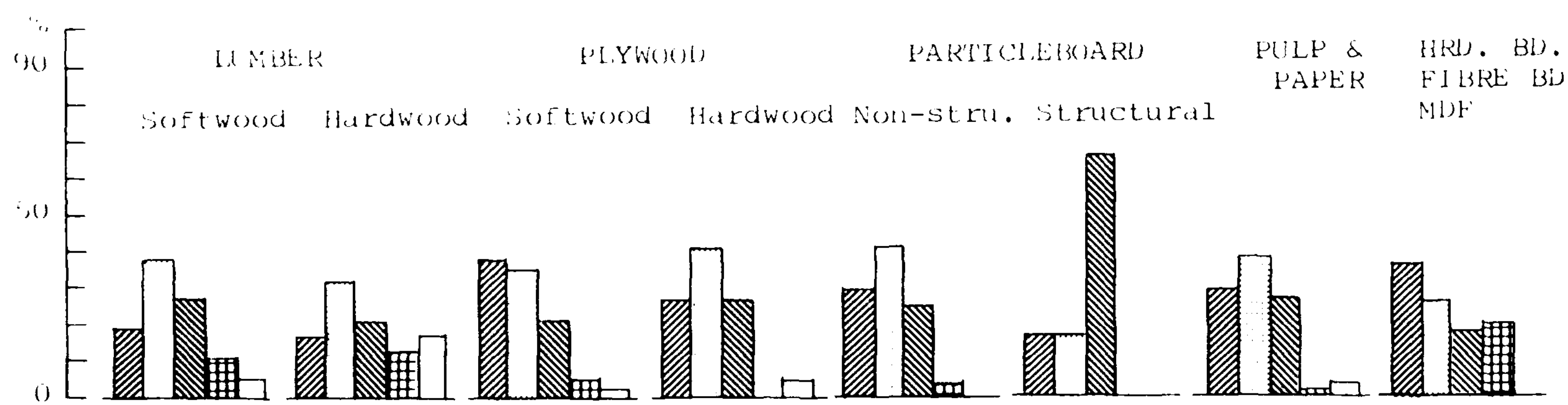

Fig. A17 (b) Percentage distribution of responses by product group for the factor: developing and implementing specialized employee training programs

Table A17. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: developing and implementing specialized employee training programs

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	35.19 (0.92)	35.66 (0.91)	48
$u_{12}(ij)=u_{123}(ijk)=0$	54.77 (0.76)	54.71 (0.76)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	59.95 (0.77)	59.57 (0.78)	69
$u_{123}(ijk)=0$	31.37 (0.88)	30.62 (0.90)	42

() critical value

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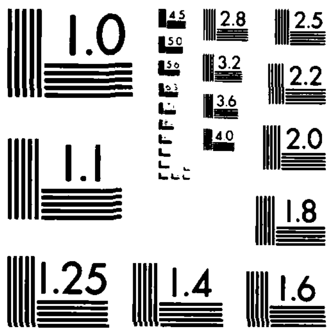

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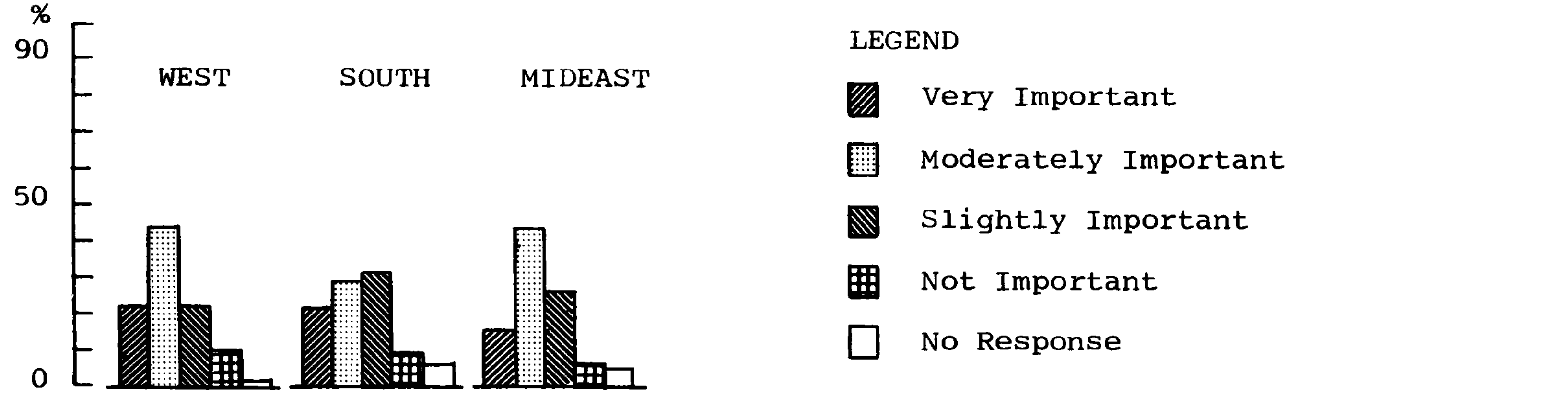

Fig. A18 (a) Percentage distribution of responses by geographical region for the factor: establishing financial incentives programs for employees

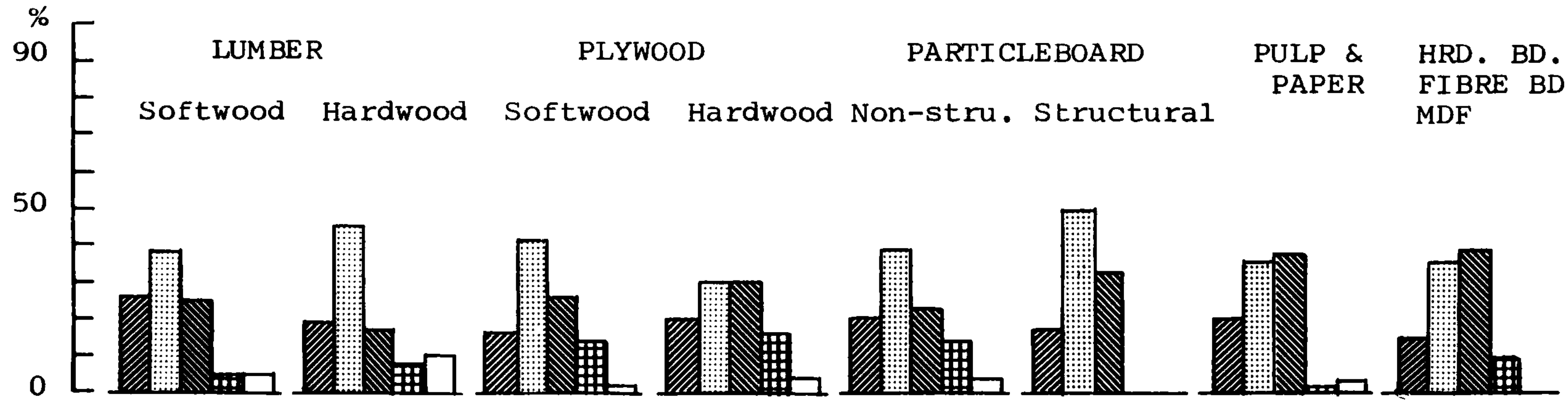

Fig. A18 (b) Percentage distribution of responses by product group for the factor: establishing financial incentives programs for employees

Table A18. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: establishing financial incentives programs for employees

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	49.87 (0.40)	49.62 (0.41)	48
$u_{12}(ij)=u_{123}(ijk)=0$	59.20 (0.76)	54.74 (0.61)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	64.69 (0.62)	67.62 (0.52)	69
$u_{123}(ijk)=0$	40.88 (0.52)	42.31 (0.46)	42

() critical value

chapter IV, the conditional independence model, $u_{12}(ik)=u_{123}(ijk)=0$ was selected. Under this model, importance level is independent of product group controlling for geographical region. The model asserts that when these "regional effects" are taken into consideration, any variation in the level of importance between product groups is random.

Cooperative research and development programs between companies

A summary of the questionnaire responses is provided in fig. A19. The data were fitted to each of the four log-linear models and the results are summarized in table A19. Using the criteria established in chapter IV, the conditional independence model, $u_{12}(ij) = u_{123}(ijk) = 0$, was selected. Under this model, importance level is independent of product group, controlling for geographical region. The model asserts that when these "regional effects" are taken into consideration, any variation in the level of importance between product groups is random.

