

AN ANALYSIS OF RELATIONSHIPS AMONG
SIZE, TECHNOLOGY AND STRUCTURE IN
A CONTEXTUALLY LIMITED SETTING,

by

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CHAPTER I

INTRODUCTION

Organizational structure continues to be a major concern of researchers. Organization and management theorists, for the most part, have brought increasingly refined concepts and more sophisticated research techniques to bear on problems within the field (Daft 1980). Yet, considerable controversy over the causes and significant correlates of structure remains. In particular, two variables, size and technology, are thought to be major determinants of structure. These two variables have been examined by a number of researchers but their findings frequently disagree (Bedian 1980).

Two early often-cited works are Woodward (1958) and Hickson, et al. (1969). The former maintained that technology was a major determinant of structure, while the latter concluded that size was the primary factor. Research by others (Child and Mansfield 1972, Zwerman 1970, Marsh and Mannari 1981) has brought little or no consensus. Blau, et al. (1976, p. 20) noted that "since the publication of these two classic studies, several attempts have been made to replicate them in different industrial and economic contexts, but so far the debate between proponents of size and technology as prime determinants of structure remains

unresolved." The focus of this study is to further clarify the way in which size and technology relate to structure.

BACKGROUND

During the first part of this century, most management theorists believed that there was one "best" way to organize business firms (Koontz and O'Donnell 1968). Pioneers from quite diverse backgrounds are often cited. Fayol (1949), Taylor (1947) and Weber (1947) are three examples. Although they were contemporaries, they worked and published in three different languages, cultures and countries. Each of the three was concerned with management, although with different aspects. Weber's viewpoint was primarily sociological and his essay hypothesized the rational-legal ideal type of organization, a more efficient type organization than either his charismatic or more traditional form of organization. Taylor's "scientific management" precepts were more directed toward efficiency and economy of labor at the operating level. Fayol's emphasis was toward derivation of basic principles of management that were presumed to be applicable to all businesses. Both Fayol and Taylor developed their approaches from observations of processes or experiments in their work. Weber's principles were developed based on an ideal type. However, all three implied that there was one best way to organize the activities of management. In fact,

Fayol (1949, p.57), referring to hierarchical levels and spans of control said, "the same framework is appropriate for all industrial concerns, of whatever kind, employing the same number of people."

Woodward (1958) argued that if there was one best or ideal organizational model, it would be revealed by comparing successful and unsuccessful firms in several industries. In her search she found not one but three structural modes whose differences seemed to be explained by differences in technology.

Woodward's work is important for several reasons. It precipitated a number of studies. Also, Luthans (1973, p. 70) states that

...the work of Joan Woodward in the 1950's marks the beginning of a situational approach to management in general. She clearly showed in the British companies studied that organizational structure and human relationships were largely a function of the existing technological situation. Armed with this and supporting followup evidence, some organizational theorists such as Lawrence and Lorsch began to call for contingency models of organizational structure.

Many studies conducted after Woodward's have resulted in a mixture of findings relative to structure. Several suggest that size is related to certain structural elements and technology to others (Child and Mansfield 1970, Zwerman 1970, Lawrence and Lorsch 1967, and Marsh and Mannari 1981). Other researchers have found that technology is not tied to

any structural variable (Hickson, et al. 1969). Finally, there appear to be some structural measures unrelated to either size or technology (Miles 1980). And, Glisson (1978, p. 393) states "that a theoretical basis is provided for considering that technological routinization could be caused by implemented organizational structure."

The variations in findings have a number of possible explanations. Among them are:

1. Technology is measured in different ways.
2. Levels of analysis are mixed; i.e., organization-level attributes in one study are compared with work-unit level or task-unit level attributes in another, or are mixed within the same study (Kimberly 1976, Rieman 1980, Fry 1982).
3. Terminology is inconsistent from one study to another.
4. Attempts to control for other variables that potentially affect structure are limited.
5. Philosophical differences in background may affect judgment. Perrow (1967) noted that organization theorists have approached organizations from biological, sociological, historical, psychological and anthropological perspectives. This has led them to attribute causes of structure to various factors. Zwerman (1970) pointed to Marxian and classical influences on perspective. He argued that Woodward's

findings parallel Marxian thought rather than classical economics because it emphasizes the impact of production technology on organizations.

6. Some measurement constructs of size and technology on the one hand may not be broad enough to isolate and identify intertypical differences, or on the other hand may be so broad as to obscure intertypical differences.

7. Methodological differences, such as variation in statistical techniques, may confound attempts at comparison (Kimberley 1976).

8. Methodological techniques may be used that are inappropriate to the type data collected (Kimberley 1976).

9. Technology and structure are confused or interchanged (Stanfield 1976). For example, Child and Mansfield (1972) called task interdependence a structural measure. Lynch (1974) called it a measure of technology.

Perhaps the diversity of thought observed above has been beneficial in that it has provided different views of structure and its concomitants. Indeed, a different methodological approach is used in this study so that additional structure-size-technology relationships may be revealed.

In an effort to keep from causing still more divergence of opinion, the measures and terminology used are drawn from prior studies. Also, organizational-level structural measures are employed with organizational-level measures of size and technology.

PURPOSE

There are essentially three objectives to be accomplished by this dissertation. First, the study attempts to provide a better understanding of the complex interrelationships among size, technology and structure. Second, a heretofore overlooked technique is used to simultaneously investigate the relationships among size, technology and structure. The third objective is to bridge some of the findings of other researchers and hopefully reduce the controversy found in the literature to date.

SIGNIFICANCE OF THE STUDY

Considerable controversy (Harvey 1968, Hickson, et al. 1969, Child and Mansfield 1972) regarding the impact of size and technology has occurred subsequent to Woodward's (1958) pioneering study. Her finding that technology is a primary determinant of structure is questioned by Hickson, et al. (1969) who argued that the effect of technology is negligible on organization-level structural elements. They contended that size is the major predictor of structure.

Structure is strongly linked to organizational success (Woodward 1958, Chandler 1962, Lawrence and Lorsch 1967, Zwerman 1970, Grinyer, et al. 1980). It also explains some

of the variance in employee reactions to jobs (Oldham and Hackman 1981). A better understanding of, and a reduction in controversy concerning the relationships among size, technology and structure should be of significant interest to academicians and practitioners.

This study differs substantially from other research on the same subject. Size, technology and structure are investigated simultaneously so that their interrelationships can be better understood. Also, several contextual (Pugh, et al. 1969) variables are controlled for by sample selection. Futhermore, this is the only study to date that utilizes homogeneous samples within categories of technology. All others have gathered data across a wide number of very diverse organizations, which is appropriate for the exploratory nature of those studies. It is hoped that the methods and controls used in this work will yield results that bring some resolution to the size-technology-structure debate.

ORDER OF PRESENTATION

The information contained in this study is ordered as follows:

Chapter One

This chapter provides the elementary background, identifies the objectives and focus of the study. The study's significance to management practitioners and theorists is stated.

Chapter Two

Chapter two details pertinent concepts from the literature. Additional research is reviewed in an attempt to achieve some consistency of definition, level of analysis and comparability of findings. Major seminal and subsequent works are cited, and those that bear directly on this work are tabulated. Size and technology are both addressed and the organization is the unit of analysis.

Chapter Three

Here, the research procedure is explained. The justification for the industries selected is given and their characteristics discussed. Reasons for statistical testing and modeling are given and control measures are developed. Measurement schemes are explained and limitations to the study are discussed. Testable research hypotheses are generated. Responses to the questionnaire are also analyzed and reported.

Chapter Four

In chapter four the data are analyzed, the hypotheses tested and results reported.

Chapter Five

Chapter five summarizes the findings of the study. Implications for management and organization theorists are stated and directions for future research are indicated.

SUMMARY

Organizational structure is identified as the focus of study. Relationships among size, technology and structure are set forth as the factors to be examined. Controversies relative to the effects of size and technology on structure are briefly noted. Study objectives are presented. The significance of the study is presented and order of the dissertation is described.

CHAPTER II

REVIEW OF THE LITERATURE

The literature review contains two major sections. First, major concepts related to the measures of structure, technology and size are discussed and the measures used in this study are established. Second, significant findings regarding structure, size and technology are reviewed.

DIMENSIONS OF STRUCTURE

Five criteria are used to establish the dimensions of structure for this study. First, measures thought to represent the basic dimensions of structure (Pugh, et al. 1968) are required. Second, the variables or measures should permit comparison of structure. Third, in consonance with one of the purposes of this study, variables should have been used in previous studies. Fourth, it is necessary that variables, and measures thereof, be suitable to the statistical techniques employed. The last criterion requires that measures be at the organizational level of analysis as opposed to work unit or job unit level of analysis.

The first three criteria are met by using measures that have been established by earlier research as structural dimensions and have demonstrated measurability and comparability (Pugh, et al. 1968, Child and Mansfield 1972,

Grinyer and Yasai-Ardekani 1980). The remaining criteria require the exercise of some care in selection from the many established variables.

Pugh, et al. (1968) set forth four elements believed to be necessary to capture the essence of structure. These are structuring of activities, concentration of authority, line control of work flow and size of supportive component. Ranson, et al. (1982, p. 2) differed slightly. They stated that

...the notion of organizational framework focuses on the differentiation of positions, formalization of rules and procedures and prescriptions of authority. Interest in these formal dimensions of structure has been heavily influenced by Weber's (1946) work on bureaucracy, which depicted precise and impersonal structures as central to the rationalization of the modern world.

The basic elements established by Pugh, et al. (1968) with the exception of relative size of supportive components are used in this study. The exception is a ratio measure that uses size as the divisor. Regression of this ratio against size leads to confounding by definitional interdependence. The fourth criterion, therefore, precludes the use of relative size of supportive components in this study.

The fifth criterion set forth above is that organizational-level measures are required since the unit of analysis is the organization. Divisions often studied, such as spans of control below the C. E. O. hierarchical level,

represent the work unit rather than the organization. Professional qualification measures, another commonly studied structural variable, is also representative of either jobs or work units rather than the organization as a whole.

Structural Dimensions Used in This Study

Five measures that appear to meet all the foregoing criteria are formalization, specialization, decentralization of authority, chief executive officer's span of control and the number of levels in the hierarchy. These five measures include all the structural measures used in prior studies at the organizational level of analysis except standardization and relative size of supportive components. Relative size of supportive components cannot be investigated using the statistical techniques employed in this study without confounding by definitional interdependence. Standardization is replaced by formalization.

Formalization in this case is defined as the degree to which rules, policies, standards and procedures are written and disseminated to members of the organization. Formalization also serves as a surrogate measure for standardization (Mintzberg 1979). Formalization is shown to be an organizational-level measure (Fry 1982) and has been used at that level in 15 studies cited by Fry. It is also one of the basic elements of organizational structure (Ranson, et al. 1980).

Specialization is not as clear cut a concept as formalization. Tyler (1973, p. 383) described the problem:

The concept of task specialization has been ambiguous in writings on organizational structure. This ambiguity has arisen from the failure to distinguish between the specialization that results from rationalization and that which results from the extension of general professional skills into a narrower field...an additional problem is how to distinguish in terms of horizontal differentiation between duties that require a great deal of expertise and those that require hardly any.

Thompson (1961) also addressed the problem as distinguishing task specialization from person specialization and noted an inverse relationship between the two.

In this instance the concept of rationalization or what Thompson called task specialization is used. Rationalization in this context means that tasks are broken down into components or sub-tasks. Each sub-task is then performed by a separate person rather than having one person do several. This is what Thompson (1961) referred to as making the work more specific. Person specialization is the adaptation of the person. Task specialization may be referred to as micro division of labor (Thompson 1961). Person specialization is a process involving extension of abilities into narrow differentiated fields by training (Thompson 1961). Both horizontal and vertical dimensions are included and no distinction is made between the two. That is, managerial job titles are assumed to define specialization in the same way

as labor or clerical titles. This is similar to the approach taken by Pugh, et al. Yitzhak and Mannheim (1970) used the same procedure to formulate a structural measure called functionalization. This measure includes three dimensions identified as differentiation, diversification and specialization. All appear to measure a phenomenon closely related to what most researchers call specialization.

Decentralization of authority is revealed by the literature as a fairly straightforward concept. This measure may be defined as the degree to which decision making is delegated or "pushed downward" within the hierarchy. Measurement, however, depends somewhat on the perceptions of the organizational member rendering an opinion (Henning and Moseley 1970). The bias is consistent and the magnitude of error due to perceptual differences has been shown to be negligible when compared with the actual authority exercised by a given incumbent (Henning and Moseley 1970).

For example, a given job incumbent may perceive that he/she has x amount of authority relative to a specific decision area, his/her peer may perceive $x+1$ and his/her superior may perceive $x+2$. But when considering that job incumbent's authority with respect to a different specific decision area all would perceive a difference in magnitude of authority on the order of $x \pm 5$, and the incumbent's

peers and superiors consistently rank the incumbent in the same direction. (See Figure 2-1.)

The Chief Executive Officer's Span of Control is simply the number of managers reporting directly to the C. E. O.

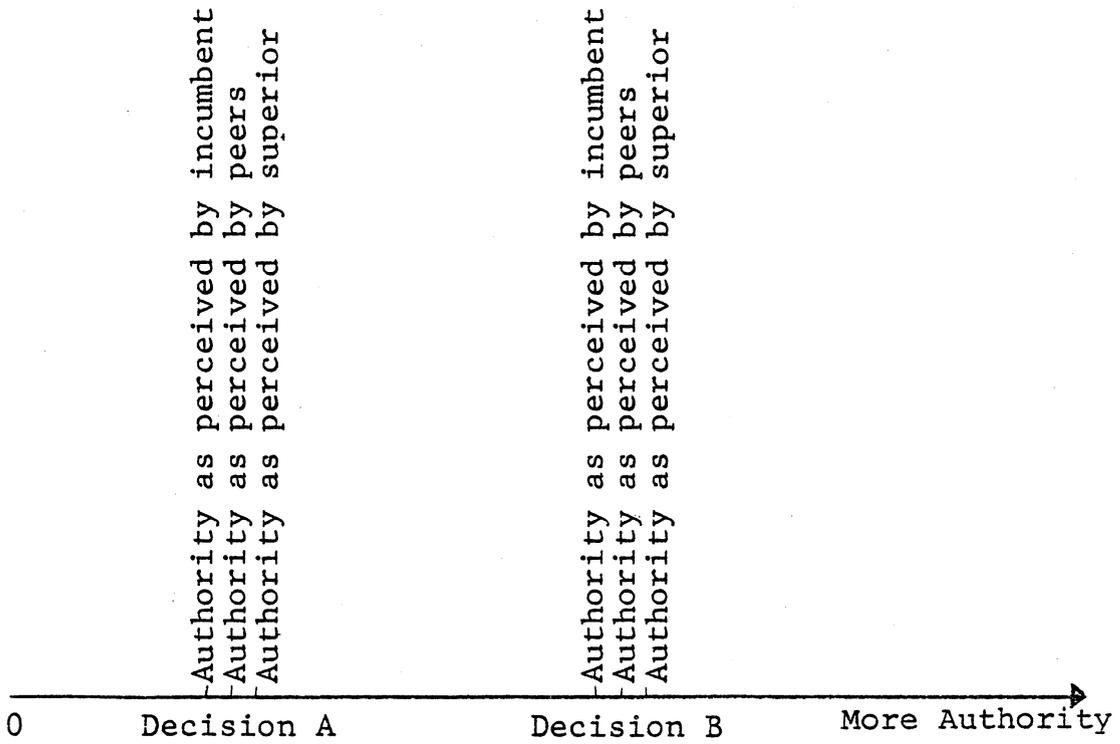
Hierarchical Levels are the longest chain from the C. E. O. to the lowest worker in the organization, including the C. E. O. and lowest worker.

All of the foregoing measures have been used in several studies and have been shown to be dimensions of structure (Grinyer and Yasai-Ardekani 1980, Marsh and Mannari 1981, Pugh, et al. 1968, Inkson, et al. 1969). They are also highly intercorrelated in those studies, indicating that they do measure some aspect of the same construct. The interrelationships among structural variables are complex (Grinyer and Yasai-Ardekani 1981), but this need not hinder their use in this case since there is ample support for arguing that there are functional relationships between each of them and size and/or technology. (See Table 2-1.)