Establishing company-wide productivity improvement programs

A summary of the questionnaire responses is provided in fig. A20. The data were fitted to each of the four log-linear models and the results are summarized in table A20. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Increased mechanization induced by an inadequate labor supply

A summary of the questionnaire responses is provided in fig. A21. The data were fitted to each of the four log-linear models and the

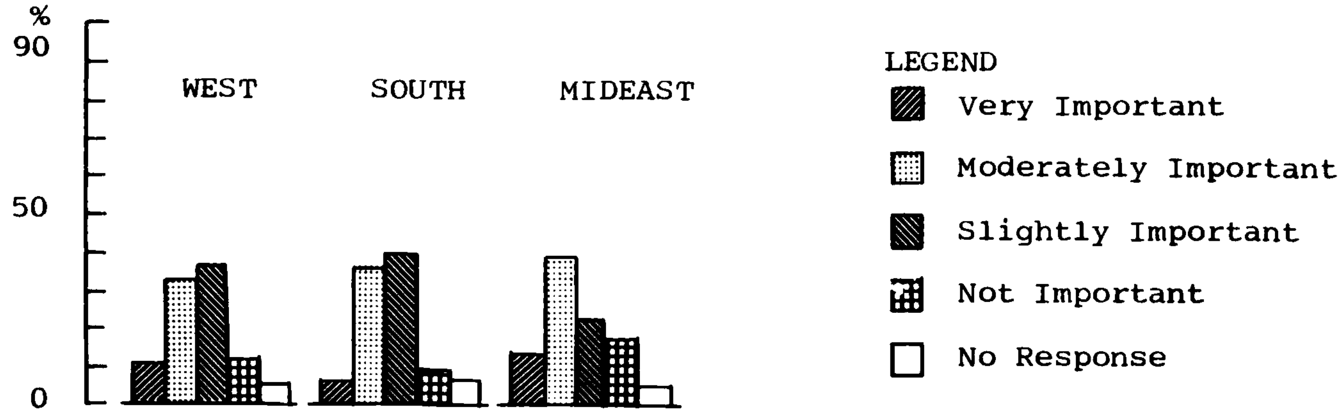

Fig. A19 (a) Percentage distribution of responses by geographical region for the factor: cooperative research and development programs between companies

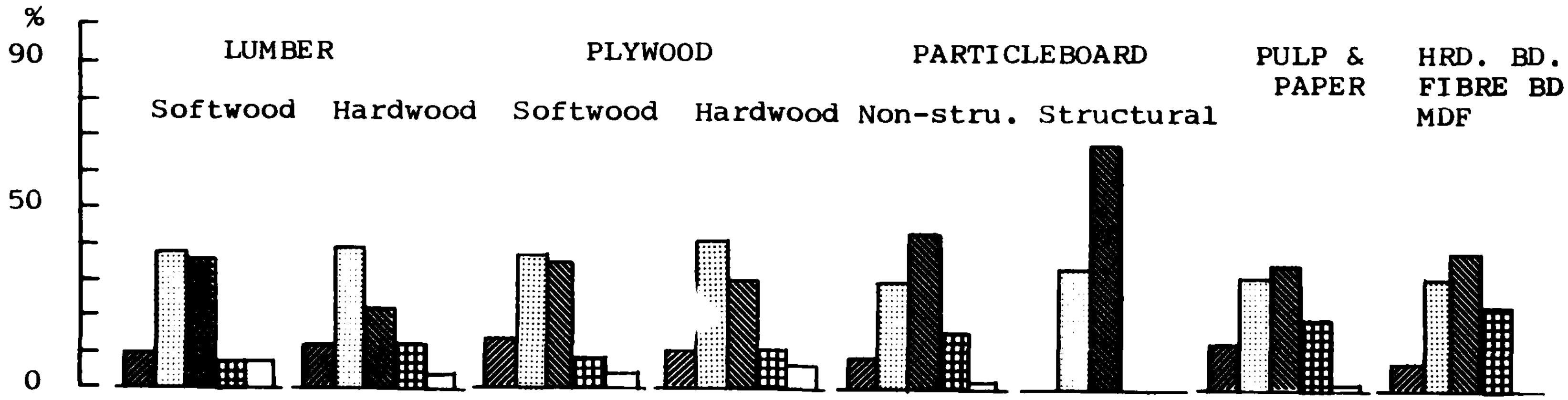

Fig. A19 (b) Percentage distribution of responses by product group for the factor: cooperative research and development programs between companies

Table A19. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: cooperative research and development programs between companies

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	43.05 (0.67)	46.13 (0.55)	48
$u_{12}(ij)=u_{123}(ijk)=0$	45.55 (0.95)	47.65 (0.92)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	55.48 (0.88)	59.15 (0.79)	69
$u_{123}(ijk)=0$	34.76 (0.78)	36.67 (0.70)	42

() critical value

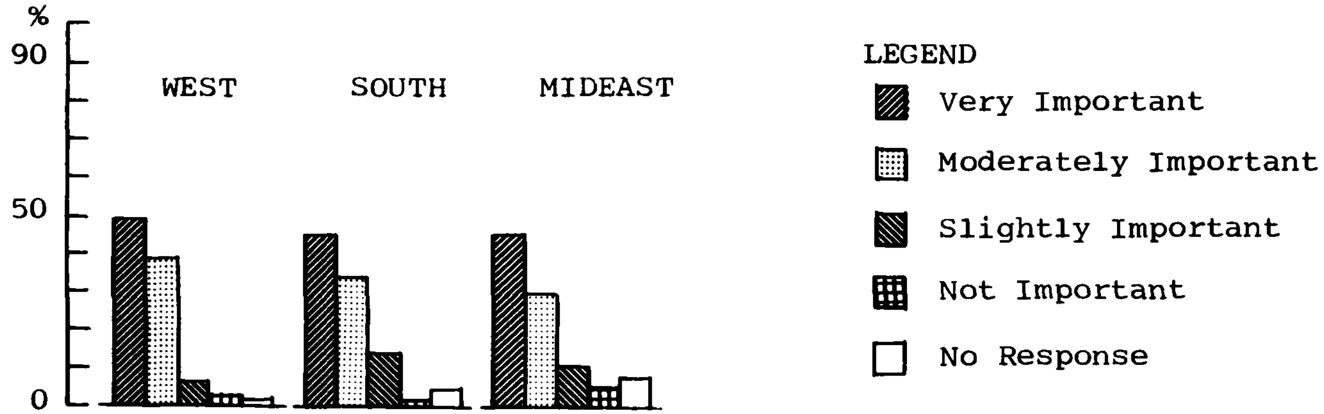

Fig. A20 (a) Percentage distribution of responses by geographical region for the factor: establishing company-wide productivity improvement programs

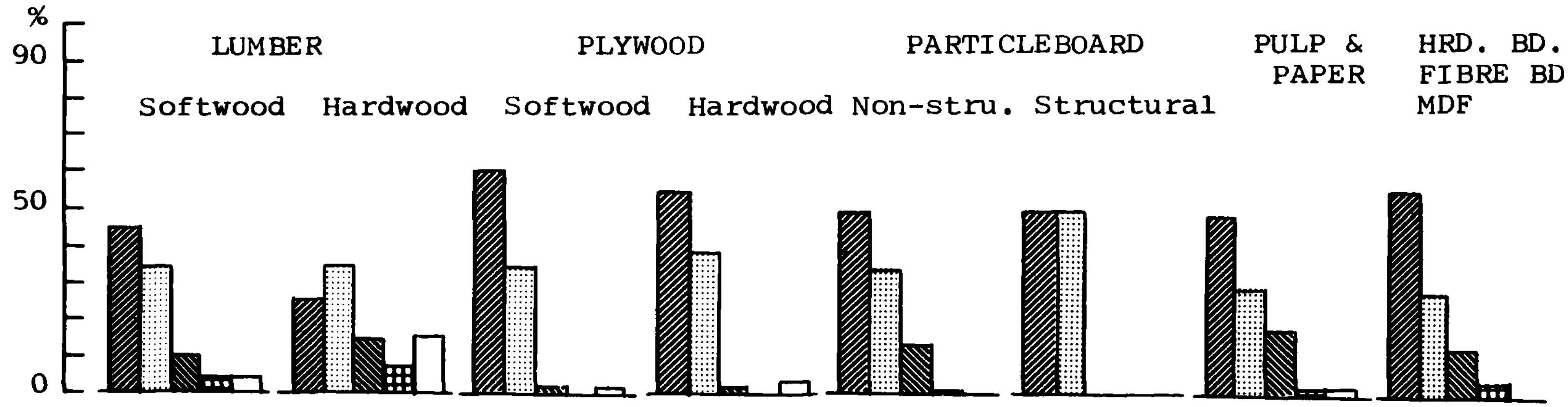

Fig. A20 (b) Percentage distribution of responses by product group for the factor: establishing company-wide productivity improvement programs

Table A20. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: establishing company wide productivity improvement programs

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	34.12 (0.93)	35.56 (0.91)	48
$u_{12}(ij)=u_{123}(ijk)=0$	49.64 (0.89)	52.16 (0.83)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	55.05 (0.89)	57.71 (0.83)	69
$u_{123}(ijk)=0$	30.37 (0.91)	30.54 (0.91)	42

() critical value

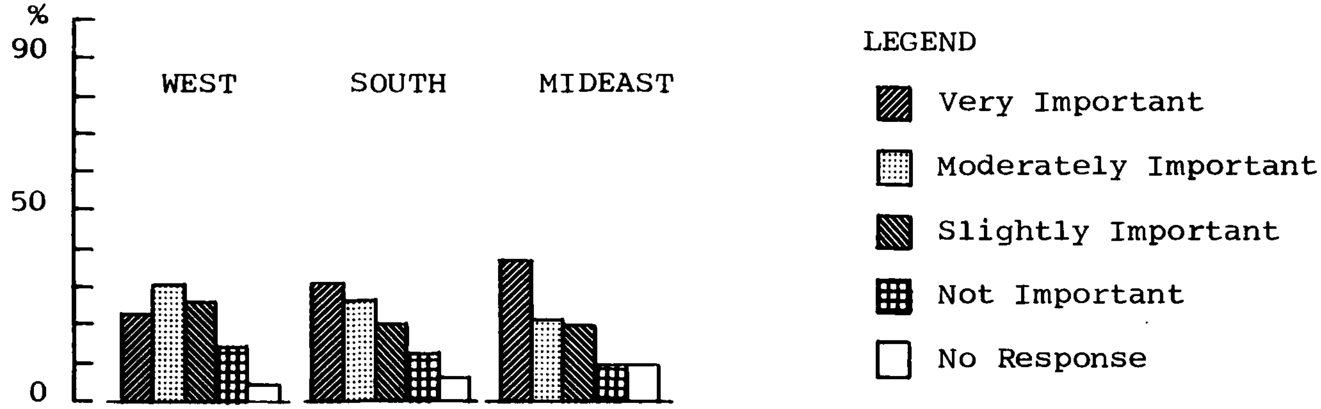

Fig. A21 (a) Percentage distribution of responses by geographical region for the factor: increased mechanization induced by an inadequate labor supply

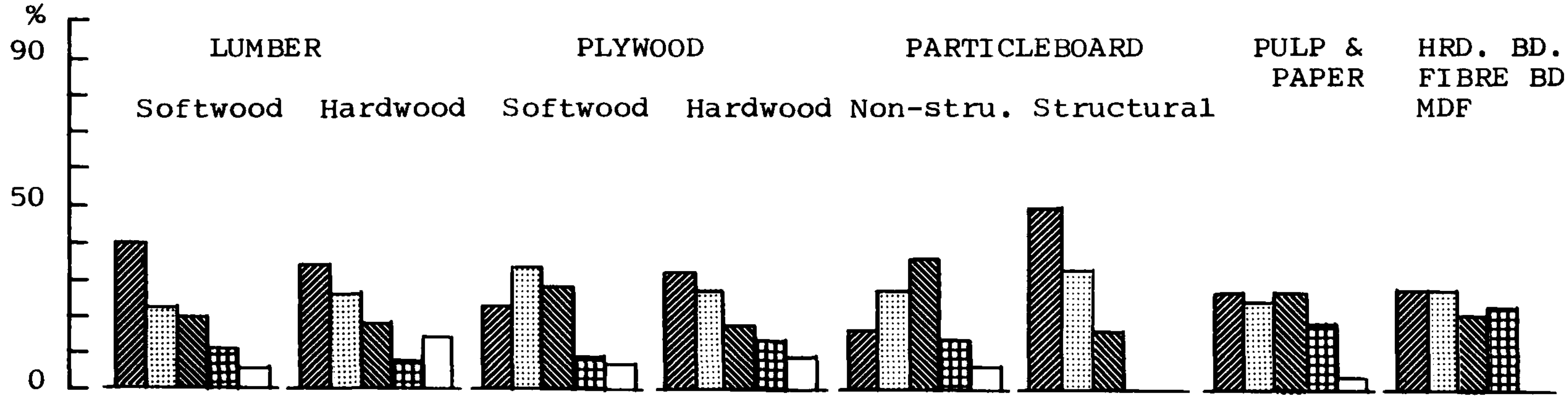

Fig. A21 (b) Percentage distribution of responses by product group for the factor: increased mechanization induced by an inadequate labor labor supply

Table A21. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: increased mechanization induced by an inadequate labor supply

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	40.68 (0.76)	41.84 (0.72)	48
$u_{12}(ij)=u_{123}(ijk)=0$	52.71 (0.82)	52.98 (0.81)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	58.47 (0.81)	59.77 (0.78)	69
$u_{123}(ijk)=0$	30.60 (0.90)	32.65 (0.85)	42

() critical value

results are summarized in table A21. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

<u>Availability of new (or better) processing equipment</u>

A summary of the questionnaire responses is provided in fig. A22. The data were fitted to each of the four log-linear models and the results are summarized in table A22. Using the criteria established in chapter IV, the conditional independence model, $u_{12}(ij)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group controlling for geographical variation. The model asserts that when these "regional effects" are taken into consideration, any variation in the level of importance between product groups is random.

<u>Development of computer-based process control equipment</u>

A summary of the questionnaire responses is provided in fig. A23. The data were fitted to each of the four log-linear models and the results are summarized in table A23. Using the criteria established in chapter IV, the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of geographical region controlling for product group. The model asserts that when these "regional effects" are taken into consideration, any variation in the level of importance is random.

<u>Questionnaire part III-government policy or program changes needed to encourage increases in the rate of productivity growth</u>

<u>Tax changes to encourage investment</u>

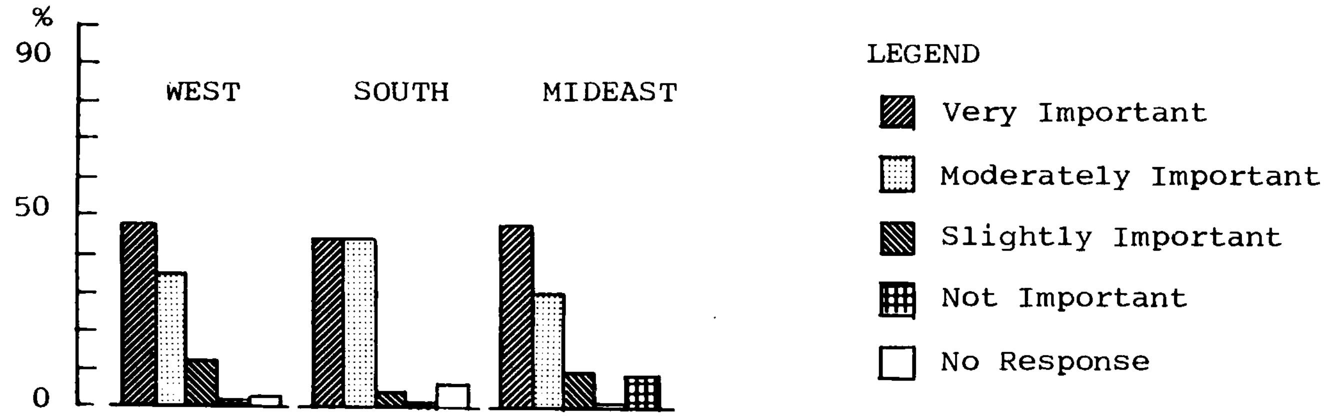

Fig. A22 (a) Percentage distribution of responses by geographical region for the factor: availability of new (or better) processing equipment

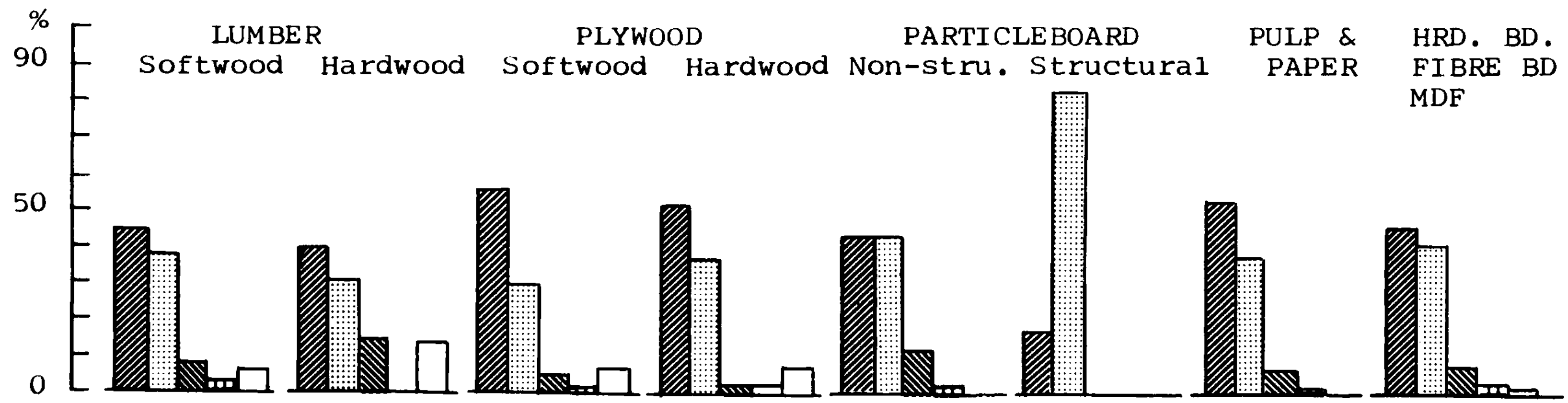

Fig. A22 (b) Percentage distribution of responses by product group for the factor: availability of new (or better) processing equipment

Table A22. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: availability of new (or better) processing equipment

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	32.47 (0.96)	31.57 (0.97)	48
$u_{12}(ij)=u_{123}(ijk)=0$	37.64 (0.99)	36.70 (0.99)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	45.96 (0.98)	44.61 (0.99)	69
$u_{123}(ijk)=0$	23.55 (0.99)	22.52 (0.99)	42

() critical value

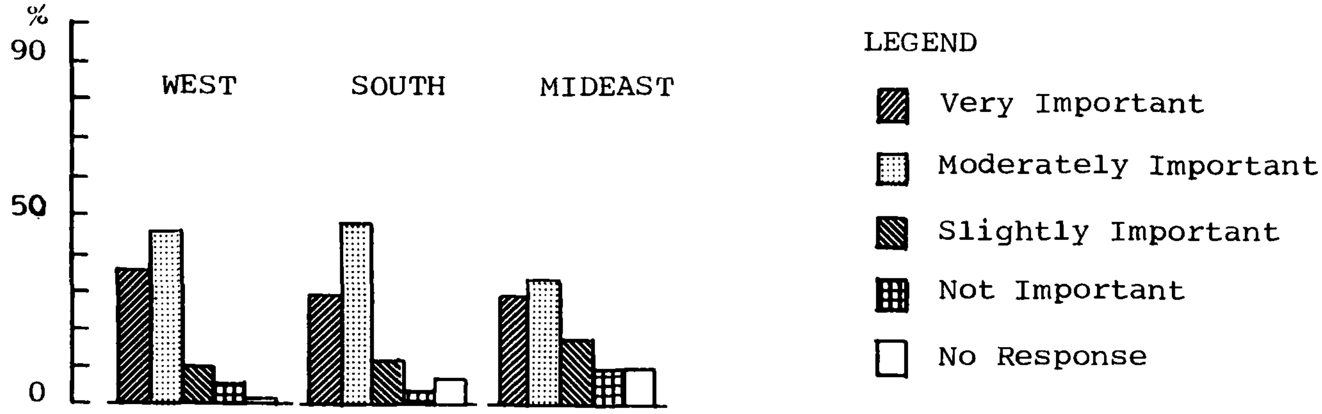

Fig. A23 (a) Percentage distribution of responses by geographical region for the factor: development of computer-based process control equipment