TECHNOLOGY CONSTRUCTS

Gillespie and Mileti (1979, p. 33) have contended that

The findings about technology in the study of organizations have been inconsistent, inconclusive, and scattered in diverse literature. This state of the art appears to be caused by methodological difficulties inherent in the assessment of organization and technology. It is our contention that social scientists have been unable to assess adequately the relationship between technology and organizations primarily because technology has



Relative amount of authority concerning Decisions A & B

Figure 2-1: Illustration of Perceived Authority Relative to Two Decision Areas

Table 2-1

Selected Findings

Study	Technology	Size Measure	Structural Measures	Findings Re: Technology	Findings Re: Size	Notes
Woodward (1958)	unit-mass-process	# employees	1. specialization 2. levels in hierarchy 3. C.E.O. span 4. written communication (formalization)	1. concave downward 2. positive 3. positive 4. concave downward	none found	no statistical measures used in this study
Harvey (1968)	technical specificity	# employees	1. # levels 2. formalization	1. positive 2. positive	none	
Hickson, et al (1969)	Woodward's & workflow integration	log # employees	1. specialization 2. levels in hierarchy 3. C.E.O. span 4. formalization 5. decentralization of authority	none found	1. positive 2. positive 3. none 4. positive 5. positive	
Zwerman (1970)	Woodward's	# employees	1. C.E.O. span 2. # levels	1. positive 2. positive	1. positive 2. positive	generally supported Woodward
Child & Mansfield (1972)	Hickson, et al.	log # employees	1. specialization 2. levels 3. C.E.O. span 4. formalization 5. decentralization	1. positive/very weakly 2. positive/very weakly 3. positive/very weakly 4. positive/very weakly 5. positive/very weakly	1. positive/stronger than tech. 2. positive/stronger than tech. 3. positive/stronger than tech. 4. positive/stronger than tech. 5. positive/stronger than tech.	1. no levels of significance cited. 2. found interactive size/technology effects/
Khandwala (1974)	modified Woodward's	log sales	1. decentralization of authority	1. nonsignificant	1. positive	
Blau, et al (1976)	Woodward's & degree of automation	log # employees	1. structural differentiation (specialization) 2. C.E.O. span 3. levels	1. nonsignificant 2. nonsignificant 3. nonsignificant	1. positive 2. positive 3. positive	nonsignificant results interpreted as support for Woodward
Marsh & Hannari (1981)	Khandwala's modified Woodward	log # employees	1. specialization 2. formalization 3. C.E.O. span 4. decentralization 5. levels	1. nonsignificant 2. nonsignificant 3. positive 4. nonsignificant 5. nonsignificant	1. positive 2. positive 3. positive 4. nonsignificant 5. nonsignificant	nonsignificant findings Re: size-decentralization and levels may be Japan characteristic

been treated as an independent variable, applied holistically to organizations, confused with structure, crudely measured, and studied mainly in manufacturing plants.

These authors also have suggested that possible solutions to these problems include treating technology as a control variable (mediating between two or more organizational aspects), developing measures that differentiate holistically between organizations, and refining existing measures or defining new measures that eliminate structural confounding and that clarify the dimensions of technology.

Dimensions of Technology

Mitcham (1978) proposed an "anatomy of technology" conceived as existing in four dimensions. He termed this "pure technology." A scale measuring this construct would have measures of:

1. technology as objects (artifacts);
2. technology as processes (making and using);
3. technology as knowledge (engineering, design); and
4. technology as volition (will, choice, discretion).

Technology as objects includes both the objects worked upon and the machines or tools that are used to perform the work. Technology as process embodies both the sequencing of the work flow and the linking of steps in the work flow. Technology as knowledge refers to the degree of understanding required to perform the work and to schedule the sequences

and the number of steps. Technology as volition means choice or discretion. In this case choice involves deciding on design of process, on objects worked on or with, on scope and application of knowledge, and on sequence or rate of work performance.

Mitcham further claimed that "in modern technology objects and knowledge tend to collapse into processes in ways that make process a much more dominant category" (Mitcham 1978, p. 264). Many authors appear to take this approach and either define technology as the process by which inputs are transformed into outputs (Woodward 1958, Hickson, et al. 1969, Hunt 1970) or leave it to the reader to make the assumption (Child and Mansfield 1972, Grimes and Klein 1973, Blau, et al. 1976, and Glisson 1978). Mitcham's technology anatomy provides a useful framework for comparing and contrasting some of the technology constructs developed by various authors.

Organizational researchers have designed a number of technology constructs (Table 2-2) in an effort to measure technology. These constructs range from unidimensional to multidimensional measures. Application varies from job-level analysis to organizational-level analysis. It appears that the level of analysis is often inappropriate to the design of the technology construct (Fry 1982).

Table 2-2

Technology Constructs

Construct	Formulated By	Replicated or Operationalized By	Criticisms	Level of Analysis	Notes
Technical Complexity Scale unit mass process	Woodward (1958)	Hickson, et al (1969) Zweriman (1970) Khandwalla (1974) Marah and Mannari (1981)	Starbuck (1965) Perrow (1967) Harvey (1968) Khandwalla (1974) Hage & Aiken (1969)	organizational (questioned by some)	criticized as being circular, reversed, folded, less than organizational level, incompletely specified
Technical Typology long-linked, intensive, mediating	Thompson (1967)	Mahoney & Frost (1974)		organizational	Mahoney & Frost studied behavioral implications
Technical Specificity Scale diffuse specific	Harvey (1968)	Litschert (1971)		organizational	operationalized at task level by Litschert (1971)
degree of routines of work	Hage & Aiken (1967)			organizational	questionable if it is organizational level - measured on subunits
operations technology scale of workflow integration measured by workflow rigidity and degree of automation	Hickson, et al (1969)	Child & Mansfield (1974) Blau, et al (1976)		organizational	questionable at organizational level
knowledge of materials & number of exceptional cases encountered in work	Perrow (1967)	Lynch (1974) Grimes, Klein & Schull (1972) Hrebniak (1974)		conceptualized as organizational	operationalized at less than organizational level

Woodward's Construct

Woodward (1958) developed a scale of technical complexity. This scale listed 10 production groups. These are:

1. production of simple units to customers' orders;
2. production of technically complex units;
3. fabrication of large equipment in stages;
4. production of small batches;
5. production of components in large batches subsequently assembled diversely;
6. production of large batches, assembly-line type;
7. mass production;
8. process production combined with the preparation of a product for sale by large batch or mass-production methods;

9. process production of chemicals in batches; and

10. continuous-flow production of liquids, gases and solid shapes. These 10 were subsequently collapsed into three categories. The first category was small batch and unit production containing the first four of the above. The second category was large batch and mass production containing the fifth through seventh above, and the last category was process production containing the last three from above.

Woodward did not specify the precise dimensions of her scale nor exactly how it was measured. She defined the term (1958, p. 14) technical complexity

...to mean the extent to which the production process is controllable and its results predictable. For example, targets can be set more easily in a chemical plant than even the most up-to-date mass-production engineering shops, and the factors limiting production are known more definitively so that continual productivity drives are not needed.

In Mitcham's terms, her scale appears to be a scale of mostly process (continuity of) and to a lesser degree a scale of knowledge. The latter assumption is based on the fact that complexity is measured by the degree to which the process is controllable and the results predictable. Mitcham's object and volition elements are not addressed.

Perrow (1967, p. 207) criticized Woodward's measure as being "not strictly speaking, technology, but a measure of type, size of production run, layout of work and size of customer order." He argued that this made it difficult to classify firms according to her scale. Also, he stated that the scale appeared to be folded. By this he meant that the more complex process firms are in many ways more similar to the least complex unit-production firms than they are to mass-production firms of intermediate complexity.

However, Perrow's argument appears questionable. When organizational-level structural variables and sub-organizational-level structural variables are separated, a different picture emerges. Woodward found number of hierarchical levels, administrative ratio and C. E. O. span of control to increase as technical complexity increased. First-line

supervisors' span of control, production unit flexibility, written communications at production level and specialization at production level are all less than organizational-level measures. They are all found to exhibit similarities for unit and process technology. They differ for mass-production technology. Ostensibly, mass-production technology is intermediate in complexity. Unit-production technology is least complex and process-production technology most complex. The data suggest that as an organizational-level measure, Woodward's scale is relatively linear. Only if employed as a sub-organizational measure does the scale appear to be folded (Perrow 1967) or circular (Hunt 1970).

Harvey (1968) claimed that Woodward's scale was reversed. This charge is less serious than Perrow's if used for differentiating between technological classes. However, such a reversed classification could lead to confusion if precise measurement of complexity of individual firms is attempted. Harvey maintained that the basic dimension of Woodward's scale was product specificity. He then developed his own scale ranging along a continuum from technical diffusion to technical specificity. Diffuse technology means many product changes in a 10-year period. Specific technology means few changes in a 10-year period. In Harvey's sample, the product changes ranged from one to 145. In Mitc-ham's terms, Harvey's scale is one of object only.

If Woodward's scale is viewed simply as technology as object, Harvey's assessment is correct. However, if other dimensions are included, his argument has less support. As stated above, Woodward's scale appears to incorporate elements of Mitcham's technology as knowledge and process. Technology as object does not appear to be part of her scale.

Hickson, et al. (1969), in an attempt to replicate Woodward's work, developed a scale of technology that appears to encompass all Mitcham's terms. Their construct distinguished three types of technology. These are:

1. operations technology - the equipping and sequencing of work flows;
2. materials technology - the classification of the different qualities of materials used in the work flow; and
3. knowlege technology - the analysis and processing of problems. Operations technology contains Mitcham's process and volition dimensions. Both materials and knowledge techniques are identical to Mitcham's dimensions.

However, when Hickson, et al., operationalized their scale, operations technology was the only type used. They measured two dimensions, work flow rigidity and degree of automation. Work flow rigidity appears to be a measure of degree of choice, and degree of automation appears to be a measure of process. Operations technology is shown to be

inadequate as an organizational-level measure (Fry 1982). Both Woodward's and Hickson's, et al., scale apparently incorporate process dimensions. They appear to differ on knowledge and volition, with Woodward's incorporating knowledge in addition to process, and Hickson's et al., incorporating volition in addition to process.

Thompson's Construct

Thompson (1967) pointed out the need for a simple, complete typology of technologies that has general applicability. He stated that earlier measures may be limited to specific categories of organizations. He then developed three technological categories, long-linked technology, mediating technology and intensive technology. Long-linked technology involves serial interdependence of tasks. Mediating technology involves the linking of clients or customers who wish to be interdependent, and the organization provides the interdependence. Intensive technology focuses on the object worked upon. A variety of techniques is applied, with the choice of technique and sequence of application determined by feedback from the object worked upon.

Thompson stated explicitly that interdependence is serial for long-linked technology. He implied that mediating technology has pooled interdependence and intensive technology has reciprocal interdependence. Miles and Snow (1980)

and Dessler (1982) also imputed pooled interdependence to mediating technology and reciprocal interdependence to intensive technology. Thompson developed several theoretical propositions that organizations must coordinate these technologies (interdependencies) in different ways. He did not define the dimensions of his construct precisely. However, the construct may be examined for the presence of Mitcham's dimensions of process, object, knowledge and discretion. The construct appears to contain all four dimensions, but they vary from one technology type to another. Process or procedure is referred to in each technology type in Thompson's discussion. Mahoney and Frost (1974, p. 125, 126) characterized the different types by both process and discretion. They argued that long-linked allows less discretion; that

...work processes were standardized and prescribed and discretion allowed in speed of work. The mediating technology is characterized by the existence of a number of standardized operating procedures which form the repertoire of the unit; discretion exists in the form of choice behavior, the selection of the most appropriate strategy for a given task from among the standardized alternatives...the intensive technology is distinguished by a lack of standardized procedures; discretionary behavior is predominant and takes the form of sequential decision making as the results of previous decisions are analyzed.

Technology as object and technology as knowledge were explicitly addressed by Thompson (1967, p. 18) who stated,

...its (intensive technology's) successful employment rests on the capacities (knowledge) poten-

tially needed, but equally on the appropriate custom combination of selected capacities as required by the individual case (object) or project.

All of Mitcham's dimensions of technology were present in the construct.

Examples also illustrate Thompson's technology typology. Long-linked technology is exemplified by an assembly-line process. Operations are performed in a given sequence. Banks are examples of mediating technology. Clients (depositors and borrowers) are served (or mediated) by organizational members using specialized knowledge and organizationally-established procedures. The organizational members' work, however, is mostly independent of other members' work, and the client's interdependence with other clients is through the organizational person that he/she is dealing with. A hospital is the best example of intensive technology. Organizational members' interdependence is determined by feedback from the client. The client may shuttle from one to another, or receive attention from several members simultaneously as his/her condition indicates.

Limitations in Operationalization of Technology Measures

Many writers assume that the technology construct needs little or no explanation beyond a superficial definition (Gillespie and Miletic 1979). For instance, the unit of analysis (organization, task, work unit) is usually specified,

and technology is defined as the means by which the organization accomplishes its work. Measurements are then made, and calculations performed. However, this procedure appears to neglect certain potential problems.

One potential problem is that levels of analysis are mixed. (See Table 2-2.) Another problem is that analysts (Hage and Aiken 1969, Khandwalla 1974, Marsh and Mannari 1981, Pugh, et al. 1969) often devise measurement schemes of either work unit technology or task technology and then aggregate these into an organizational technology score. Then inferences are made relative to organizational-level variables. Two problems arise from this practice. First, a choice must be made of which best represents the organization's technology - unit scores or the total of task or work unit scores. Second, authors using multiple measures of technology appear to have ignored the basic nature of their chosen surrogates. If the operationalized measures are scalar quantities then little or no problem exists. However, if they are vector quantities or a mixture of scalar and vector quantities, then two or more vector quantities may tend to cancel. If so, the true nature of technology in that instance is obscured.

Other researchers (Lynch 1974, Mohr 1971) have computed work-unit scores and study work-unit variables. Still others (Hrebeniak 1974) have examined the relationship between

task or job technology and job-level attributes. At least one study (Morrisey and Gillespie 1975) explored the mismatch between job technology and organizational technology as a cause of organizational conflict.

The foregoing serve to illustrate that technology is an extremely complex variable, and that ambiguous or meaningless results are likely when technology measures are indiscriminately used as analytical tools. Useful research findings are more likely to result if there is a comparable level of analysis across measures, and the technology construct employed takes into account the complete "anatomy" of technology (Fry 1982). These constraints may prove difficult or impossible to accommodate and still avoid some of the other problems mentioned when attempts are made to measure and compute organizational technology scores.

Technology in This Study

Two technology constructs are used in this study. They are those of Woodward and Thompson. Two constructs are used because no single construct appears to meet the delimiting characteristics required for this study. These characteristics are:

1. The construct(s) must differentiate between technological classes of organizations.

2. The construct(s) must be characteristic of the whole organization as the organization is the unit of analysis.

3. The construct(s) should be one(s) that have been used in earlier studies. One purpose of this study is to attempt to bring some resolution to the controversy over the effect of technology on structure.

4. All of Mitcham's dimensions of technology must be included. Thompson's construct meets all the criteria except one. It has not been used at the organization level of analysis. Woodward's scale appears to meet all the criteria, although it has been criticized on several points. Hickson, et al. (1969) argued that it is applicable only to the operating core. However, Fry (1982) demonstrated that it is appropriate at the organizational level. He cited 11 studies that used a form of her scale at the organization level of analysis and one that used it at the job level of analysis. The only use that was inappropriate was at the job level. Fry's findings also indicate that Perrow's (1967) charge that Woodward's scale was inadequately specified may be groundless.

Other technological constructs shown in Table 2-1 and previously discussed are suspect at the organizational level (Fry 1982), or may be subject to one or more of the problems mentioned. Using Thompson's and Woodward's constructs

simultaneously, a grid (Figure 2-2) is constructed that clearly differentiates between technological classes of organizations. It should not be assumed that all cells in Figure 2-2 can be filled. For instance, Thompson (1967, p. 18) noted that intensive technology is a custom technology only.