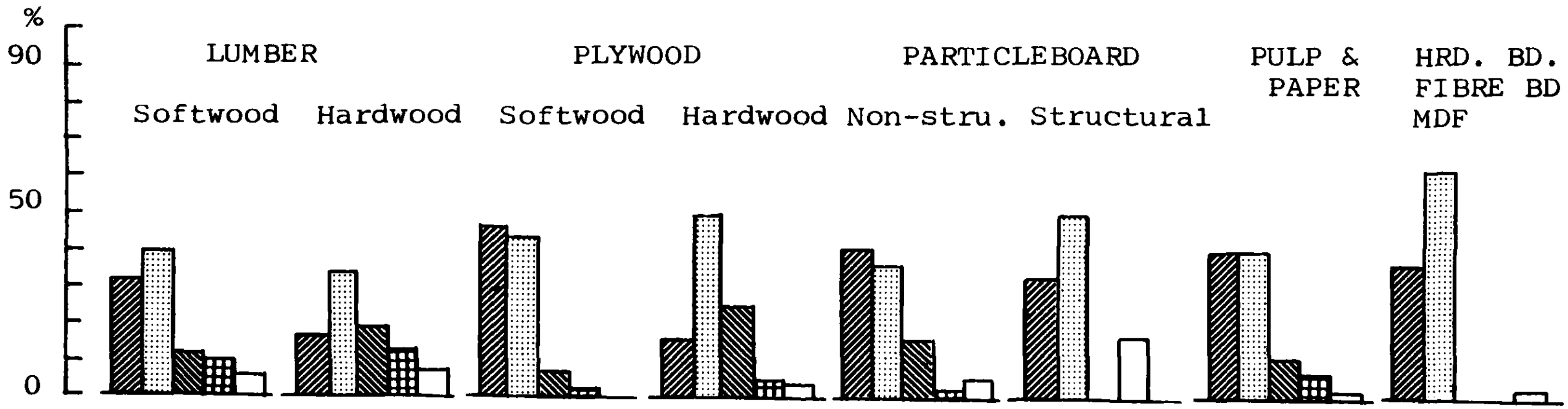

Fig. A23 (b) Percentage distribution of responses by product group for the factor: development of computer-based process control equipment

Table A23. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the factor: development of computer based process control equipment

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	39.16 (0.81)	38.74 (0.83)	48
$u_{12}(ij)=u_{123}(ijk)=0$	66.67 (0.42)	64.69 (0.35)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	75.98 (0.26)	75.82 (0.27)	69
$u_{123}(ijk)=0$	31.91 (0.87)	32.60 (0.85)	42

() critical value

A summary of the questionnaire responses is provided in fig. A24. The data were fitted to each of the four log-linear models and the results are summarized in table A24. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Develop a national productivity improvement plan to encourage faster diffusion of knowledge

A summary of the questionnaire responses is provided in fig. A25. The data were fitted to each of the four log-linear models and the results are summarized in table A25. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model importance level is independent of industry group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Policies to stimulate research and development within private firms

A summary of the questionnaire responses is provided in fig. A26. The data were fitted to each of the four log-linear models and the results are summarized in table A26. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

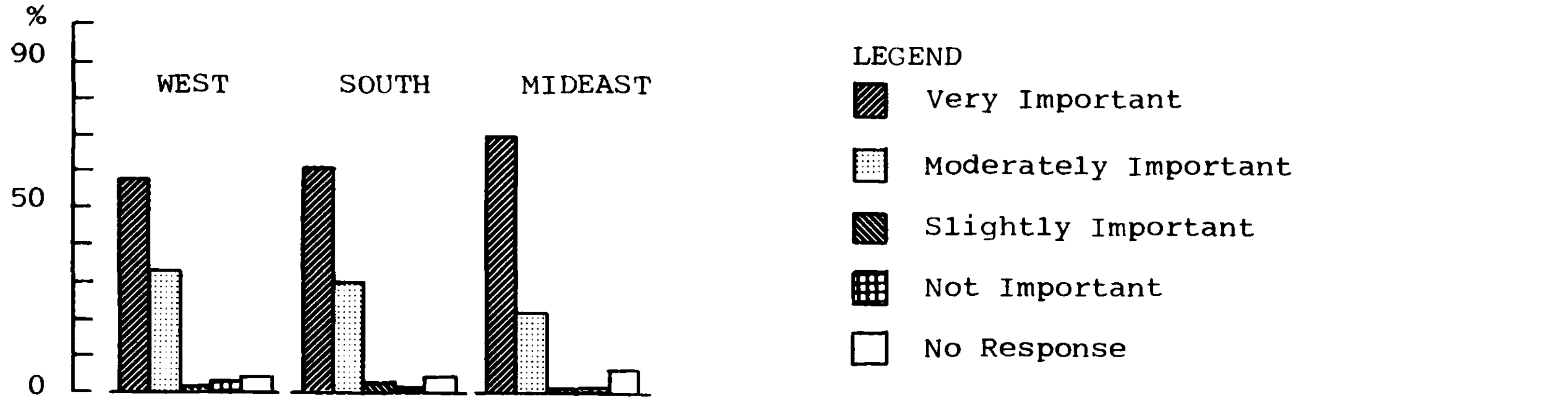

Fig.A24 (a) Percentage distribution of responses by geographical region for the policy: tax changes to encourage investment

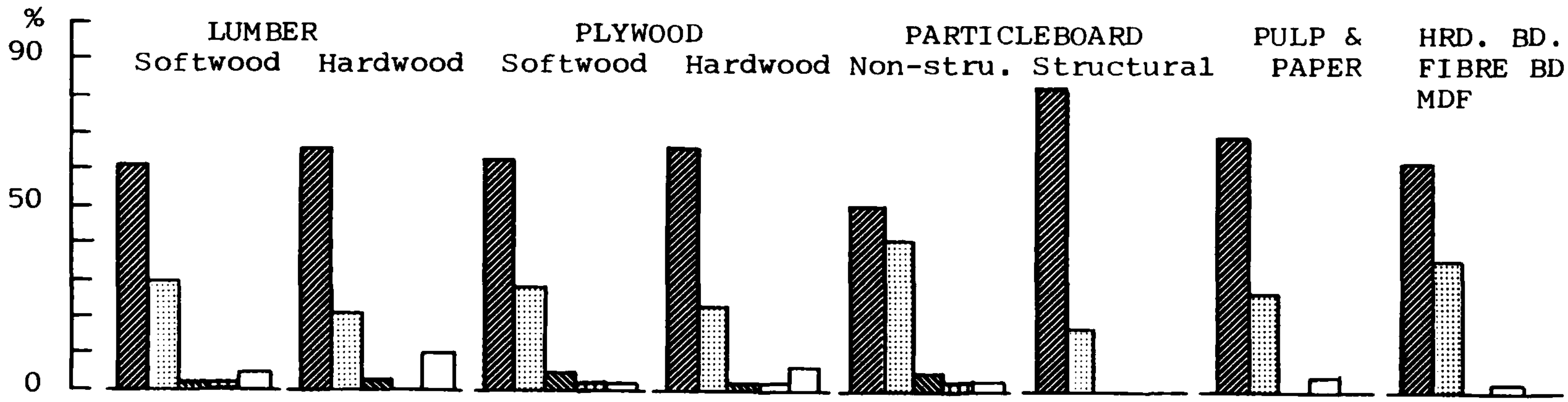

Fig.A24 (b) Percentage distribution of responses by product group for the policy: tax changes to encourage investment

Table A24. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the policy: tax changes to encourage investment

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	28.08 (0.99)	26.68 (0.99)	48
$u_{12}(ij)=u_{123}(ijk)=0$	38.47 (0.99)	34.93 (0.99)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	43.50 (0.99)	39.47 (0.99)	69
$u_{123}(ijk)=0$	24.80 (0.98)	23.95 (0.99)	42

() critical value

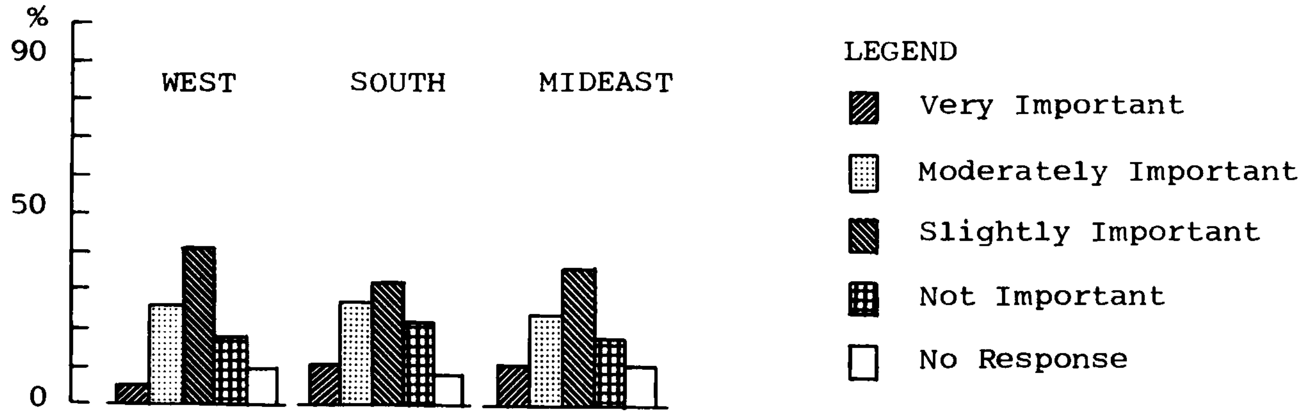

Fig. A25 (a) Percentage distribution of responses by geographical region for the policy: develop a national productivity improvement plan to encourage faster diffusion of knowledge