MEASURES OF SIZE

Kimberley (1976), in a review of 80 empirical studies relating size and structure, observed a number of problems. These are generally categorized as

1. differences in conceptualization,
2. lack of clarity of definition,
3. confounding of findings by definitional interdependence,
4. lack of intertypical comparability, and
5. the role of size left unspecified.

He claimed that size as a concept in organizational literature is so ambiguous that one is unable to specify its role relative to structure. He then proposed that the conceptual basis of measures of size used in future research be thoroughly specified. He also called for comparability of size measure across organizations. Additionally, he pointed out that the relationship of size to structure should be specified. Also, the size measure and technology measure must be definitionally independent for this study.

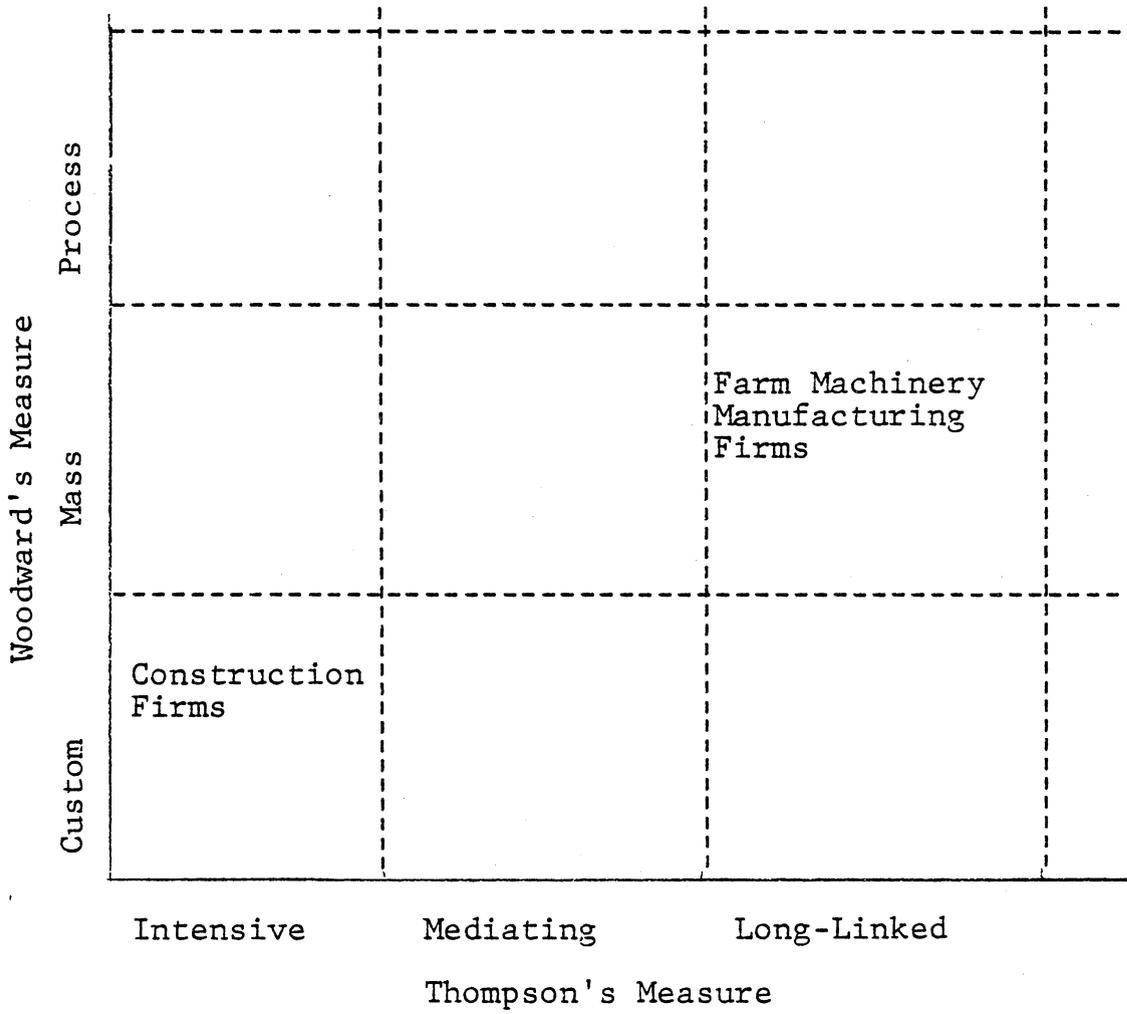


Figure 2-2: Technology Grid Using Woodward's and Thompson's Measures

Size in This Study

Essentially the same approach taken by Child (1973) and others (Pugh, et al. 1968, Hall 1962) is taken here. That is, people and their work are being "structured" or organized; hence, number of people in the organization is used as a measure of size. This measure also permits a link to the literature. Kimberley's review of 80 empirical studies found that 64 used number of people or the logarithm of number of people as the measure of size.

Other measures were considered but rejected for various reasons. Sales, total assets or other capacity measures such as plant size are less likely to be comparable between the two industries chosen. Additionally, dollar value of assets may be a measure of technology (Kimberley 1976) as well as size. For example, firms having long-linked technology often have heavy investments in assembly-line equipment and are more capital intensive than firms doing the same job with an intensive technology.

Other studies that have used physical capacity measures (e.g. Anderson and Warkov 1961), found a high correlation between those measures and the number of people in the organization. Also size, measured by number of employees is assumed to cause structure, with the relationship mediated by technology. The assumption of causality is based on

Meyer's (1972) longitudinal study, and others' (Aldrich 1972, Pugh 1968, Ranson, et al. 1980, Miles 1980) theoretical arguments, and cannot be tested in this cross-sectional study. The mediating effect of technology is examined here.

REVIEW OF STUDIES

Although there are many studies that examine some of the size-technology-structure relationships, relatively few of them do so concurrently at the organizational level. These latter are cited in Table 2-1 in chronological order. Several precautions are in order. The measures may not be directly comparable, and some findings may be questioned based on appropriateness of statistical methods. These are noted in the seventh column of the table.

The general findings are that size is more strongly linked to structure than is technology. When Hickson, et al (1969), partialled out technology, they found that statistically significant technology effects disappeared altogether. However, it should be noted that when performance was considered (Woodward 1958, Zwerman 1970, Khandwalla 1974), successful firms tended to conform to structural models whose differences were linked to differences in technology. This latter note was borne out by Lawrence and Lorsch (1967), although size was not addressed in their study.

The more consistent findings shown in Table 2-1 are that structural variables increase in magnitude as size and technological complexity increase. Woodward, Blau, et al., and Child and Mansfield, however, found that for some structural variables (specialization, formalization) an increase in magnitude occurred over a partial range of technical complexity and then decreased over the remainder of the range. This phenomenon may have been the result of the technology scale or may have been due to mixing levels of analysis as noted earlier in this chapter.

Findings on Structural Variables

Although structure in general has been linked to both technology and size, their relationships to specific structural dimensions demonstrate substantial variation.

Formalization

Woodward's variable, written communications, is assumed to approximate formalization listed in Table 2-2. However, she measured the amount of written communication at the production, rather than at the organization level. She found that written communication was low for custom-production firms, high for mass-production firms and low for process-production firms. Harvey found a positive correlation between formalization and technology using his technology measure. His scale ranged from technically diffuse (many

products or product changes) to technically specific (few products or product changes). If it is assumed that Woodward's process technology corresponds to Harvey's technically specific technology, their findings appear to reinforce one another. Their results suggest that formalization is linked to technology.

Other findings differ. Hickson, et al. (1969) and Marsh and Mannari (1981) found a relationship between size and formalization only. Hickson, et al., using both Woodward's and their own scale found no link to technology in either case. Marsh and Mannari used a modified Woodward scale, but generated only negative results. One possible reason for differences was variation in sample characteristics (Hickson, et al. 1969 and Donaldson 1976). The above findings demonstrate that relationships among size, technology and formalization remain unresolved.

This study approaches the question from a different perspective. It hypothesizes that both size and technology are linked to formalization and that the effect of technology varies across size. The Aston group hypothesized this but did not examine it in their study.

C. E. O. Span of Control

The span of control of the Chief Executive Officer, as well as the span of other managers within the organization, is one of the first variables addressed by organization

theorists. Graicunas (Urwick 1974) expressed in mathematical terms how interactions with and among immediate subordinates may impose a limit on a given span of control. Udell (1967) identified additional variables that relate to span of control, some of which appear to relate to technology and others to dimensions of structure. These imply that C. E. O. span of control may be a function of variables other than size or technology.

However, Woodward found that C. E. O. span of control was strongly related to technology and not to size. Hickson, et al., Blau, et al., and Child and Mansfield were not able to replicate her findings and, in fact, their results suggested opposite relationships. On the other hand, Zwerman and Marsh and Mannari found that it was linked to both size and technology.

Specialization

The literature reveals no consistent definition of specialization. It has been termed differentiation, functionalization, and diversification. All appear to have common elements.

Woodward alone has found a link between technology and specialization, but her finding was not supported by statistical measures. Hickson, et al., Child and Mansfield, Blau, et al., and Marsh and Mannari found specialization linked only to size. However, these researchers computed

technology scores and made computations based on those scores, in an attempt to compare the effects of technology and size on specialization. Woodward simply classified firms according to technological complexity. Computation of technology scores may be misleading. (See page 25 of this study.) However, the preponderance of evidence indicates that specialization is much more a function of size than technology.

Decentralization of Authority

None of the authors listed in Table 2-1 found decentralization of authority to be linked to technology. Hickson, et al., Child and Mansfield and Khandwalla found a strong link between decentralization of authority and size. Marsh and Mannari found no relationship to either size or technology. Khandwalla's finding may not be directly comparable since his size measure is the logarithm of sales and the others used logarithm of number of employees. Marsh and Mannari's finding may be attributable to the Japanese culture. All the other studies were done in the U. S. or Britain, countries that have many cultural similarities. The Japanese culture differs in many ways from those of the U. S. and Britain. United States management has been shown to be different from Japanese management in some ways (Schonberger 1982, Lincoln, et al. 1981) and to exhibit similarities in others (Pascale 1978). Pascale (1978, p. 106)

stated that "While there are differences, the preponderance of evidence suggests wide areas of commonality between Japanese and American communications and decision-making practices." So, the influence of culture on decentralization is unclear. The most likely occurrence is that decentralization of authority is positively linked to size.

Number of Hierarchical Levels

The number of levels in a hierarchy along with C. E. O. span of control may be defined as a shape or configuration variable. Several studies (Worthy 1950, Carzo and Yanouzas 1969, Jones 1969) have linked number of hierarchical levels to performance. However, the studies disagree. Carzo and Yanouzas favored taller structures or more hierarchical levels. Jones and Worthy favored flatter structures with fewer hierarchical levels. None of these researchers looked at the number of levels as linking performance to technology and size. Miner (1978, p. 286) noted that

The available research evidence fails to support the proponents of flat structures, although it does not universally favor tall structures either...at one time it seemed probable that the emergence of tall or flat structures could be explained as a consequence of different types of production technology...at present, it appears that increasing company size is the major cause of expansion in the vertical hierarchy.

No consensus is evident among the authors cited in Table 2-1. Woodward and Harvey found the number of hierarchical levels to be related to technology alone. Zwerman

found the dimension to be linked to size and technology. Hickson, et al., Blau, et al., and Child and Mansfield linked it to size only. Marsh and Mannari found it related to neither size nor technology.

SUMMARY

The literature review that has been performed in this chapter was done in two ways. First, the nature of each construct (structure, technology, size) was discussed and the measures used in this study were established. Second, studies that had been done at the organizational level of analysis and that had considered size, technology and structure simultaneously were reviewed.

Structure at the organizational level was found to have four basic dimensions. These are structuring of activities, concentration of authority, line control of work flow and administrative component. These were found to have been operationalized in various forms. The forms chosen for this study are decentralization of authority (concentration of authority), C. E. O. span of control (structuring of activities and line control of work flow), specialization (structuring of activities), number of hierarchical levels (line control of work flow), and formalization (formalization of rules and procedures). Administrative component cannot be studied using the statistical techniques used in this study.

Technology and its relationships to structure and size was found to be very complex. Technology was found to have four basic dimensions, object, process, knowledge and volition. Of the technology constructs found in the literature, Thompson's typology was found to be complete in all four dimensions. Woodward's was found to have the dimensions of knowledge and process. Fry demonstrated that Woodward's construct is operable at the organizational level of analysis. Thompson's has not been operationalized at the organizational level to date. The two constructs, Woodward's and Thompson's, are used simultaneously to classify firms in this study. Technology is used as a control or mediating variable, and two classifications are established. These are intensive-custom production and long-linked mass-production technology. This simultaneous application of two constructs provides a clear distinction between two classes of firms.

Size was found to be an ambiguous variable. It may be measured by physical capacity of the organization, personnel available to the organization and discretionary resources available to the organization. In this study, number of employees is used. This is used by most authors. Number of employees also is thought to have better intertypical comparability than other measures.

Review of literature that had investigated size, technology and structure simultaneously revealed no consensus on their interrelationships. This was attributed to conceptual methodological variation. The conclusion is that more research is needed.

CHAPTER III

SOURCES AND METHODS OF INVESTIGATION

This chapter details the research hypotheses, methodology and sample selection criteria used in this study. Information regarding the response to the survey is reported and measurement of the variables is described. Also, a basis for interpretation of regression equations derived from the data is developed. Rationale for the selection of construction firms (custom technology) and farm machinery firms (mass technology) is given.

HYPOTHESES

There are two general and 20 specific hypotheses to be tested. The first general hypothesis is that structural measures will vary systematically across size. This hypothesis has substantial support from the literature (Table 2-1). The second general hypothesis is that two different technologies used as control variables will yield significantly different structural responses across size. This hypothesis has essentially no support from research findings in the literature. However, Hickson, et al. (1969), reasoned that technology may significantly affect small firms, but the effect would disappear for very large firms. These two general hypotheses lead to the following specific hypotheses.

Formalization

Research findings for those who found a relationship between size and formalization are consistent (Table 2-1, column 6). As size increases, organizations become more formal. The following hypotheses are then developed:

H1.1: Formalization will increase as size increases for custom-technology firms.

H1.2: Formalization will increase as size increases for mass-technology firms.

Additionally, in the studies that compare structures for mass-technology and custom-technology firms (Woodward 1958, Zwerman 1970, Marsh and Mannari 1981) (See Table 2-1, column 5.), mass-technology firms were found to be more formal. Using these findings and Hickson, et al's. argument that differences in structure due to technology disappear as size becomes larger, the following hypotheses are developed:

H1.3: Formalization will be greater for small mass-technology firms than for small custom-technology firms.

H1.4: The difference in formalization between mass-technology firms and custom-technology firms will decrease as size increases.

Chief Executive Officer's Span of Control

Those who found C. E. O. span of control to be related to size agree that as size increases so does C. E. O. span of control. Accordingly, the following hypotheses are stated:

H2.1: The C. E. O. span of control will increase as size increases for mass-technology firms.

H2.2: The C. E. O. span of control will increase as size increases for custom-technology firms.

Only two, Woodward and Zwerman, of those cited in Table 2-1 found a difference in C. E. O. span due to technology. In both cases, the C. E. O. span was greater for mass-technology firms than for custom-technology firms. Using these findings and Hickson, et al's. reasoning, the following hypotheses are given:

H2.3: The C. E. O. span of control will be greater for small mass-technology firms than for small custom-technology firms.

H2.4: The difference in C. E. O. span of control between mass- technology and custom-technology firms will decrease as size increases.

Specialization

Those who found specialization linked to size (Table 2-1, column 6) are consistent. The variables are positively correlated. The following hypotheses are then stated:

H3.1: Specialization will increase as size increases for mass- technology firms.

H3.2: Specialization will increase as size increases for custom-technology firms.

Woodward and Marsh and Mannari (Table 2-1, column 5) found mass-technology firms to be more specialized than custom-technology firms. However, the difference in specialization between mass-technology firms and custom-technology firms may not disappear. Given the nature of construction work requirements, it is expected that there will be no convergence as size increases.

Construction firms (custom-technology firms) are expected to be reasonably specialized because of the work they perform even when small. Then, as size increases numbers will increase within specialties at a much greater rate than the increase of number of specialties. For example, a firm may have an electrician, a carpenter, a plumber and a mason, and as the firm grows no new specialties would be added but the number employed within each specialty would grow. However, a machinery firm (mass technology) would be expected to break jobs down into a greater number of specialties as size increases.