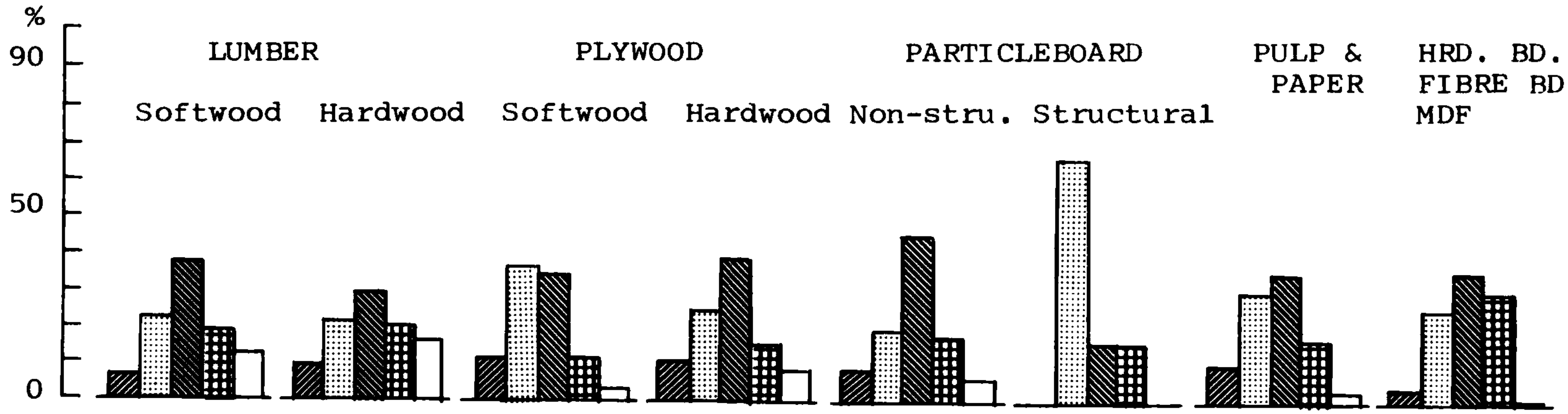

Fig. A25 (b) Percentage distribution of responses by product group for the policy: develop a national productivity improvement plan to encourage faster diffusion of knowledge

Table A25. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the policy: develop a national productivity improvement plan to encourage faster diffusion of knowledge

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	44.72 (0.61)	46.17 (0.55)	48
$u_{12}(ij)=u_{123}(ijk)=0$	52.33 (0.83)	53.19 (0.81)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	57.05 (0.85)	58.22 (0.82)	69
$u_{123}(ijk)=0$	39.56 (0.58)	40.62 (0.583)	42

() critical value

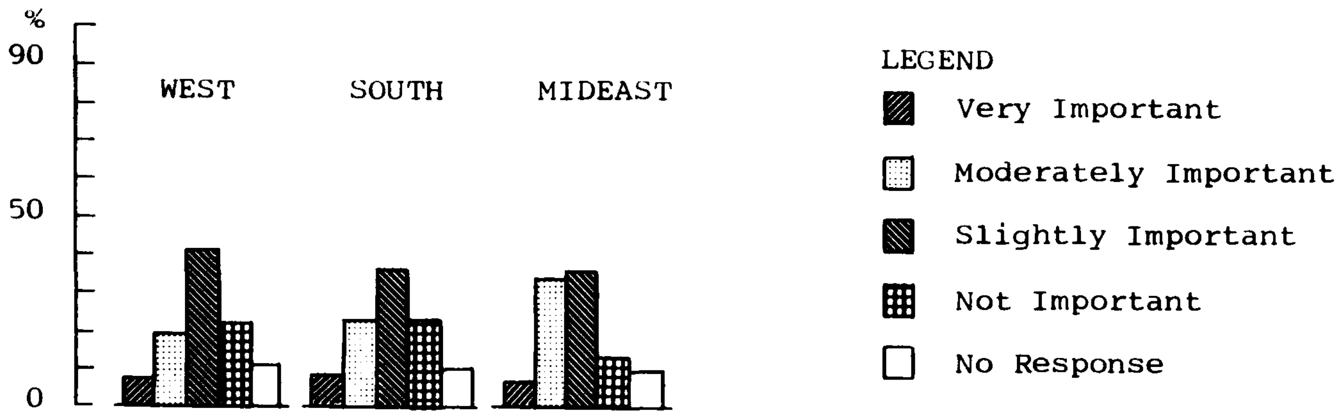

Fig. A26 (a) Percentage distribution of responses by geographical region for the policy: policies to stimulate research and development within private firms

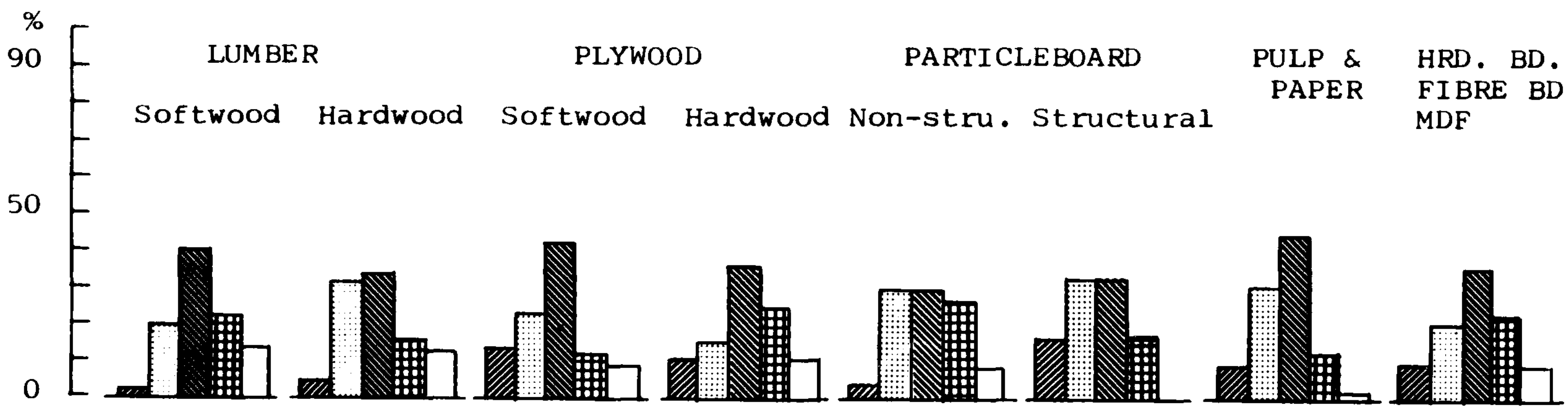

Fig. A26 (b) Percentage distribution of responses by product group for the policy: policies to stimulate research and development within private firms

Table A26. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the policy: policies to stimulate research and development within private firms

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	42.11 (0.79)	39.77 (0.71)	48
$u_{12}(ij)=u_{123}(ijk)=0$	56.98 (0.69)	55.71 (0.73)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	62.27 (0.70)	59.24 (0.79)	69
$u_{123}(ijk)=0$	37.20 (0.68)	36.48 (0.71)	42

() critical value

Policies to stimulate research by government agencies or universities

A summary of the questionnaire responses is provided in fig. A27. The data were fitted to each of the four log-linear models and the results are summarized in table A27. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Policies to promote market stability

A summary of the questionnaire responses is provided in fig. A28. The data were fitted to each of the four log-linear models and the results are summarized in table A28. Using the criteria established in chapter IV, the joint independence model, $u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of product group and geographical region jointly--that is, there is no apparent statistical relationship between importance level, product group and geographical region.

Policies to stimulate the housing sector

A summary of the questionnaire responses is provided in fig. A29. The data were fitted to each of the four log-linear models and the results are summarized in table A29. Using the criteria established in chapter IV, the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of geographical region controlling for product group. The model asserts that when these "product group effects" are taken into consideration, any regional variation in the level of importance is random.

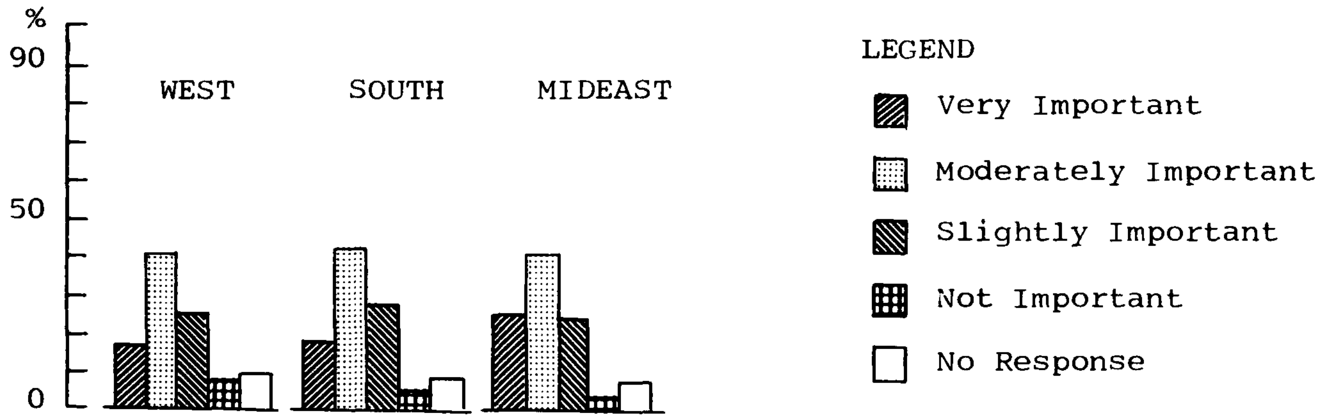

Fig. A27 (a) Percentage distribution of responses by geographical region for the policy: policies and funds to stimulate research by government agencies or universities

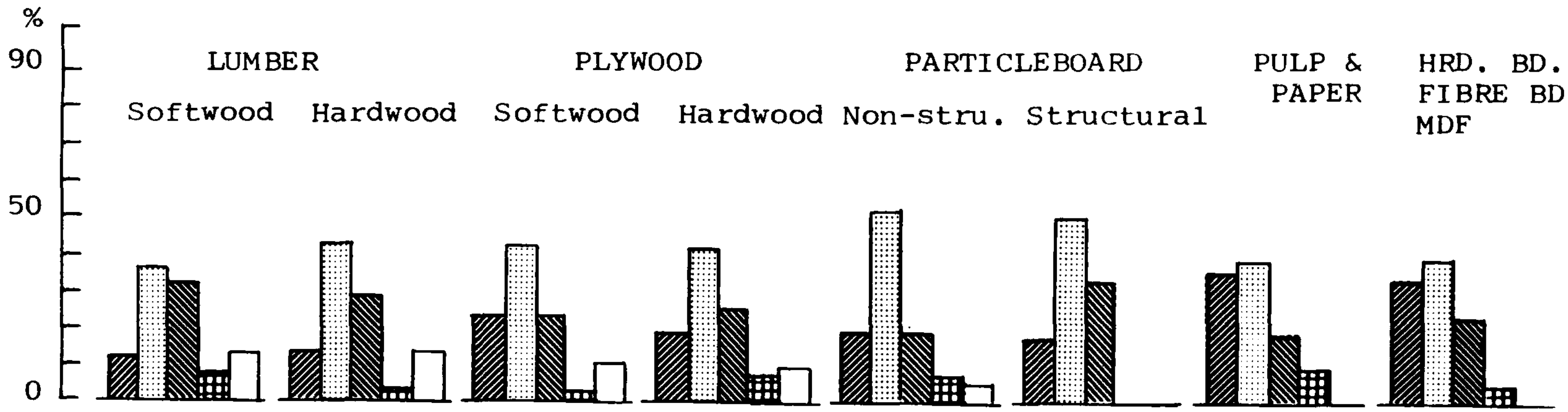

Fig. A27 (b) Percentage distribution of responses by product group for the policy: policies and funds to stimulate research by government agencies or universities

Table A27. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the policy: policies to stimulate research by government agencies or universities

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	38.34 (0.83)	38.64 (0.81)	48
$u_{12}(ij)=u_{123}(ijk)=0$	50.64 (0.87)	50.66 (0.87)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	57.78 (0.83)	58.60 (0.81)	69
$u_{123}(ijk)=0$	33.10 (0.84)	33.98 (0.83)	42

() critical value

Fig. A28 (a) Percentage distribution of responses by geographical region for the policy: policies to promote market stability

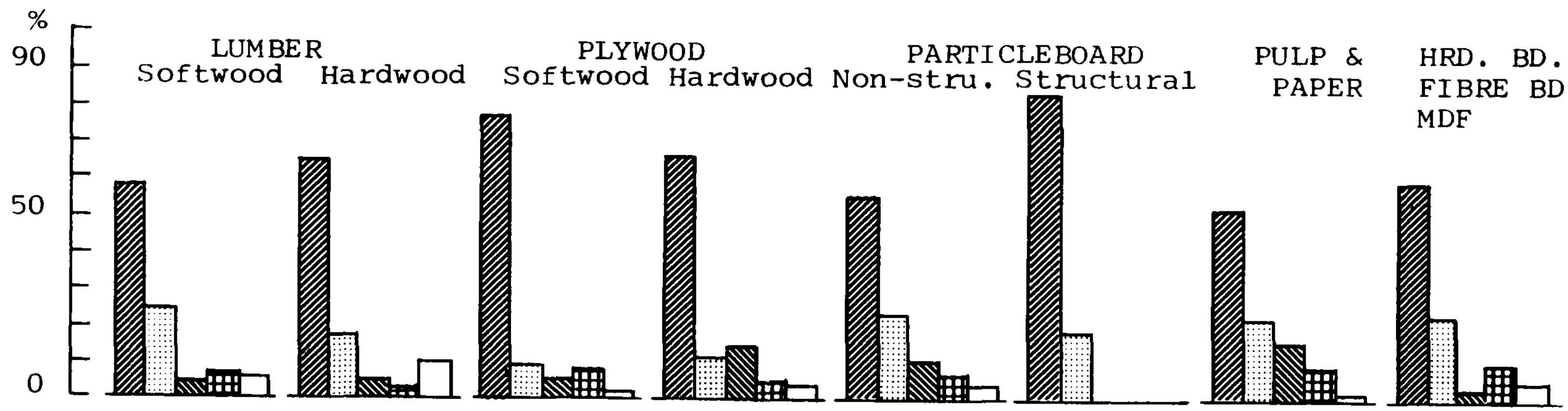

Fig. A28 (b) Percentage distribution of responses by product group for the policy: policies to promote market stability

Table A28. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the policy: policies to promote market stability

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	28.72 (0.99)	29.81 (0.98)	48
$u_{12}(ij)=u_{123}(ijk)=0$	47.66 (0.92)	47.43 (0.93)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	48.49 (0.97)	48.70 (0.97)	69
$u_{123}(ijk)=0$	28.00 (0.95)	29.06 (0.93)	42

() critical value

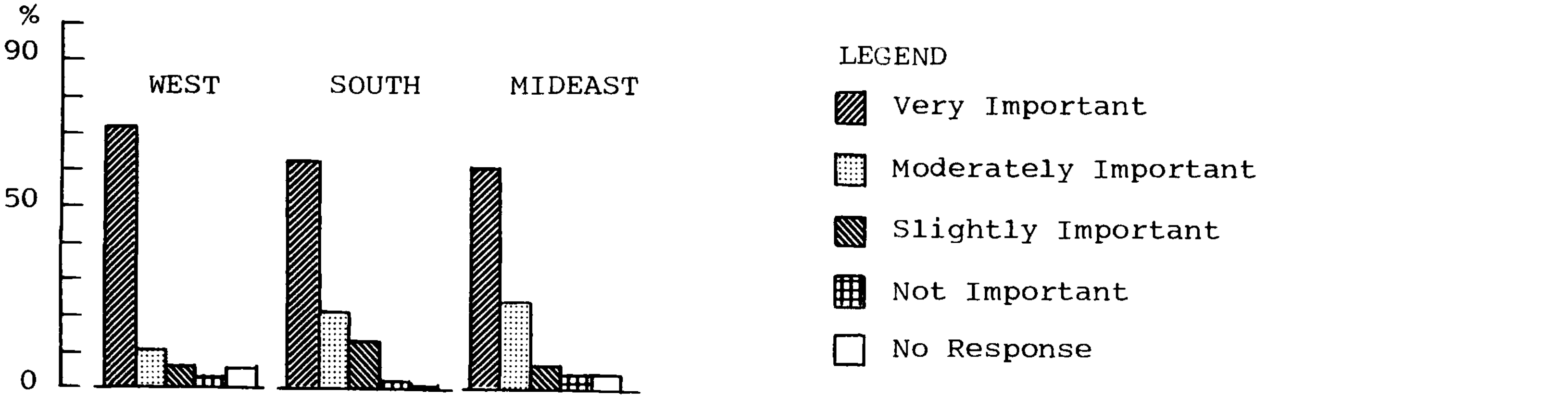

Fig. A29 (a) Percentage distribution of responses by geographical region for the policy: policies to stimulate the housing sector

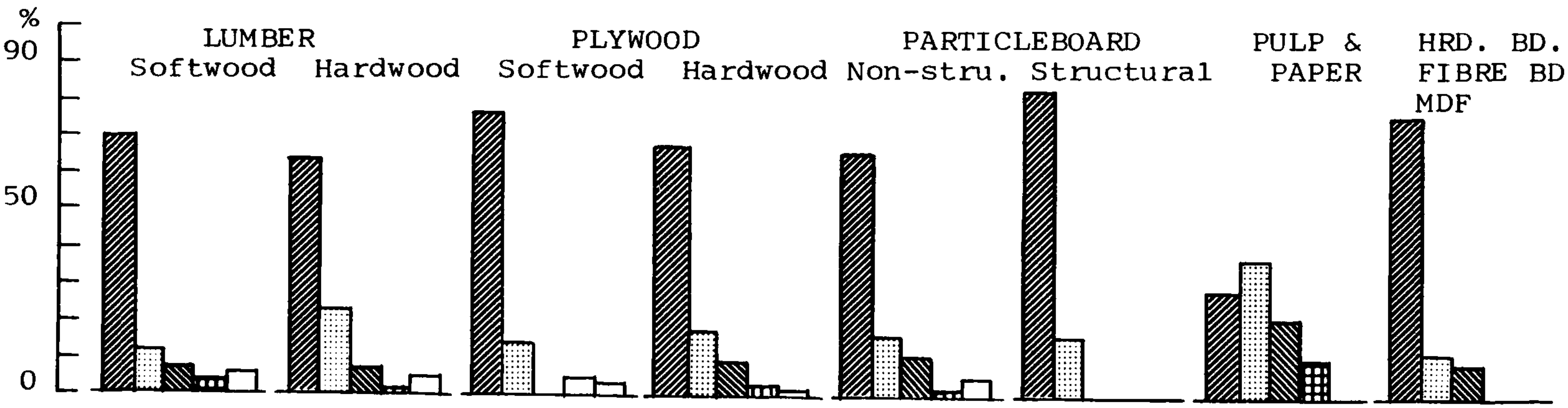

Fig. A29 (b) Percentage distribution of responses by product group for the policy: policies to stimulate the housing sector

Table A29. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the policy: policies to stimulate the housing sector

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	29.39 (0.98)	28.97 (0.99)	48
$u_{12}(ij)=u_{123}(ijk)=0$	59.76 (0.59)	58.94 (0.62)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	67.98 (0.51)	68.03 (0.51)	69
$u_{123}(ijk)=0$	25.72 (0.98)	24.09 (0.99)	42

() critical value

Policies to reduce the cyclic boom to bust nature of the housing industry

A summary of the questionnaire responses is provided in fig. A30. The data were fitted to each of the four log-linear models and the results are summarized in table A30. Using the criteria established in chapter IV, the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$, was selected. Under this model, importance level is independent of geographical region controlling for product group. The model asserts that when these "product group effects" are taken into consideration, any regional variation in the level of importance is random.