Two other possibilities are that in construction firm's specialties may be limited or "bled off" by subcontracting, except in very large firms where specialization may approach that of manufacturing firms. If the latter is assumed, specialization may increase very little over the lower range of size, then increase very rapidly for the upper range in size. This possibility will be investigated. Nevertheless,

in an effort to keep all statements of hypotheses consistent, the following hypotheses are proposed:

H3.3: Small mass-technology firms will be more specialized than small custom-technology firms.

H3.4: The difference in specialization between mass-technology firms and custom-technology firms will decrease as size increases.

Decentralization of Authority

Research findings (Table 2-1, column 6) are almost unanimous that size is linked to decentralization of authority. Only Marsh and Mannari (1981) were unable to confirm such findings. Their discordant finding may be due to several factors, including sample selection, measurement selection or cultural relativism. In accordance with the majority of findings, the following hypotheses are stated:

H4.1: Decentralization of authority will increase as size increases for mass-technology firms.

H4.2: Decentralization of authority will increase as size increases for custom-technology firms.

The link between technology and decentralization of authority is more tenuous than the link between size and decentralization of authority. Only Child and Mansfield (1972) indicated that decentralization of authority is greater as technology, i.e., work flow integration, increases. Van De Ven, Delbecq and Koneig (1976) argued

that reciprocal interdependence (intensive technology) requires greater work flow integration than does serial interdependence (long-linked technology). Acceptance of this argument indicates that the custom-technology firms should be more decentralized than mass-technology firms. This argument is supported by Stinchcombe's (1959) findings. Considering the above, and Hickson, et al.'s. argument that structural differences may disappear as size becomes large leads to the following hypotheses:

H4.3: Decentralization of authority will be greater for small custom-technology firms than for small mass--technology firms.

H4.4: The difference in decentralization of authority between small custom-technology firms and small mass-technology firms will decrease as size increases.

Number of Hierarchical Levels

Hickson, et al. (1969), Zwerman (1970), Child and Mansfield (1972), and Blau, et al. (1976), found number of hierarchical levels positively correlated with size where size was measured as logarithm of number of employees.

Harvey (1968) and Woodward (1958) used number of employees and found no relationship between number of hierarchical levels and size. Marsh and Mannari (1981) used logarithm of number employees and found agreement with Harvey and Woodward. If the majority standpoint is accepted then the following hypotheses are indicated:

H5.1: Number of hierarchical levels will increase as size increases for mass-technology firms.

H5.2: Number of hierarchical levels will increase as size increases for custom-technology firms.

The findings of Woodward, Harvey and Zwerman indicated that mass-technology firms have more hierarchical levels than custom-technology firms. Taking their findings and Hickson, et al's. argument that structural differences due to technology may disappear as size grows large, gives the following hypotheses:

H5.3: Small mass-technology firms will have a greater number of hierarchical levels than small custom-technology firms.

H5.4: The difference in number of hierarchical levels between mass-technology firms and custom-technology firms will decrease as size increases.

Methodology

If the foregoing hypothesized relationships between size and structural variables exists, then linear regression models will graphically portray them. The regression models will also portray models that differentiate between mass and custom technology where such differences occur. Additionally, linear regression allows statistical testing of the hypothesized relationships discussed above.

A set of two equations, one for each technology category, is derived for each structural variable. Size is the independent variable and structure the dependent variable in each case.

The equations derived in each case have the form

$$Y_{1j} = a_1 + b_1x_{1j} + e_{1j}$$

for mass-production technology, and

$$Y_{2i} = a_2 + b_2x_{2i} + e_{2i}$$

for custom technology, where

$Y_{1i,1j}$ -- $Y_{ni,nj}$ = structural variables

$a_{1,2}$ = intercepts

$b_{1,2}$ = regression coefficients

$x_{1j,2j}$ = size measure

$e_{1j,2i}$ = error term.

The model intercept terms in this case are structure intercepts, which are conceptually meaningless if they are non-zero terms. They compute to be either zero or negative structure. Where a negative structure term is found, a positive-size intercept is implied that has conceptual meaning. The size intercept can be computed by setting structure equal to zero and solving each equation above yielding

$$x_{1j} = -a_1/b_1 = x_{01}$$

for mass technology, and

$$x_{2i} = -a_2/b_2 = x_{02}$$

for custom technology where

$$x_{ij}, x_{2i}, a_n, b_n$$

are as defined above, and

$$x_{on}$$

is the log size intercept.

The statistical models derived can then be tested for equality of intercepts

$$H_0: x_{01} = x_{02}$$

or the alternative

$$H_A: x_{01} \neq x_{02}.$$

Equality of intercepts implies no structural difference between custom and mass technology for small firms.

Likewise, the slope term can be tested with the null hypothesis

$$H_0: b_1 = b_2$$

and the alternative hypothesis

$$H_A: b_1 \neq b_2.$$

Five possible inferences may be drawn based on possible combinations of slopes and intercepts. First, if slopes and intercepts do not differ statistically, then there is no effect attributable to technology (Figure 3-1). Second, if the intercepts are common but slopes statistically differ, then the effect of technology is significant as size increases (Figure 3-2). Third, it is also possible that the intercepts differ statistically and slopes remain the same (Figure 3-3). In this case, technology's effect is constant across size. Fourth, the intercepts could differ statistically and the slopes diverge (Figure 3-4). In this case, technology would have an effect on the structure of small firms and the effect would increase as size increases. The fifth possibility is that the intercepts differ and the