Policies to accelerate the harvest of public timber

A summary of the questionnaire responses is provided in fig. A31. The data were fitted to each of the four log-linear models and the results are summarized in table A31. Although the no-three-factor interaction model, $u_{123}(ijk)=0$, appears to fit the data best given the criteria established in chapter IV, the conditional independence model, $u_{13}(ik)=u_{123}(ijk)=0$, was selected instead since the standardized values for the estimated $u_{12}(ij)$ terms (under the no-three-factor interaction model) indicated that no terms were significantly different from zero. Under the conditional independence model, importance level is independent of geographical region controlling for product group. The model asserts that when these "product group effects" are taken into consideration, any regional variation in the level of importance is random.

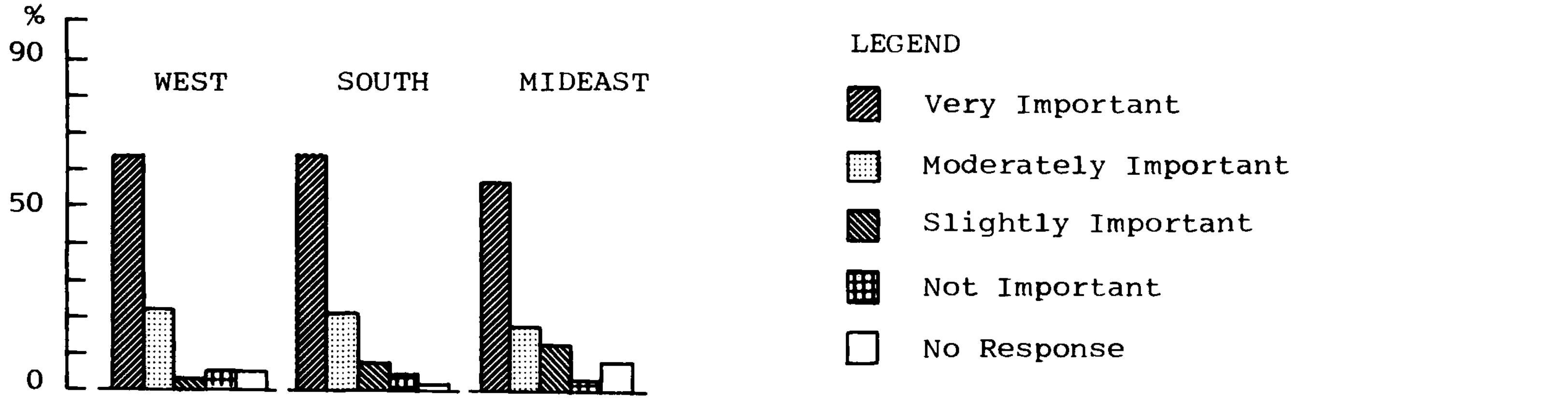

Fig. A30 (a) Percentage distribution of responses by geographical region for the policy: policies to reduce the cyclic boom to bust nature of the housing industry

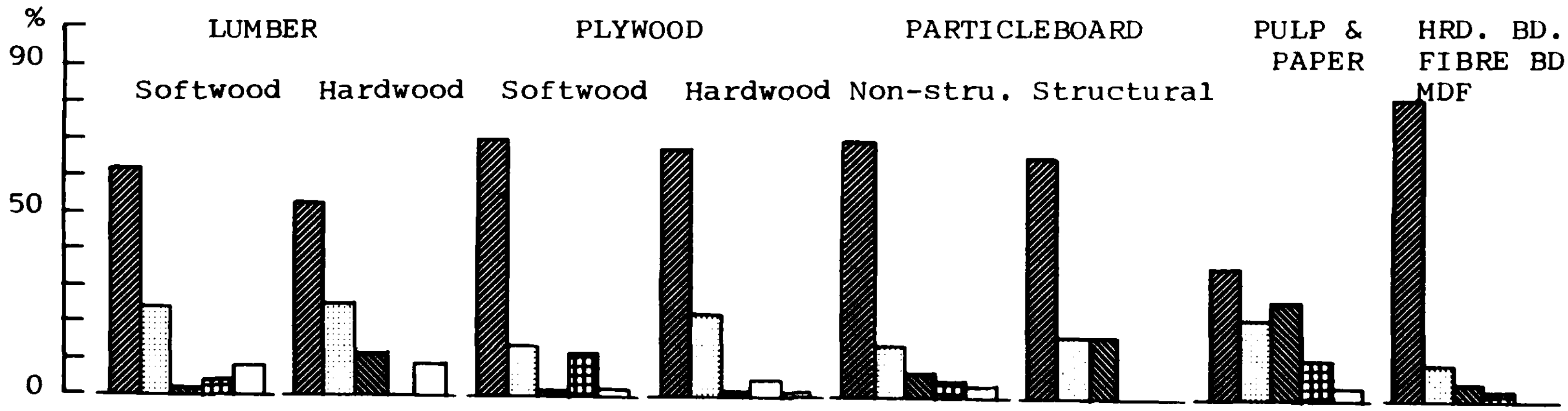

Fig. A30 (b) Percentage distribution of responses by product group for the policy: policies to reduce the cyclic boom to bust nature of the housing industry

Table A30. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the policy: policies to reduce the cyclic boom to bust nature of the housing industry

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	31.58 (0.97)	32.91 (0.95)	48
$u_{12}(ij)=u_{123}(ijk)=0$	75.64 (0.13)	70.13 (0.25)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	78.08 (0.21)	75.81 (0.27)	69
$u_{123}(ijk)=0$	30.48 (0.91)	31.20 (0.89)	42

() critical value

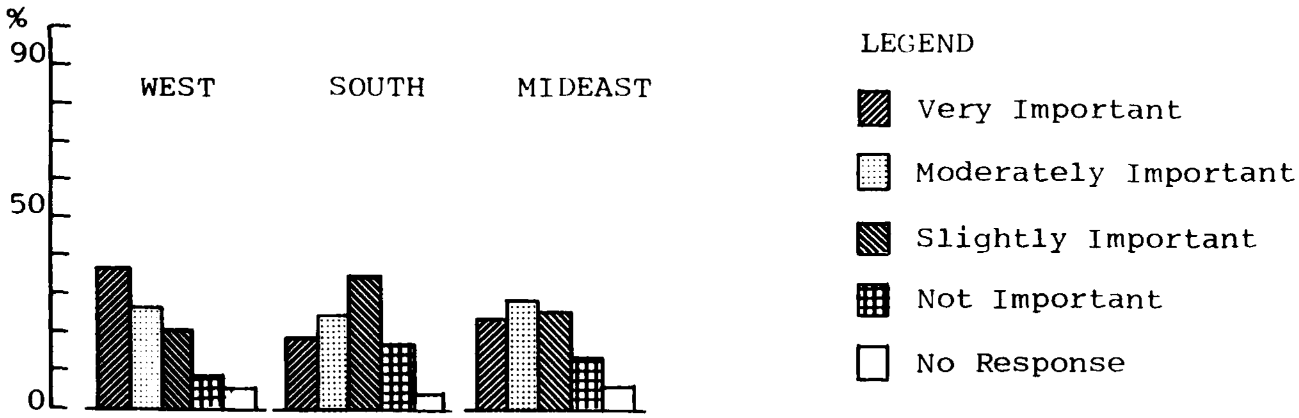

Fig. A31 (a) Percentage distribution of responses by geographical region for the policy: policies to accelerate harvest of public timber

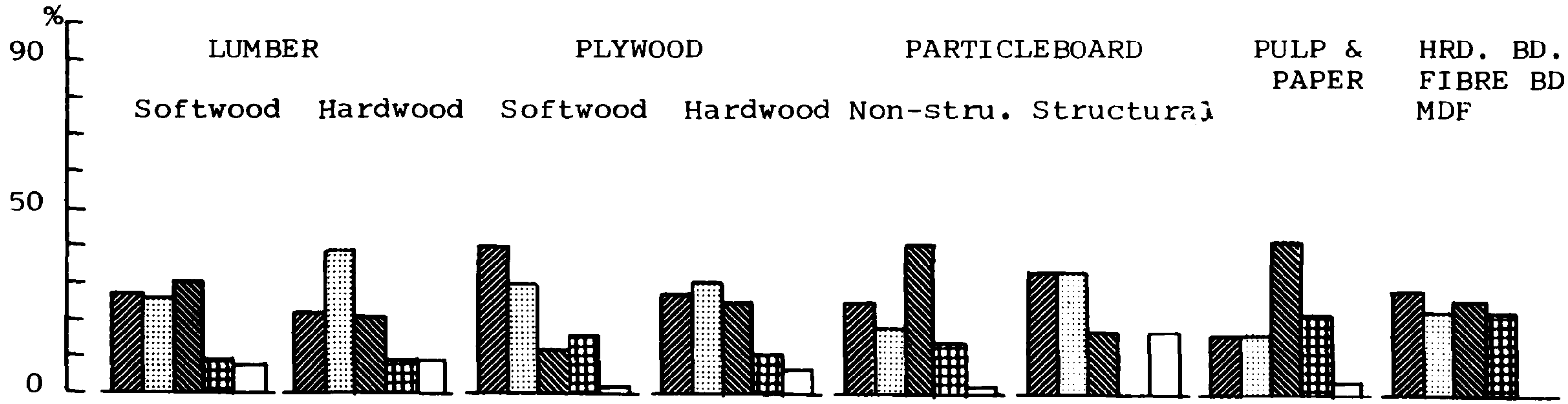

Fig. A31 (b) Percentage distribution of responses by product group for the policy: policies to accelerate harvest of public timber

Table A31. Values of the chi-square goodness-of-fit statistics, X^2 and G^2, for the log-linear models for the policy: policies to accelerate the harvest of public timber

Model	X^2	G^2	Degrees of Freedom
$u_{13}(ik)=u_{123}(ijk)=0$	45.37 (0.58)	48.37 (0.46)	48
$u_{12}(ij)=u_{123}(ijk)=0$	59.74 (0.59)	63.74 (0.45)	63
$u_{12}(ij)=u_{13}(ik)=u_{123}(ijk)=0$	75.93 (0.26)	78.65 (0.20)	69
$u_{123}(ijk)=0$	34.61 (0.78)	35.72 (0.74)	42

() critical value

UNIVERSITY OF MINNESOTA
TWIN CITIES

College of Forestry
Department of Forest Products
Kaufert Laboratory
2004 Folwell Avenue
St. Paul, Minnesota 55108

The University of Minnesota, College of Forestry, is undertaking a major research effort to identify policies and programs needed to stimulate productivity growth in the forest industry sector. (We are concerned here with productivity in the processing stage, not in timber growing.)

We would appreciate your views on this subject by completing the enclosed questionnaire. This will involve about 20 minutes of your time. The questionnaire deals with the likely causes of the recent decline in the productivity growth rate and the actions needed to improve productivity.

Your participation as a production manager is critical to the success of the study. Industry viewpoints provide direct and critical insights into the problems involved and contribute the realistic actions needed to improve productivity growth.

The final report of the overall effort will include a thorough review of existing information on productivity in the forest products sector and analysis of the 300 or so returns expected from this questionnaire. A detailed case study of the structural particleboard industry, and a general analysis of the impacts of utilization research will be additional reports. If you would like a copy of the final report, please check the appropriate box on the questionnaire "cover sheet."

We thank you in advance for your consideration of our request to participate in the study.

A self-addressed, stamped envelope is enclosed for return of the completed questionnaire. We would appreciate your response by

Sincerely,

John Haygreen, Head
Department of Forest Products

Hans Gregersen
Professor
Forest Economics

JH:HG/cms

Enclosures

Two weeks ago a questionnaire was mailed to you seeking your views about the important factors involved in productivity growth in the U.S. forest products industry. Your name was drawn in a random sample of mills in the United States.

If you have already completed and returned the questionnaire, please accept our sincere thanks. If not, please do so today. Because it has been sent to only a small, but representative, sample of mills it is extremely important that yours also be included in the study if the results are to accurately represent industry viewpoints.

If by some chance you did not receive the questionnaire, or it got misplaced, please contact us and another will be sent to you immediately.

Sincerely,

John G. Haygreen
Head, Department of Forest Products
University of Minnesota
(612) 373-1205

UNIVERSITY OF MINNESOTA
TWIN CITIES

College of Forestry
Department of Forest Products
Kaufert Laboratory
2004 Folwell Avenue
St. Paul, Minnesota 55108

Several weeks ago we wrote to you seeking your views concerning the important factors involved in productivity growth in the U.S. forest products industry. As of today we have not yet received your completed questionnaire.

Your participation as a production manager is critical to the success of the study. Industry viewpoints provide direct and critical insights into the problems involved and contribute to the realistic actions needed to improve productivity growth.

We are writing to you again because of the significance each questionnaire has to the usefulness of this study. Because the questionnaire has been sent to only a small, but representative sample of mills it is extremely important that yours also be included in the study if the results are to accurately represent industry viewpoints.

In the event that your questionnaire has been misplaced, a replacement is enclosed.

Your cooperation is greatly appreciated.

Sincerely,

John Haygreen
Professor

Hans Gregersen
Professor

JH/HG:rd

Enclosure

Background:

Forest Industry Productivity Trends

Falling labor productivity growth rates[1] for the U.S. economy have become a persistent problem. From 1973-1977 aggregate labor productivity growth rates have averaged 0.4 percent annually falling from an average annual rate of 2.1 percent during the period 1950-1973. Although part of this decline has been attributed to significant changes in the composition of output (notably the rapid expansion of the services sector), declines in labor productivity growth are evident at the sectoral level as well. Productivity growth for U.S. manufacturing increased at an average annual rate of 2.2 percent between 1973 and 1979. Productivity growth rates for the U.S. forest industries have followed a similar, but more pronounced, pattern. Changes in the labor productivity growth rates for some selected forest industries are indicated in Table 1.

Labor productivity is influenced by many varied and often inter-related factors. The objective of this survey is to gain some insight into the relative importance of the factors involved in the process of labor productivity change as viewed by the U.S. forest products industry. With a clear definition of which factors are most important in each situation, it becomes easier to design solutions or prescriptions which emphasize the key bottlenecks.

Table 1. Average annual change in output per employee-hour.

Industry	1958-73 (percent)	1973-78 (percent)
U.S. manufacturing	2.7	2.2
Sawmills and Planing Mills	3.1	1.4
Paper, Paperboard and Pulpmills	4.0[a]	2.1
Corrugated and Solid Fiber Boxes	3.5	2.6
Veneer and Plywood	5.0	2.7
Wood Household Furnishings	2.7	-0.6
Folding Paperboard Boxes	2.0[b]	-0.1

[a] 1947-1973

[b] 1963-1973

Source: Productivity Indexes for Selected Industry, 1979 Ed., BLS #2054.

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[1] Labor productivity is measured as value added/man hour of labor.

UNIVERSITY OF MINNESOTA
FOREST INDUSTRY PRODUCTIVITY GROWTH STUDY

QUESTIONNAIRE FOR
FOREST INDUSTRY REPRESENTATIVES
(time to complete: 20 minutes)

Do you want us to send you a copy of the final report on this study?

☐ Yes ☐ No

Your Name: ______________________________

Name of Company: ______________________________

Address: ______________________________

(If you prefer not to have your company name associated with this response, please indicate below the major product categories with which your firm is associated.)

____ softwood lumber
____ hardwood lumber
____ softwood plywood
____ hardwood plywood and veneer
____ particleboard
____ structural particleboard (OSB, waferboard)
____ pulp, paper and paperboard
____ fibreboard, hardboard, MDF

If you have any questions, please call one of the following persons:

Hans Gregersen (612) 373-1754
John Haygreen (612) 373-1205

Please return the completed questionnaire to:

Ms. Anne Strees, Project Coordinator
College of Forestry
University of Minnesota
110 Green Hall
1530 North Cleveland Avenue
St. Paul, MN 55108

Part I. Factors contributing to the decline in the rate of productivity growth.

Instructions: A list of factors contributing to the decline in the productivity growth rate is provided below. Please indicate the degree to which you believe each factor has been important in the decline in the productivity growth rate in your specific forest products industry by circling the appropriate importance level.

Then please rank (in descending order) the **five** factors that you believe to have had the greatest influence on the decline in the productivity growth rate in your specific forest products industry (e.g., greatest influence = 1, second greatest = 2, etc.).

Space is provided at the end of this section to list any other factors that you believe to be important.

Rank	**Factor**	**Importance**			
____	Decreasing average log size	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Rapid increases in the price of fossil fuels	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Increased proportion of inexperienced unskilled workers in the labor force	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Adversary labor (unions) — management relations	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Plants operating at less than full capacity as a result of volatile product markets (cyclical markets)	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Limited commercial availability of new technology and equipment	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Cost of new equipment	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Barriers to diffusion of new technology through the industry	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Finance cost of capital	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Inadequate expenditure on research and development	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Cost of complying with environmental regulations	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Cost of complying with worker safety regulations (OSHA)	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Tax laws	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	Government harvesting policies on publicly owned timber lands	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
	Others (please specify)				
____	______________________________	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
____	______________________________	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important

Part II. Factors stimulating an increase in the rate of productivity growth.

Instructions: Please indicate the degree to which you believe the following factors could be important in stimulating an increase in the rate of productivity growth in your specific forest products industry by circling the appropriate importance level.

Then, please rank (in descending order) the **five** factors that you believe would be most important in a program to increase the rate of productivity growth in your specific forest products industry (e.g., greatest influence = 1, second greatest = 2, etc.).

Space is provided at the end of this section for any other factors that you believe to be important.

Rank	Factor	Importance			
___	Increased expenditures for research and development by private firms	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Increased federal (state) expenditures for research	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Developing and implementing specialized employee training programs	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Establishing financial incentives programs for employees	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Cooperative research and development programs between companies	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Establishing company-wide productivity improvement programs	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Increased mechanization induced by an inadequate labor supply	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Availability of new (or better) processing equipment	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Development of computer-based process control equipment	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
Other (please specify)					
___	______________________	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	______________________	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important

Part III on next page.

Part III. Government policy or program changes needed to encourage increases in the rate of productivity growth.

Instructions: A list of policies to encourage increases in the rate of productivity growth has been provided below. Please indicate the degree to which you believe each policy could be instrumental in stimulating an increase in the rate of productivity growth in the forest products industry by circling the appropriate importance level.

Then, please rank (in descending order) the **five** policies that you believe could have the most influence in stimulating an increase in the rate of productivity growth in the forest products industry (e.g., greatest influence = 1, second greatest = 2, etc.).

Space is provided at the end of this section for any other policies that you believe to be important.

Rank	**Factor**	**Importance**			
___	Tax changes to encourage investment	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Develop a national productivity improvement plan to encourage faster diffusion of knowledge	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Policies to stimulate research and development within private firms	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Policies and funds to stimulate research by government agencies or universities	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Policies to promote market stability	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Policies to stimulate the housing sector	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Policies to reduce the cyclic boom to bust nature of the housing industry	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	Policies to accelerate harvest of public timber	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
Other (please specify)					
___	______________________	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important
___	______________________	☐ Very important	☐ Moderately important	☐ Slightly important	☐ Not important

Fig. A37. Breakdown of geographical regions.