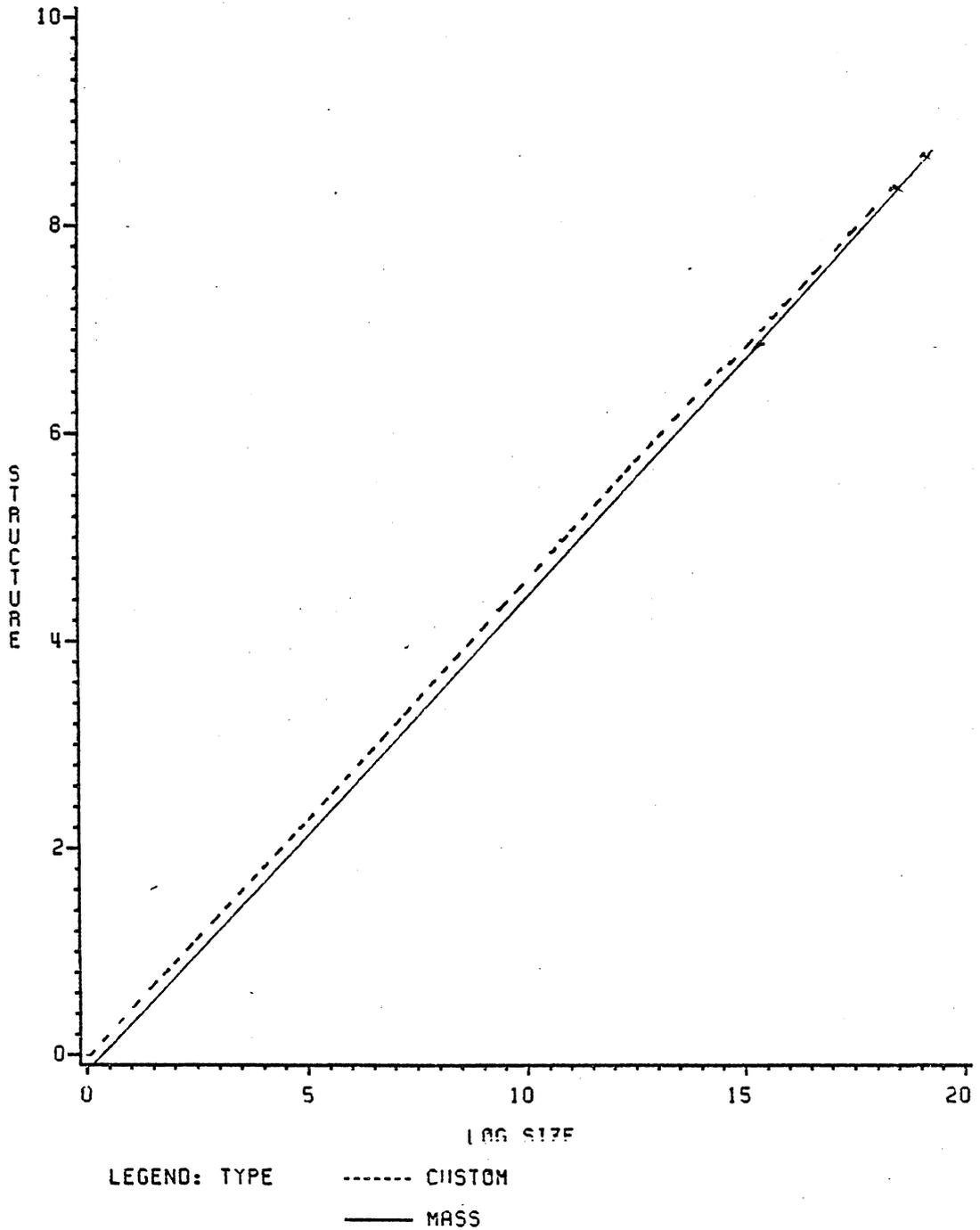


FIGURE 3-1: GRAPH OF STRUCTURE VERSUS LOG SIZE

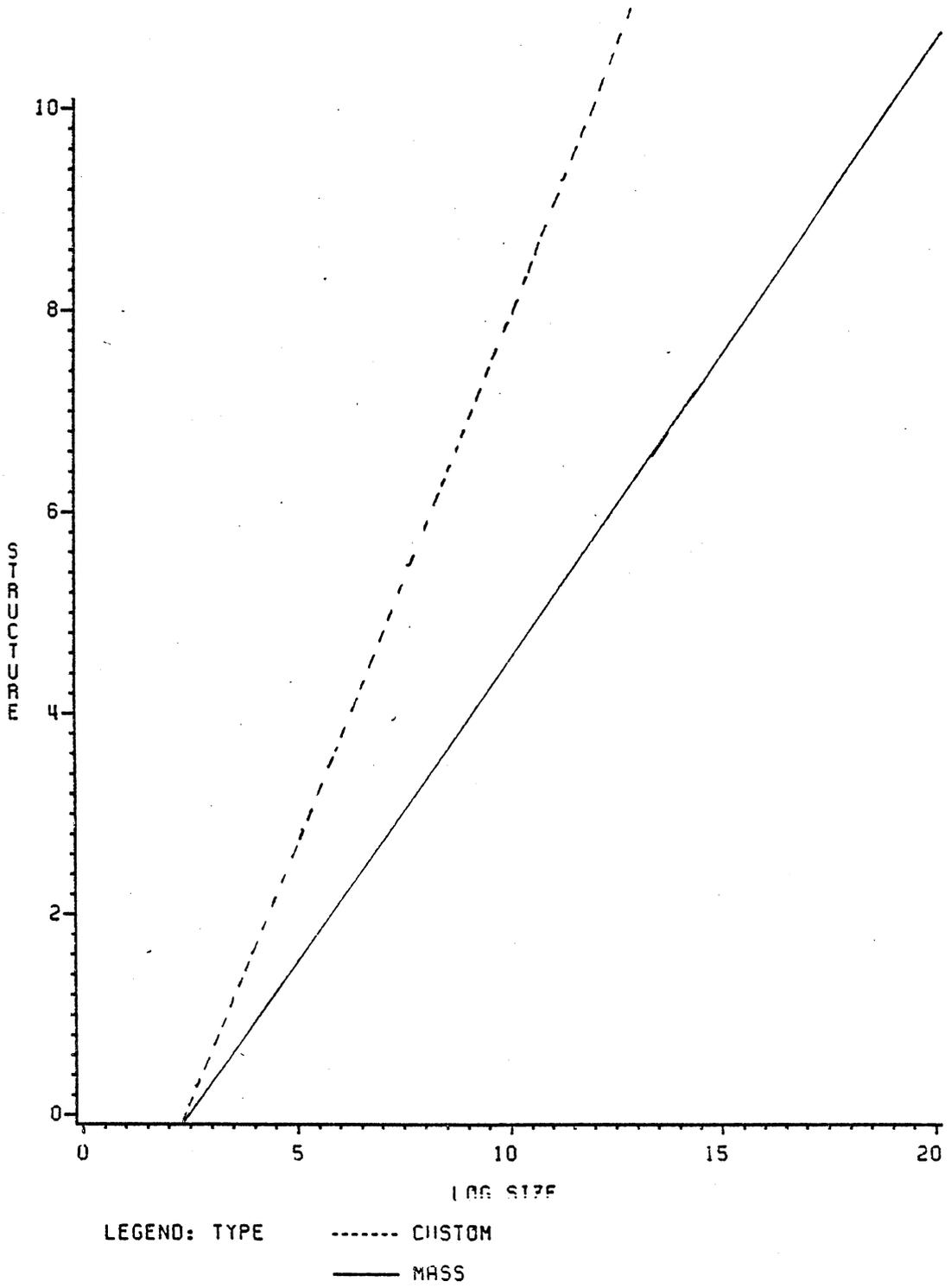


FIGURE 3-2: GRAPH OF STRUCTURE VERSUS LOG SIZE

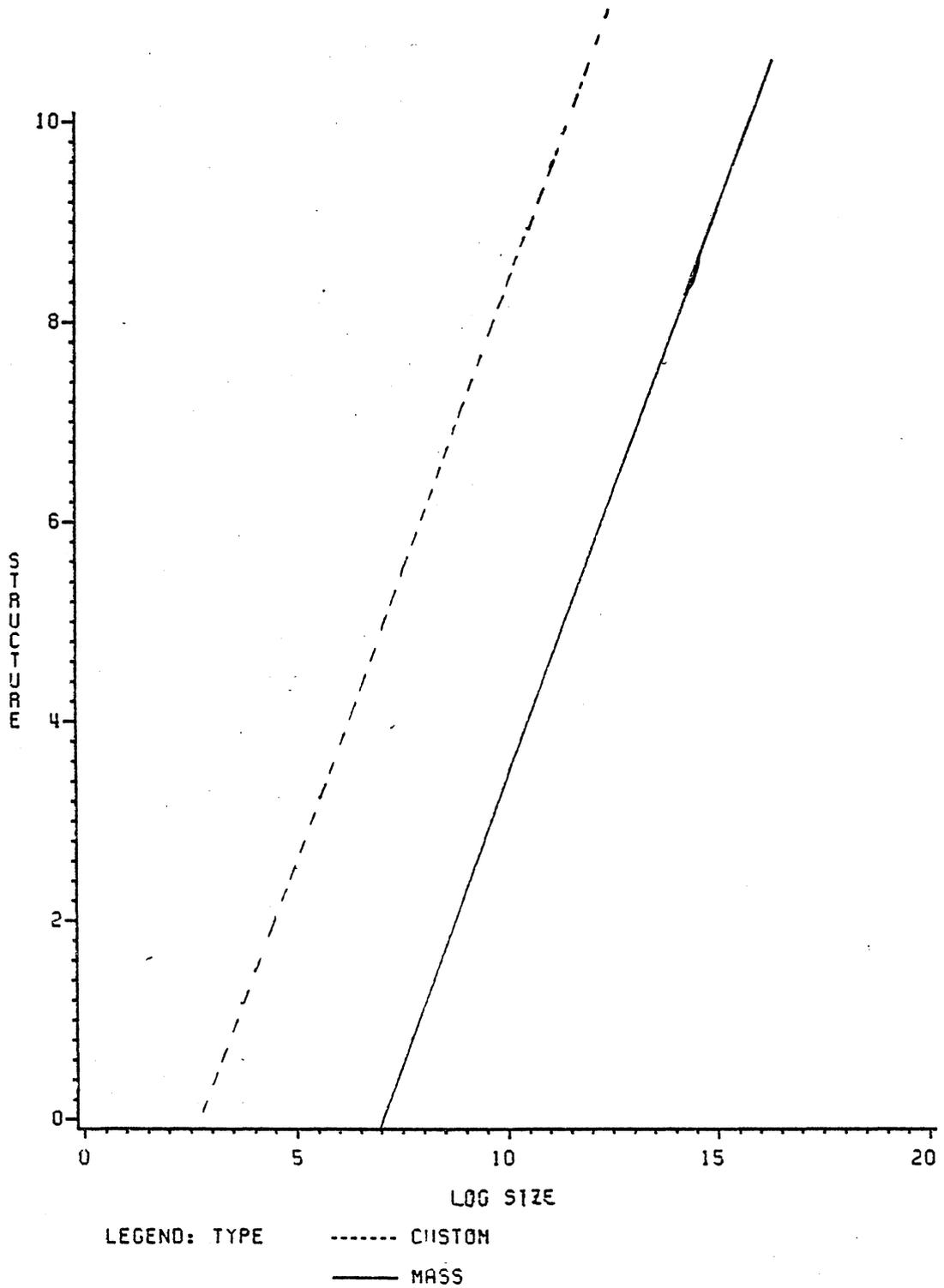


FIGURE 3-3: GRAPH OF STRUCTURE VERSUS LOG SIZE

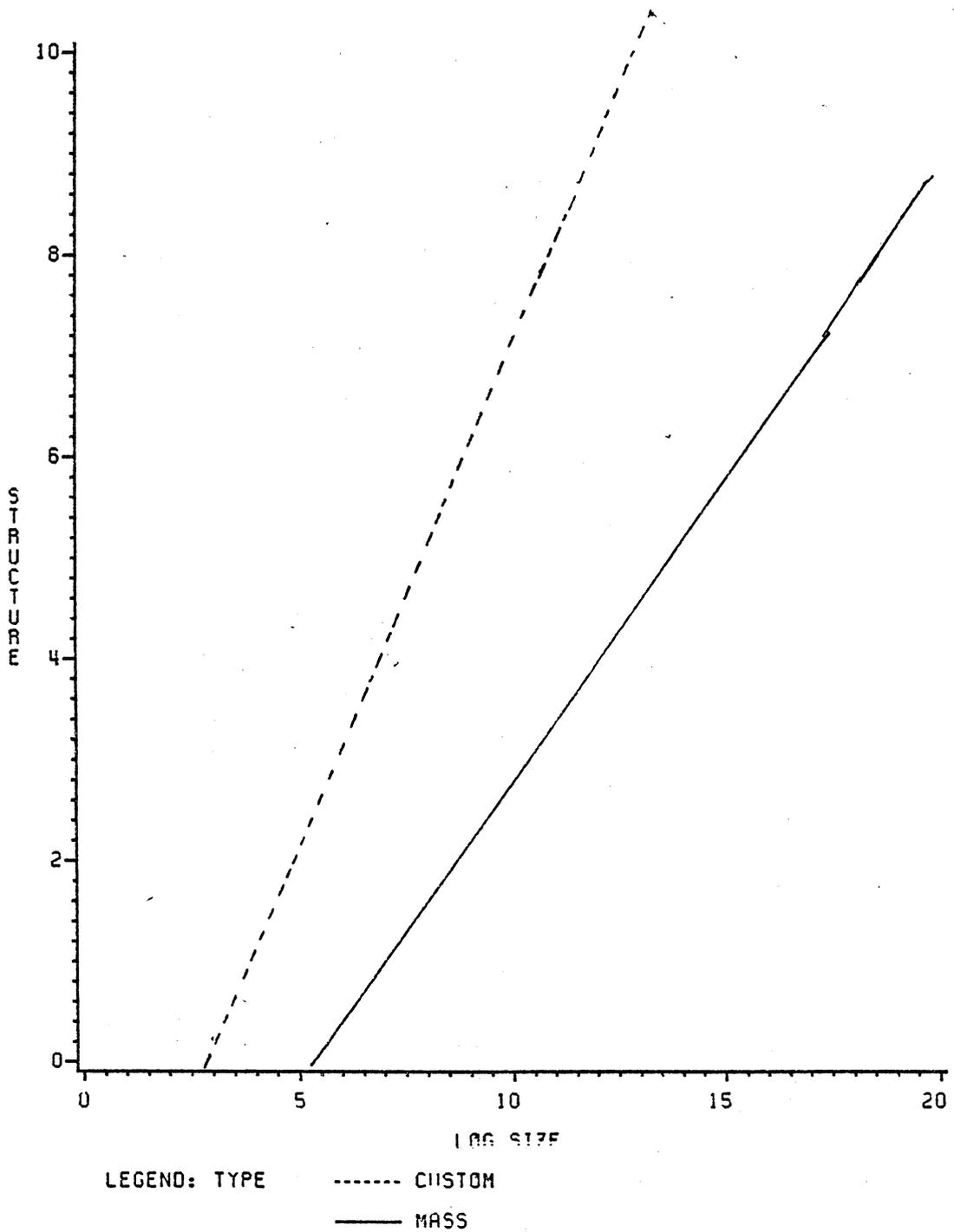


FIGURE 3-4: GRAPH OF STRUCTURE VERSUS LOG SIZE

slopes converge (Figure 3-5), which in turn indicates that significant structural differences found in small firms that are attributable to technology disappear as size increases. If the foregoing research hypotheses are true, Figure 3-5 portrays the relationships among size, technology and structure.

Sample Selection

Several criteria were used to select the two industries from which the samples were drawn. First and perhaps foremost, a clear dichotomy of technology is sought. Farm and garden machinery (SIC 352), and general building contractors, non-residential buildings (SIC 154) provide the appropriate dichotomy.

Construction has been classified as a custom-production technology by Stinchcombe (1959), and as intensive technology by Thompson (1967) and Eccles (1981). Machinery manufacturing has been classified as mass-production technology by Stinchcombe and as long-linked by Thompson. Thus, a dichotomy is established using two separate measures. The custom-mass dichotomy provides a desired link to the literature, and the intensive-long-linked dichotomy ensures that an organization-level measure is employed simultaneously. Also, both industries are affected in similar fashion by a number of contextual factors that could in turn affect

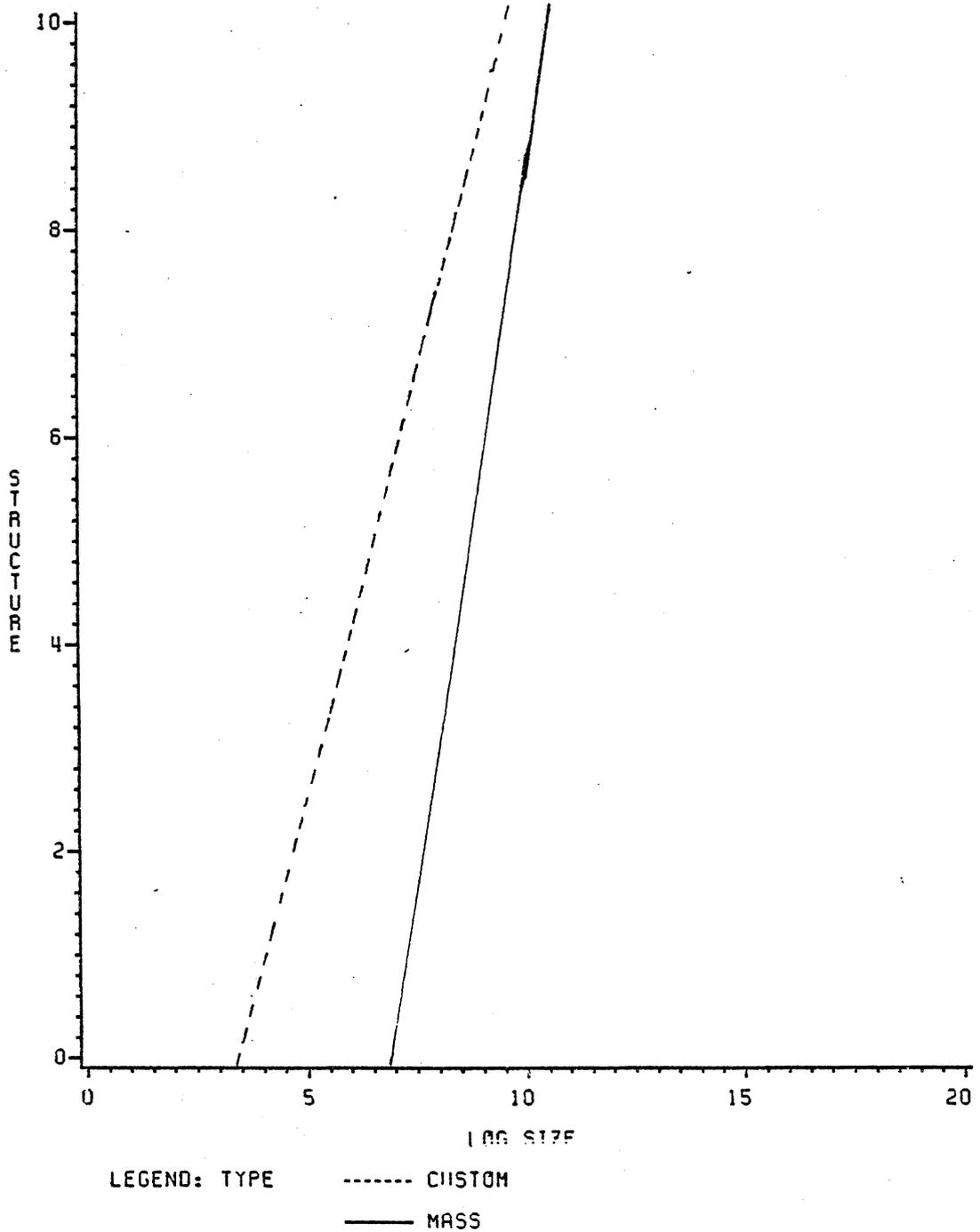


FIGURE 3-5: GRAPH OF STRUCTURE VERSUS LOG SIZE

structure. Burns and Stalker (1961) argued that one type of structure is appropriate for rapidly changing conditions and a different type structure appropriate to more stable conditions. The two industries sampled for this study operate in similar environments. Both are affected in a similar manner by economic cycles, and both exhibit very similar indices of instability and growth over time (Information Canada , 1973, p. 106, p. 119).

Other contextual variables within the industries that are thought to affect structure are organizational age, unionization, dispersal of ownership, multiple locations and distance of those locations from headquarters, and degree of subcontracting (Eccles 1981, Miles 1980, Dessler 1980, Jackson and Morgan 1982). Questions concerning these variables are included in the research questionnaire (Appendix 2). Appropriate calculations are made in chapter four so that the effects of those contextual variance on structure are controlled for.

Additionally, only the corporate form was selected for the study. Subsidiary or divisional corporations were excluded in an effort to eliminate structural differences due to differences in organizational autonomy (Pugh, et al., 1969). However, both publicly-held and closely-held corporations were included in order to achieve an adequate range in size.

Sample Response

Data for the study were collected in the spring of 1982. Eighty firms were selected, 40 from each technology category. (See Appendix 1.) It was found that two in each category had gone out of business. Each of the remaining 76 firms was contacted and the appropriate person to fill out the questionnaire was identified. All agreed to participate in the study and were mailed questionnaires. However, the response was substantially less than 100 percent. (See Table 3-1.)

Although the response was less than hoped for, the size distribution for construction firms ranged from 40 to 12,000, and for machinery firms ranged from 12 to 2,900. (See Table 3-2.) Two large machinery firms (7,400, 3,000) declined to answer and another of the large firms (2,700) had gone out of business after initially being contacted about the study. It is felt that the samples are representative of the two industries. Many of the firms in both industries had decreased substantially in size during the past two years. This is consistent with the earlier argument that both industries are subject to and respond in essentially the same way to macroeconomic forces.

Table 3-1

Sample Response Characteristics

	<u>Construction Firms</u>	<u>Machinery Firms</u>
Initial selected number	40	40
Merged or out of business before first contact	2	2
Contacted by phone and agreed to participate	38	38
Response on first mailing	16	21
Unusable returns	1	0
Declined to fill out	0	1
Sold out or merged	0	1
Contacted by phone and second mailing	5	6
Second response	0	4
Declined to answer	0	2
Net usable response	15	21
Percent usable response	39%	55%
Overall response rate	46%	

Table 3-2

Number of Employees of Firms in Samples

Construction Firms (n = 15)	Machinery Firms (n = 21)
12005	2902
7350	908
2200	752
1000	682
856	510
228	494
130	455
100	417
100	350
68	281
64	270
45	252
41	245
40	231
40	160
	151
	115
	82
	81
	55
	12

Measurement of Variables

As discussed above, selection of the building construction industry and farm and garden machinery manufacturing industry controls for some contextual factors. Additionally, firms were selected from within those industries so that the sample is homogeneous with respect to other variables. Data on other contextual variables thought to affect structure were gathered by questionnaire (Appendix 2). When computations demonstrated significant interactions with structural measures, corrections were made so that only the effects remaining were attributed to technology and size. This allowed inferences to be drawn and testing of hypotheses on technology, size and structure.

Computations of measures of size, structural variables and extraneous contextual variables were straightforward. Organizational age is simply the number of years to the nearest year the company has been in existence. Number of employees is the number of full-time employees plus half the number of half time or more employees plus one fourth the number of less than half-time employees. Log transforms are then taken of the sum of number of employees and used as the final measure of size.

Unionization of the work force is similar to one of Pugh, et al. (1969), dependence variables. A unionized firm is scored one, a non-unionized firm is scored zero. The

dispersal of operating sites score is one times the number of sites within 10 miles plus two times the number from 10 to 25, plus three times the number over 25. Udell (1967) shows some structural variables to be a function of distance of sites from headquarters as well as number of operating sites. Dispersal of ownership is scored one for under 10 stockholders, two for 10 to 25 stockholders and three for over 25. Subcontracting is measured as a percent of total sales.

Questions 8, 9, 10 and 11 (Appendix 2) measure formalization. These were adapted from Inkson, Pugh and Hickson (1970) and are scored essentially in the same fashion. The total score for an organization was computed by summing the values for each blank checked with each subsequent lower blank space scoring an integer higher, the first being zero in each instance. The lowest score possible is zero and the highest 13.

Questions 12, 13 and 14 measure specialization and are also adapted from Inkson, Pugh and Hickson and were also scored in similar fashion. The score in this case was the sum reported for 13 and 14 plus the number of blanks checked for 12.

Question 15 measures the C. E. O. span and the number of levels in the organization. The titles of managers reporting directly to the C. E. O. are counted.

Secretarial or clerical positions reporting directly to the C. E. O. were excluded. All hierarchical levels found in the organization were counted.

Question 16 measures decentralization of authority. This variable was shown to load on work rule changes, marketing decisions and expenditure variables (Grinyer and Yasai-Ardekani 1980). The score was the sum of the numbers shown in the blanks.

Size Versus Log Size Consideration

As noted above, most researchers cited used log number of employees as a measure of size. The most frequent reason given was that the structure/size relationship is log-linear. The evidence from the data in this study clearly indicates that the relationship is log-linear.

In all but one case, log size yielded a higher r^2 than size measured directly. The exception was specialization found in construction firms (Table 3-3). Additionally, log size gave negative or near zero y-axis (structure) intercepts while size yielded large positive y-axis intercepts, a meaningless measure. The shift of y-axis intercepts (Figure 3-6) indicates curvilinearity, concave downward, for structure plotted against size.

Interpretation of Regression Models Near Zero

Significantly different x-axis (log-size) intercepts for the two technological categories indicate that

Table 3-3

Parameters for Structure Regressed vs. Size and Regressed vs. Log Size

	<u>Size</u>				<u>Log Size</u>			
	<u>a</u>	<u>b</u>	<u>P ></u>	<u>r²</u>	<u>a</u>	<u>b</u>	<u>P ></u>	<u>r²</u>
Machinery formalization	8.32	.0004	.005	.347	- 5.66	2.8719	.0001	.559
Construction formalization	6.43	.0005	.064	.240	1.21	1.1017	.020	.349
Machinery specialization	38.96	.0542	.0005	.480	-114.10	32.0431	.0001	.598
Construction specialization	15.33	.0344	.0001	.860	-182.21	46.0738	.003	.495
Machinery decentralization	.40	6.91 x 10 ⁻⁵	.059	.174	0.20	.0416	.029	.226
Construction decentralization	.42	1.76 x 10 ⁻⁵	.114	.180	0.27	.0325	.097	.197
Machinery levels	5.55	.0011	.056	.178	1.20	.8755	.002	.402
Construction levels	5.18	.0002	.057	.251	2.53	.5458	.003	.499
Machinery span	6.06	.0006	.549	.019	2.33	.7239	.179	.093
Construction span	5.52	.0001	.357	.066	2.43	.6002	.008	.426

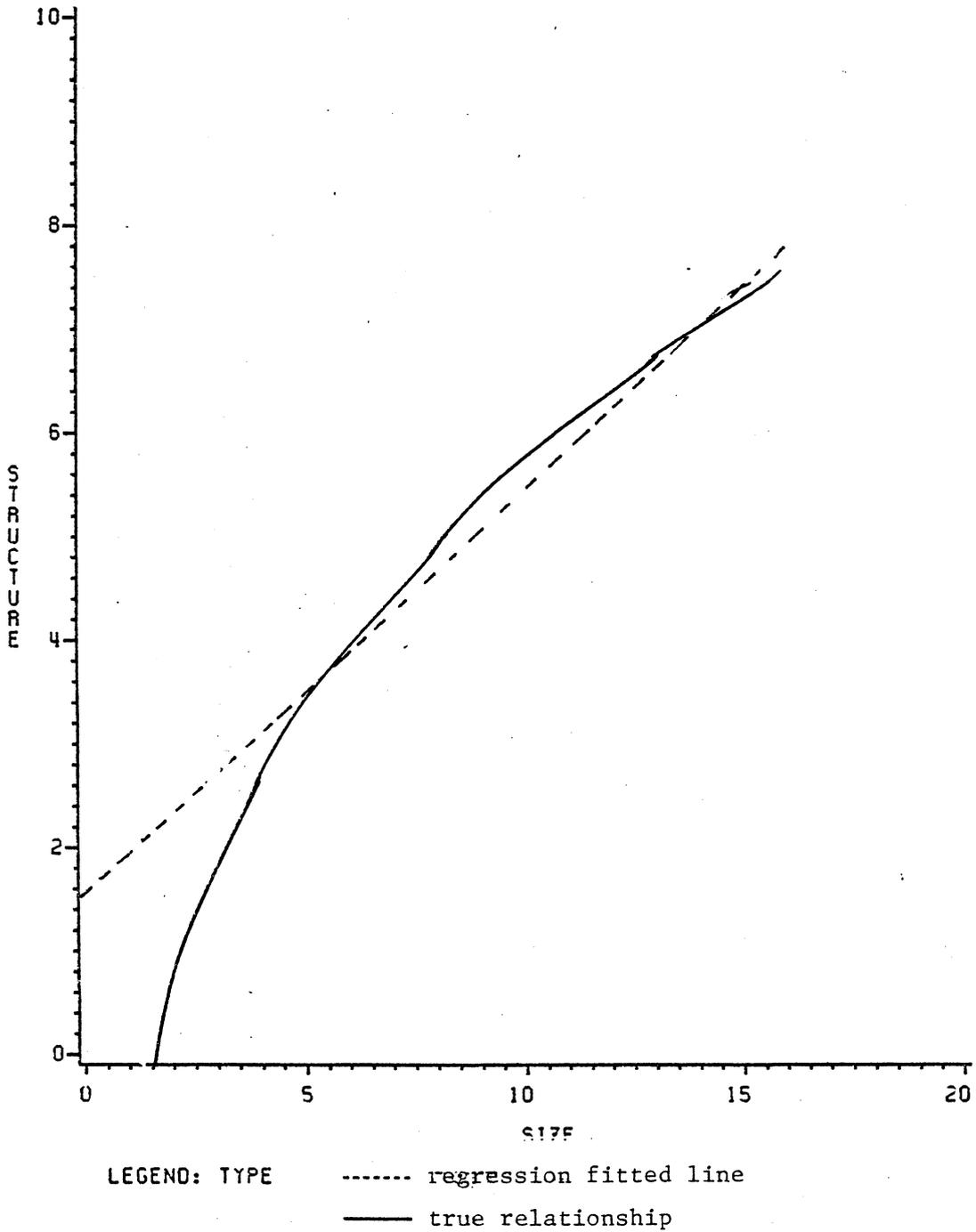


FIGURE 3-6: GRAPH OF STRUCTURE VERSUS SIZE

technology has a significant effect on the structure of small firms. However, regression modeling yields y-axis (structure) intercepts. Negative structural intercepts, although conceptually meaningless in themselves, indicate positive log-size intercepts. These are assumed to be the points at which significant structural measures commence. There are probably sharp discontinuities near these points where curves bend sharply toward zero. In these cases, structure is below the threshold of measure when instruments of this study are used.

Most of the structural measures should be discontinuous for very small firms. Frederick, Bohlen and Warren (1976) argued that most structure disappears at about 10 employees. Several of the regressions derived here indicate small positive structural intercepts, which must be interpreted as spurious and are assumed to be zero.

Level of Significance

The level of significance used is .05. This is more conservative than earlier studies of similar relationships (Hickson, et al. 1969, Child and Mansfield 1972, Zwerman 1970, Harvey 1968). Such a limit seems judicious since this study uses more closely-drawn samples and is not exploratory in nature. Exceptions to the .05 level of significance are made where two statistics are compared, and it is more conservative to use a non-zero figure. In some cases, one

statistic was found significantly different from zero, and another not significantly different from zero. When this occurred the number found non-significant was used rather than equating it to zero.

SUMMARY

This chapter presents the research hypotheses, data analysis methods and an explanation of the measurement and scoring of variables. The rationale for selection of the industries and firms within those industries is given. Variables thought to affect structure other than size and technology were discussed. Controls for these variables by sample selection or by measurement and computational techniques were developed.

Theoretical bases for the research hypotheses are developed. In the absence of literature support, null and alternative hypotheses are structured to be consistent with those that do have a theoretical basis.

Details of the response rate of the 76 queried firms is reported. Evidence supporting the use of log number of employees rather than number of employees is given, and a basis for interpretation of x-axis (log-size) intercepts is provided. Justification for use of a .05 level of confidence is given.

CHAPTER IV

ANALYSIS AND RESULTS

The results of the study are reported in this chapter. Relationships among firm size, technology and the structural variables discussed in chapter two are analyzed, and statistical inferences regarding the hypotheses developed in chapter three are drawn. Also, relationships between structural variables and organization age, unionization, dispersal of facilities, number of stockholders and degree of subcontracting are noted.

Preliminary Analysis

The relationships among size, technology and structure are the focus of this study. However, several contextual variables have potential for obscuring or confounding those relationships. The samples were selected to minimize the effects of some contextual variables. Contextual variables controlled for by sample selection are dependence on parent corporations, macroeconomic conditions, elimination of proprietorships and partnerships and rate of industry growth and industry stability. (See chapter three.)

Other contextual variables thought to affect structure (See chapter two.) could not be controlled for by sample selection. These are organization age, unionization of work

force, dispersal of facilities, dilution of ownership and degree of subcontracting. Data were collected and measurements made on these variables. (See chapter three.)

Structural Linkage to Control Variables

Correlations between each structural variable and each contextual variable are computed to check for significant linkages (Tables 4-1, 4-2). For mass-production technology firms formalization is linked to unionization and dilution of ownership, specialization is linked to dispersal of facilities, dilution of ownership, decentralization is linked to unionization and number of levels is linked to degree of subcontracting. For custom-production technology only three significant linkages occur. Both formalization and number of hierarchical levels are linked to dispersal of facilities. Additionally, formalization is negatively linked to degree subcontracting. of subcontracting. Each of these linkages indicates a need for caution in interpreting the relationships among size, technology and structure. These linkages are considered when the hypothesized relationships among size, technology and structure are tested later in this chapter.

Structural Linkages to Technology and Size

The preliminary finding is that structure is linked to size and technology. Eight of the 10 (Table 4-3) slopes of the regression models show a link to size. The exceptions

Table 4-1

Mass-Production Technology Firm Correlation Coefficients

	<u>Age</u>	<u>Size</u>	<u>Unionization</u>	<u>Dispersal of Facilities</u>	<u>Dispersal of Ownership</u>	<u>Degree of Subcontracting</u>	<u>Log Size</u>
Formalization	.26 (.25)*	.59 (.005)	.47 (.03)	.05 (.83)	.45 (.04)	.35 (.12)	.75 (.0001)
Specialization	.29 (.20)	.69 (.0005)	.41 (.07)	.43 (.05)	.64 (.002)	.11 (.62)	.77 (.0001)
Decentralization	.25 (.26)	.42 (.06)	.54 (.01)	-.28 (.21)	.28 (.22)	.22 (.34)	.46 (.03)
C. E. O. span	-.05 (.81)	.14 (.55)	.06 (.78)	-.05 (.82)	.07 (.76)	.06 (.78)	.30 (.18)
Levels	.28 (.22)	.42 (.06)	.30 (.18)	.31 (.18)	.29 (.20)	.62 (.003)	.63 (.002)

*Significance level

n = 21

Table 4-2

Custom Production Technology Firm Correlation Coefficients

	<u>Age</u>	<u>Size</u>	<u>Unionization</u>	<u>Dispersal of Facilities</u>	<u>Dispersal of Ownership</u>	<u>Degree of Subcontracting</u>	<u>Log Size</u>
Formalization	.14 (.62)*	.49 (.06)	.15 (.60)	.60 (.02)	.23 (.40)	-.63 (.01)	.59 (.02)
Specialization	-.04 (.87)	.93 (.0001)	-.22 (.43)	.42 (.12)	.02 (.93)	-.45 (.09)	.70 (.003)
Decentralization	-.32 (.24)	.42 (.11)	.01 (.97)	.45 (.09)	.01 (.98)	.14 (.62)	.44 (.10)
C. E. O. span	.08 (.78)	.26 (.36)	.47 (.07)	.67 (.006)	.43 (.10)	.38 (.16)	.65 (.008)
Levels	-.03 (.90)	.50 (.06)	.34 (.21)	.75 (.001)	.50 (.06)	.28 (.30)	.71 (.003)

*Significance level

n = 15

are custom-technology decentralization of authority and mass-technology C. E. O. span of control. Also, two sets of regression models, formalization and specialization, appear to be differentiated by technology. However, as noted above, these findings must be interpreted in light of relationships to several contextual variables. The following tests of hypotheses are done with these contextual variables taken into consideration.

TEST OF HYPOTHESES

All hypotheses are tested in essentially the same manner. That is, each structural variable is examined for significant relationships with size, technology and other contextual variables discussed above. Where significant relationships among structure and those other contextual variables occur, appropriate calculations are made to isolate the effects of size and technology on structure.

Formalization

Since each technology category has different significant correlations between formalization and certain variables other than log size, each will be discussed separately. Then the categories will be discussed in conjunction with one another to demonstrate how they affect the tests of hypotheses.

In the mass-technology firm sample, significant correlations occur between formalization and both unionization and dilution of ownership. (See Table 4-1.) In a cross-sectional study such as this, it is not possible to tell which of the factors are causally related, although as previously stated, size is assumed to be causally related to structure. However, the magnitude of relationships can be estimated and at least some inference of causality can be drawn by using suitable techniques.

Partial correlation may be used to isolate the effects due to any given variable. In this instance, partialling out unionization gives

$$Pr_{f,LS:u} = .665, P < .01$$

and partialling out dilution of ownership gives

$$Pr_{f,LS:0} = .680, P < .01$$

which indicates that log size has a much greater effect than either unionization or dilution of ownership when explaining formalization for the mass-technology firm sample.

If unionization and dilution of ownership are also functions of size, the last inference would be more strongly supported. Calculations can be made to examine these relationships using the formula

$$r_{f,u} \approx r_{LS,u} r_{LS,f}$$

and

$$r_{f,o} \approx r_{LS,o} r_{LS,f}$$

where

$r_{f,u}$ = correlation between formalization and unionization,

$r_{LS,u}$ = correlation between log size and unionization,

$r_{LS,f}$ = correlation between log size and formalization,

$r_{f,o}$ = correlation between formalization and ownership;

$r_{LS,o}$ = correlation between log size and ownership.

If equality occurs (a rare occurrence) or more likely a small statistically insignificant difference results, the inference can be made that log size is causally related to both unionization and dilution of ownership (Cohen and Cohen 1975).

When the calculations are done for formalization, unionization and log size

$$.474 \approx (.532)(.747) = .397$$

and for formalization, dilution of ownership and log size

$$.449 = (.570)(.747) = .431$$

results. This implies that both unionization and dilution of ownership are functions of log size. The inference that for mass technology log size has a much greater effect on formalization than either unionization or dilution of ownership is supported.

The relationships for the custom-technology sample differ from those of the mass-technology sample. Significant correlations here were found for formalization and subcontracting and for formalization and dispersal of facilities. (See Table 4-2.) Partialling out dispersal of facilities gives

$$Pr_{f,LS:d} = .186, \text{ N. S.}$$

and partialling out subcontracting leaves

$$Pr_{f,LS:s} = .415, \text{ N. S.}$$

which implies that log size has essentially no significant effect on formalization or that it is less important than dispersal of facilities and degree of subcontracting.

Looking at the equation

$$r_{f,d} = r_{f,LS} r_{d,LS}$$

computes as

$$.599 = (.591)(.858) = .507$$

which indicates a probable causal link to log size for both formalization and dispersal of facilities. A similar computation for subcontracting

$$-.684 \neq (.591)(-.491) = -.290$$

indicates that subcontracting may have an inverse causal relationship with formalization. Indeed, an argument can be made for this, and it was discussed in chapter three. The high negative correlation between formalization and degree of subcontracting may be partly due to the way formalization was measured. Part of the formalization score was determined by the number of jobs requiring written position descriptions. If subcontractors provide some of the jobs that would ordinarily require position descriptions then the formalization score would be reduced.

The foregoing then leads to the conclusion that the slope coefficient for custom-technology firms is likely

smaller than calculated for the regression equation. The effect on tests of hypotheses is addressed below.

Tests of Formalization Hypotheses

Simple regression of formalization versus log size yields significant models for both machinery and construction firms. The models are:

mass-technology formalization = $-5.656 + 2.8719 \log$
size,

and

custom-technology formalization = $1.21 + 1.101 \log$
size.

Both slopes are statistically significant and both intercepts statistically insignificant; however, formalization intercepts need to be converted to log size intercepts in order to be interpreted. Since both are insignificant, they could be interpreted as zero intercepts. In fact, to have conceptual meaning, the positive intercept must be interpreted that way. The negative intercept for machinery firms gives a log size intercept of 1.969, which corresponds to a size of seven employees.

Testing this intercept using the formula

$$t = \frac{\text{intercept}}{(s^2(1/b)^2 1/n + (\bar{y}/b^2)^2 1/SSX)^{1/2}}$$

where

x_o = log size intercept

s^2 = model mean square

b = model slope

$p = 1/b$

y = dependent variable mean

SSX = error sum of squares

n = sample size

\bar{y} = mean y

$l = (y/b^2)$

$t = 1/SXX$

yields

$$t = 2.461, P < .01,$$

so the intercept is statistically significant.

However, when the two log-size intercepts are tested for significant difference using

$$t = \frac{x_{oc} - x_{om}}{(s^2((\frac{p_m^2}{n_m} + l_{mm}^2 t_m) + (\frac{p_c^2}{n_c} + l_{cc}^2 t_c)))^{1/2}}$$

where

s^2 = pooled mean square

x_{om} = mass-technology log size intercept

x_{oc} = custom-technology log size intercept

b_m = mass-technology slope

b_c = custom-technology slope

n_m = mass-technology sample size

n_c = custom-technology sample size

$p_m = 1/b_m$

$p_c = 1/b_c$

$l_m = y/b_m$

$t_m = 1/SSX_m$

$t_c = 1/SSX_c$

$$t = .727, \text{ N. S.}$$

Statistical significance would have little meaning anyway since there is little practical difference between seven employees and zero employees.

A test of slopes using the formula

$$t = \frac{b_m - b_c}{(s^2 [t_m + t_c])^{1/2}}$$

where variables are defined as above gives

$$t = 2.461, P < .01.$$

A caveat is in order here because of the effect of dispersal of facilities and degree of subcontracting on custom-technology formalization. The variables affecting mass-technology firms were negligible and those affecting custom-technology firms were significant, therefore, the test presented above is conservative since the slope would be even smaller for custom-technology firms.

The above results support the hypothesis:

H2.1: Formalization will increase as size increases for custom-technology firms;

and tenuously support the hypothesis:

H2.2: Formalization will increase as size increases for mass-technology firms.

Support is not provided for the hypotheses:

H2.3: Formalization will be greater for small mass-technology firms than for small custom-technology firms.

H2.4: The differences in formalization decrease as size increases.

In fact, the exact opposite is indicated, although the relative slopes are as predicted by the hypotheses. Figure 4-1 depicts the relationship. The data indicate that formalization begins near zero for both mass-technology firms and

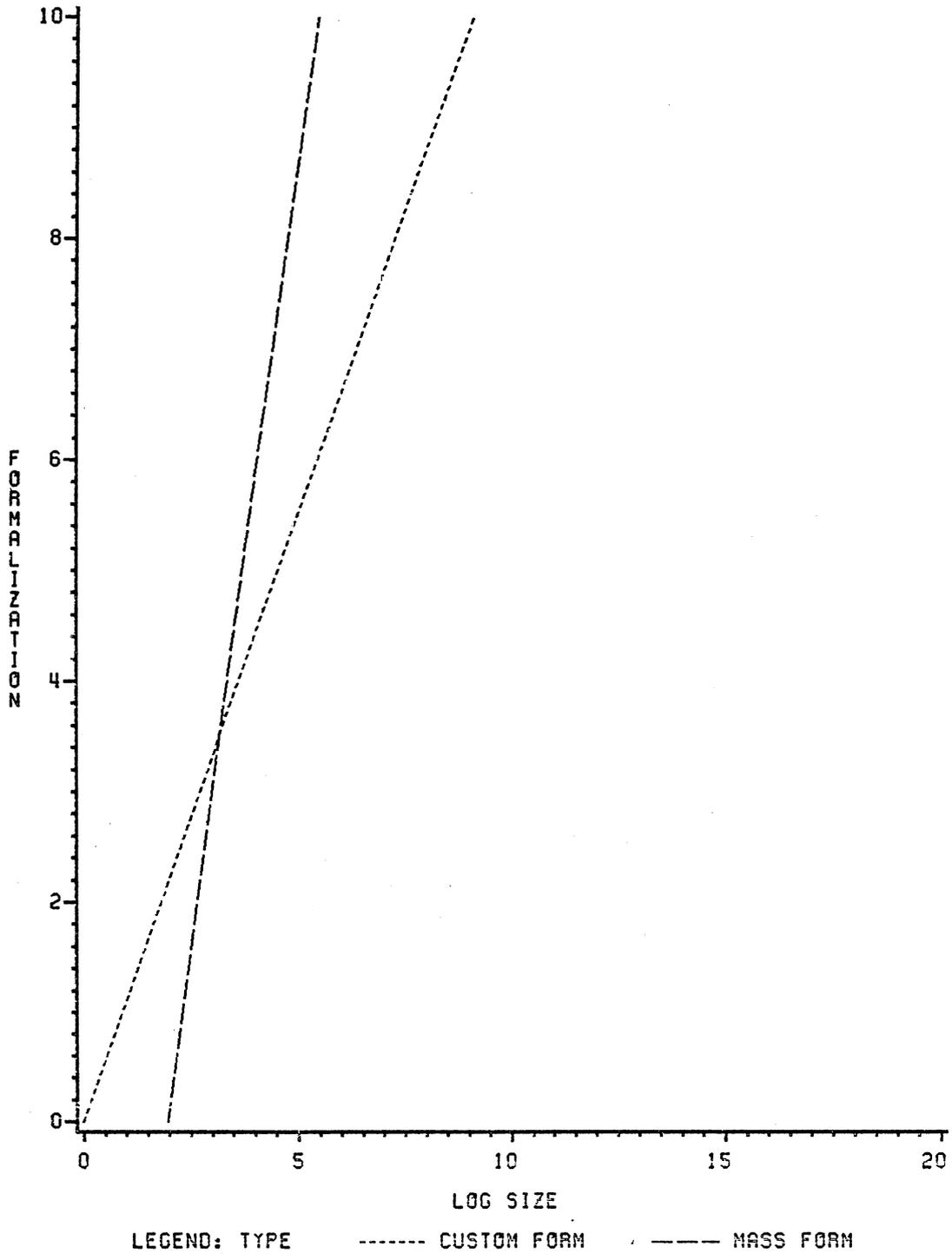


FIGURE 4-1: GRAPH OF FORMALIZATION VERSUS LOG SIZE

custom-technology firms. However, as size increases, mass-technology firms formalize more than custom-technology firms of corresponding size.

C. E. O. Span of Control

The custom-technology firms and mass-technology firms sampled each have different sets of correlates with C. E. O. span of control (Tables 4-1, 4-2). The same procedure used for formalization above was employed. No significant correlates were found for the mass-technology sample. Log size and dispersal of facilities are correlated with C. E. O. span of control for the custom-technology sample.

Partialling out dispersal of facilities for the custom-technology sample yields

$$Pr_{c,LS:d} = .201, \text{ N. S.}$$

and calculating

$$r_{c,u} = r_{d,LS} r_{c,LS}$$

gives

$$.671 = (.858)(.653) = .560$$

where

$r_{c,d}$ = correlation coefficients for C. E. O. span and dispersal of facilities,

$r_{d,LS}$ = correlation coefficient for dispersal of facilities and log size,

$r_{c,LS}$ = correlation coefficient for C. E. O. span and log size,

$Pr_{c,LS:d}$ = partial correlation coefficient for C. E. O. span of control and log size with dispersal of facilities held constant.

Tests of C. E. O. Span of Control Hypotheses

The data suggest that C. E. O. span of control is not a function of size for either the mass-technology sample or the custom-technology sample. However, a "worst case" test would be if the regression model (See Table 4-3.), mass-technology C. E. O. span of control = .724 log size, is true and custom-technology C. E. O. span of control is not a function of size. No significant difference in slopes is found in this case. Of course, if both slopes are equal to zero, no significant difference is found. The latter appears to be the most tenable assumption for these samples. The conclusion is that C. E. O. span of control is not a function of size and no moderating effect can be attributed to technology. Therefore, no support is found for the hypotheses:

Table 4-3

Regression Model Parameters

	<u>slope</u>	<u>P ></u>	<u>y-intercept</u>	<u>P ></u>	<u>x-intercept</u>	<u>P ></u>
Mass-technology formalization	2.8719	.0001	-5.656	.103	1.969	.01
Custom-technology formalization	1.1017	.020	1.21	.625	-0-	--
difference	1.702	.01	--	--	1.969	N.S.
Mass-technology specialization	32.04	.0001	-114.10	.003	3.561	.0005
Custom-technology specialization	48.07	.003	-182.207	.030	5.687	.0005
difference	16.03	N.S.	--	--	2.126	.0005
Mass-technology decentralization	.0416	.029	.2042	.054	-0-	--
Custom-technology decentralization	.0325	.097	.2709	.023	-0-	--
difference	.0091	N.S.	--	--	--	--
Mass-technology C. E. O. span	.724	.179	2.32	.437	-0-	--
Custom-technology C. E. O. span	.600	.008	2.43	.049	-0-	--
difference	.124	N.S.	--	--	--	--
Mass-technology levels	.875	.002	1.20	.395	-0-	--
Custom-technology levels	.546	.003	2.53	.013	-0-	--
difference	.329	N.S.	--	--	--	--

$N_c = 15$

$N_m = 21$

H2.1: The span of control for custom-technology firm C. E. O.'s will increase as firm size increases.

H2.2: The span of control for mass-technology firm C. E. O.'s will increase as size increases.

H2.3: The C. E. O.'s span of control will be greater for small mass-technology firms than for small custom-technology firms.

H2.4: The difference in C. E. O. span of control between the two technology categories will decrease as size increases.

Specialization

The custom-technology firm category had no correlations between specialization and age, unionization, dispersal of facilities, dilution of ownership or degree of subcontracting that are significant. Dispersal of facilities and dilution of ownership are both significant correlates of specialization for the mass-technology category. (See Tables 4-1, 4-2.)

Calculating the partials for the mass-technology sample renders

$$Pr_{S,LS:d} = .754, P < .01$$

and

$$Pr_{S,LS:d} = .643, P < .01$$

where

$Pr_{S,LS:d}$ = partial correlation coefficient for specialization and log size with dispersal held constant, and

$Pr_{S,LS:d}$ = partial correlation coefficient for specialization and log size with dilution of ownership held constant.

So the conclusion is that log size is the major contributor in explaining specialization for the mass-technology sample. Therefore, the regression equations can be compared directly.

Tests of Specialization Hypotheses

The regression models are

mass-technology specialization = $-114.099 + 32.043 \log \text{ size}$
and

custom-technology specialization = $-182.207 + 46.074 \log$
size.

Solving for log size intercepts yields

$$\log \text{ size} = 3.591$$

for mass-technology firms (corresponds to size = 36 employees, and

$$\log \text{ size} = 3.956$$

for custom-technology firms (corresponds to size = 52 employees). Each of these is statistically significant, $P < .0005$, and differ significantly, $P < .0005$.

However, the slopes did not differ significantly. The implication is that technology distinguishes between the two samples. Furthermore, the effect is constant across size. (See Figure 4-2.)

The results support the hypotheses:

H3.1: As size increases, specialization will increase custom-technology firms.

H3.2: As size increases, specialization will increase mass-technology firms.

H3.3: Small mass-technology firms are more specialized than are small construction technology firms.

Support is not provided for the hypothesis:

H3.4: The difference between specialization for construction firms and machinery firms will decrease as size increases.

Although the regression slopes predict that the latter hypothesis is true, a test for significant differences showed no significance. Figure 4-2 represents the relationship, with slopes assumed to be equal at the lesser figure, i.e., slope = 32.043.

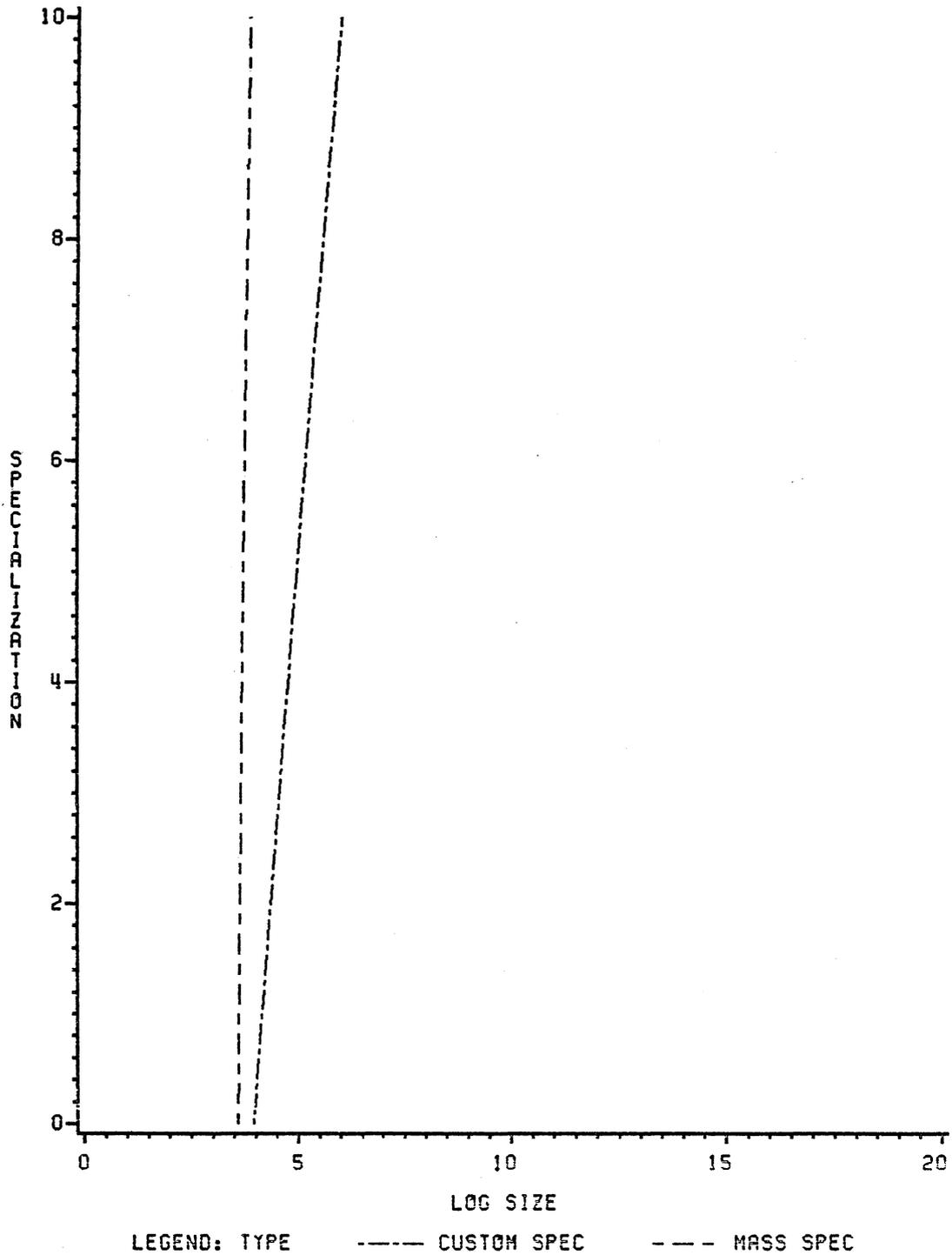


FIGURE 4-2: GRAPH OF SPECIALIZATION VERSUS LOG SIZE

Decentralization of Authority

The custom-technology sample exhibited no significant correlations of decentralization of authority with age, unionization, dispersal of facilities, dilution of ownership, degree of subcontracting or log size. The mass-technology sample decentralization of authority did correlate significantly with log size and with unionization. Partialling out unionization gives

$$P_{r_{A,LS:u}} = .260, \text{ N. S.},$$

where

$P_{r_{A,LS:u}}$ = partial correlation coefficient of decentralization of authority and log size with unionization held constant

and calculating

$$r_{a,u} \approx r_{a,LS} r_{u,LS}$$

where

$r_{a,u}$ = correlation coefficient between decentralization of authority and unionization

$r_{a,LS}$ = correlation coefficient between decentralization of authority and log size

ru,LS = correlation coefficient between unionization and log size
gives

$$.541 \neq (.532)(.476) = .253$$

so it cannot be assumed that both decentralization of authority and unionization are causally linked to log size.

This clouds the picture somewhat when attempts to interpret the data are made. Also, the custom-technology sample regression coefficient is not statistically significant. So, several interpretations can be based on the findings. Each interpretation depends on the assumptions made.

First, it is assumed that the intercepts are zero for both regression models since the small positive intercepts are conceptually meaningless. Also, if a cutoff of .05 is used, the mass-technology regression intercept is interpreted as zero. The custom-technology regression slope indicates no model, therefore, no intercept.

Second, the assumption could be made that both models are as shown by their calculated slopes. These are as follows:

mass-technology decentralization = .0417 log size,

and

custom-technology decentralization =

.0325 log size.

This would represent the conservative approach if it is assumed that the effect of unionization on mass-technology decentralization of authority can be neglected. Following this approach a test of slopes indicates no significant difference between the two.

A third assumption is that mass-technology decentralization of authority is not a function of log size, but is a function of unionization or some other undetermined factor or factors. It is further assumed that custom-technology decentralization of authority is a function of log size with the model as shown above. Again, a test of difference in slopes shows insignificant difference, with the mass-technology model slope equated to zero.

A fourth assumption is that the mass-technology model is as described above and that decentralization of authority among custom technology firms is not a function of size. Again, a test for difference in slopes renders no significant difference.

Of course, a fifth assumption, and under the circumstances the most likely interpretation, is that for both categories decentralization is not a function of size. In any event, it seems that there is no detectable difference between models.

Tests of Hypotheses

There is then no support for the hypotheses:

H4.1: As size increases authority will be more decentralized in custom-technology firms.

H4.2: As size increases authority will be more decentralized in mass technology firms.

H4.3: Decentralization of authority is greater for small custom-technology firms than for small mass-technology firms.

H4.4: The difference in decentralization between mass-technology firms and custom-technology firms will decrease.

Hierarchical Levels

Both the mass-technology and the custom-technology samples are found to have significant positive correlations with number of hierarchical levels and log size. Additionally, number of hierarchical levels is positively correlated with dispersal of facilities for the custom-technology sample and with degree of subcontracting for the mass-technology sample. Investigating the partials of these shows

$$Pr_{e,LS:d} = .188, N. S.$$

for the custom-technology sample where

$Pr_{e,LS:d}$ = partial correlation for levels and log size with dispersal held constant, and

$$P_{e,LS:s} = .623, P < .01$$

for the mass-technology sample where

$Pr_{e,LS:s}$ = partial correlation for number of hierarchical levels and log size with degree of subcontracting held constant.

Also calculating

$$r_{e,d} = r_{d,LS} r_{d,LS}$$

where

$r_{e,d}$ = number of hierarchical levels and dispersal of facilities correlation,

$r_{d,LS}$ = dispersal of facilities and log-size correlation, and

$r_{e,LS}$ = number of hierarchical levels and log-size correlation

gives

$$.747 \approx .605.$$

Thus, it is likely that both levels and dispersal of facilities are functions of log size for the custom-technology sample.

Tests of Hypotheses on Hierarchical Levels

The above indicates two alternative situations for the regression models. First, it can be assumed that the model slope coefficients are as shown, that is

custom-technology number of hierarchical levels = .546
log size

and

mass-technology number of hierarchical levels = .875
log size.

A test difference in slopes yields

$$t = 1.157, \text{ N. S.}$$

However, if it is assumed that dispersal of facilities has a greater effect on number of hierarchical levels than does log size, a different situation emerges. The models then become

mass-technology number of hierarchical levels = .875
log size,

and

custom-technology number of hierarchical levels = 0 log
size
and

$$t = 3.088, P < .005.$$

The partials calculated are evidence favoring the latter interaction. Inspection of the organization charts furnished by respondents suggests the above finding. Several charts that show geographically-dispersed facilities also have managerial levels and titles interposed that are not shown for firms that are not dispersed.

If the latter set of models is accepted, then support for the following hypothesis is furnished.

H5.1: The number of levels will increase as size increases for machinery firms.

Support is not supplied for the hypotheses:

H5.2: The number of hierarchical levels will increase as size increases for construction firms.

H5.3: The number of hierarchical levels will be greater for small machinery firms than for small construction firms.

No support is provided for the hypothesis:

H5.4: The difference between number of levels of machinery firms and construction firms will decrease as size increases.

Figure 4-3 shows the slopes as indicated by the models assuming a maximum slope of .546 for construction firms, for illustration only. The difference is suspected to be greater than shown.

Thus, it appears that technology does distinguish between technology categories for hierarchical levels. However, it cannot be stated that the effect of size on number of levels is modified by technology.

SUMMARY

Analysis of the Data Collected in This Study

This chapter presents the analysis of data relevant to the hypotheses of the study and rationale for interpretation of the data. Each hypothesis is tested and the results reported. Formalization, specialization and number of hierarchical levels are found to be linked to size and technology. C. E. O. span of control and decentralization of authority are not linked to size or technology. A more complete discussion of the findings is found in chapter five.

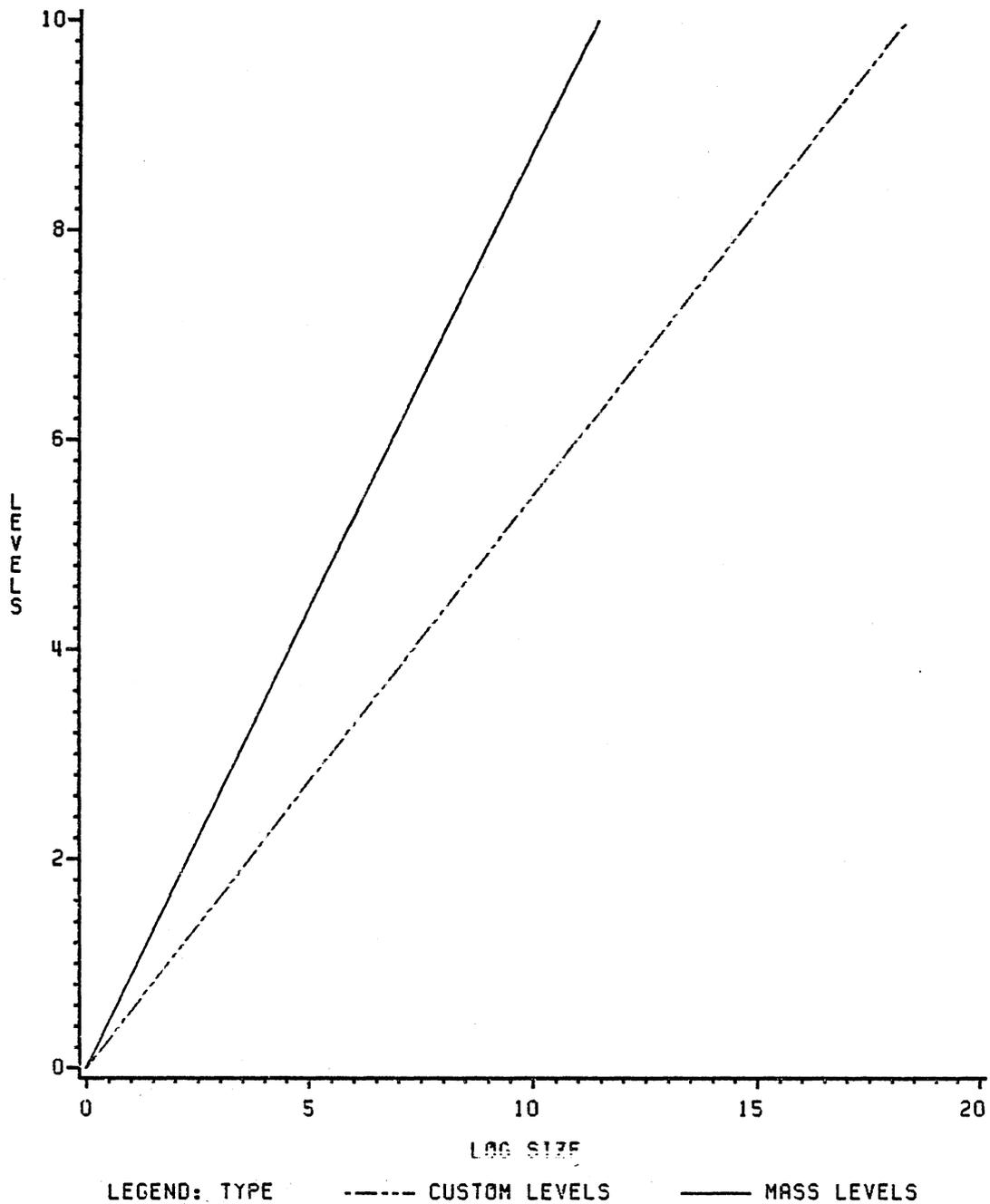


FIGURE 4-3: GRAPH OF NUMBER OF HIERARCHICAL LEVELS
VERSUS LOG SIZE

CHAPTER V

CONCLUSIONS

General Conclusions

Based on the study findings, four general conclusions seem appropriate. First, it appears that it is misleading to attempt to relate any of the variables considered in this study to structure as a monolithic concept. It appears more appropriate to relate specific dimensions of structure to specific contextual variables. Second, it appears that size and technology are related to three of the five dimensions of structure considered in this study. However, the relationships vary substantially. (See Figure 5-1.) Third, linear regression appears to be a particularly useful tool for investigating relationships among organizational variables such as size, technology and structure. Fourth, it appears that use of technology in a holistic and categoric fashion is a valuable approach. Each of these four conclusions is discussed below.

Structure

Many researchers (See Table 2-1.) discuss the relationships among size, technology and structure as if the relationships were constant with respect to all dimensions of structure. However, they then note considerable variation

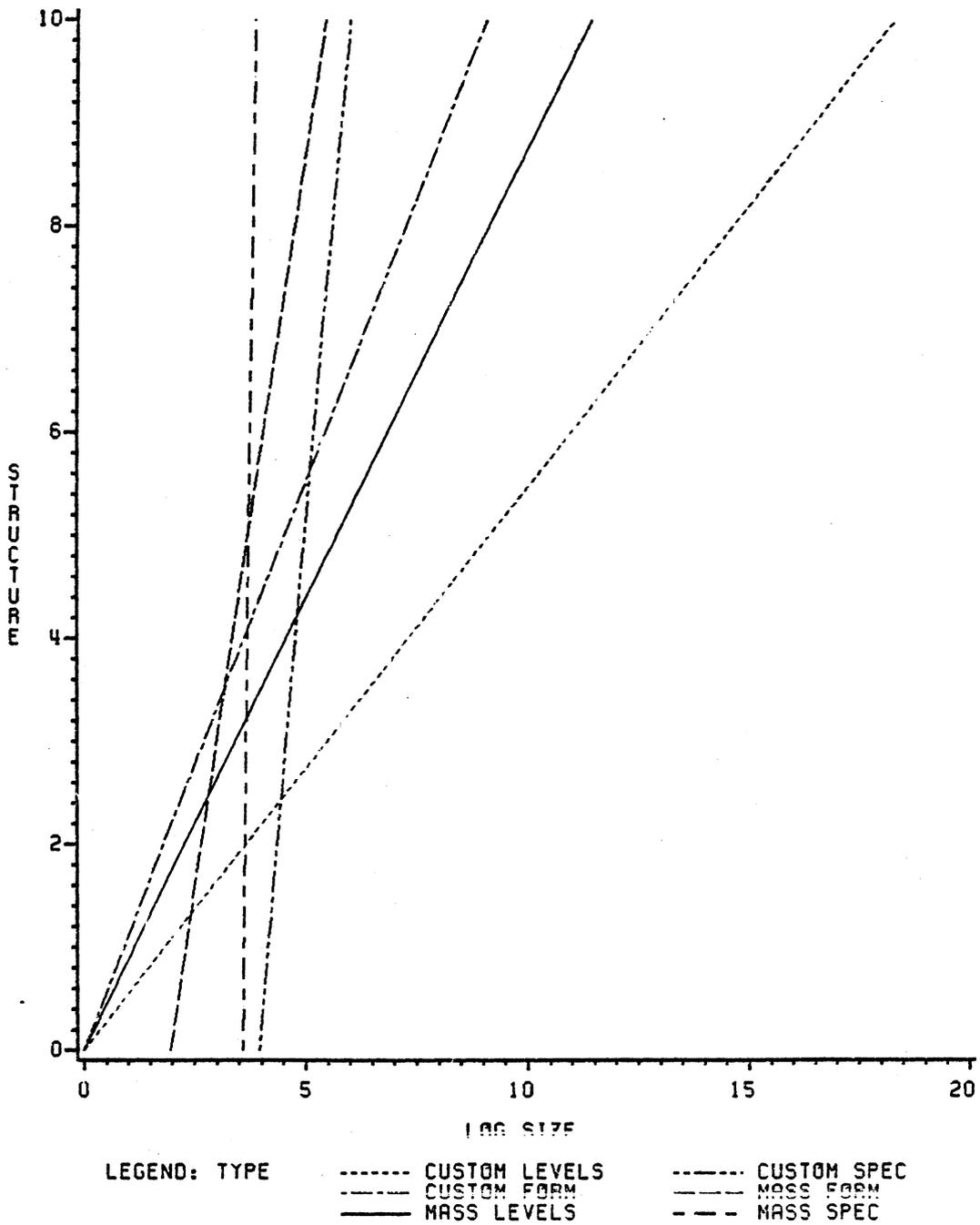


FIGURE 5-1: GRAPH OF STRUCTURE VERSUS LOG SIZE

in relating size and technology to specific structural dimensions. In this study the basic hypothesis, that the relationship of size to structure would be modified by technology, was based on the same assumption. The results of the study are clear that the assumption of a unitary concept of structure does not hold. As in the studies cited in Table 2-1, substantial variation in relationships of size and technology to specific structural dimensions was found. (See Figure 5-1.)

Structure, Size and Technology

The analyses performed in chapter four indicated that technology modifies the effect of size on some dimensions of structure. This effect was measurable on three of the five dimensions of structure examined in this study. The three structural variables affected by both size and technology were formalization, specialization and number of hierarchical levels. Both decentralization of authority and C. E. O. span of control appear to be unrelated to either size or technology.

The results of this study regarding formalization, specialization and number of hierarchical levels appear to bridge studies that found these three variables linked to either size, or technology, but not both. Woodward (1951) alone found specialization to be solely linked to technology. Hickson, et al. (1969), Blau, et al. (1976), and Marsh

and Mannari (1981) linked specialization to size only. Formalization was linked to technology only by Woodward (1958) and Harvey (1968), and to size only by Hickson, et al. (1969), Blau, et al. (1976) and Marsh and Mannari (1981). Number of hierarchical levels was linked to technology only by Harvey (1968) and Woodward (1958), and to size only by Hickson, et al. (1969) and Blau, et al. (1976).

The findings of this study support the findings of the studies that linked structural variables to both size and technology. Child and Mansfield (1972) link both formalization and specialization to size and technology. Zwerman (1970) and Child and Mansfield (1972) link number of hierarchical levels to both size and technology.

The reasons for variation among the findings of the studies is not clear. A number of possible causes were discussed in chapter two of this dissertation. However, this study incorporates more controls on potentially confounding variables than any of the above cited studies. Therefore, it is concluded that formalization, specialization and number of hierarchical levels are clearly linked to both size and technology.

The findings of several studies on C. E. O. span of control and decentralization of authority are mixed. Woodward (1958) alone found C. E. O. span of control to be linked to technology. Blau, et al. (1976) found C. E. O.

span of control to be linked to size. Zwerman (1970) and Child and Mansfield (1972) found C. E. O. span of control to be linked to both size and technology. Hickson, et al. (1968) and Marsh and Mannari (1981) found C. E. O. span to be linked to neither size nor technology. These latter findings are supported by this study.

Hickson, et al. (1968) and Khandwalla (1974) linked decentralization of authority to size only. Child and Mansfield link decentralization of authority to both size and technology. Marsh and Mannari (1981) linked decentralization of authority to neither size nor technology, a finding supported by this study. As noted above, the controls used in this study lead to the conclusion that C. E. O. span of control and decentralization of authority are not linked to size and/or technology.

Use of Linear Regression

Linear regression models graphically illustrate how variables interrelate with one another. In this study, a comparison of means (Table 5-1) of structural variables would have shown formalization to be the only structural variable to differ from custom technology to mass technology. Linear regression also gives an indication of the threshold at which specific structural dimensions begin, and the rate at which structure accrues with respect to size.

Table 5-1

Statistical Parameters of Structural Measures

	<u>means</u>	<u>standard deviations</u>	<u>ranges</u>
Custom-technology formalization	7.267	3.637	0 - 13
Mass-technology formalization	10.24	4.44	2 - 18
Sig. level	t = 2.773 p < .005		
Custom-technology specialization	71.00	127.58	8 - 512
Mass-technology specialization	63.24	47.87	5 - 164
Sig. level	t = .334 p < .40		
Custom-technology decentralization	.450	.143	.200 - .667
Mass-technology decentralization	.435	.101	.243 - .575
Sig. level	t = .482 p < .35		
Custom-technology C. E. O. span	5.73	1.79	3 - 9
Mass-technology C. E. O. span	6.33	2.74	2 - 14
Sig. level	t = .966 p < .20		
Custom-technology levels	5.53	1.51	4 - 9
Mass-technology levels	6.05	1.60	3 - 9
Sig. level	t = 1.431 p < .10		
	N _c = 15		
	N _m = 21		

Technology as a Holistic Measure

Using technology as a control variable as suggested by Gillespie and Mileti (1976) does appear to be a fruitful approach. One advantage is the avoidance of meticulous measurement problems. Many of the differences found in earlier research seem to stem from technology measurement difficulties. Use of technology as a classificatory variable also permits more global use of the variable and relieves researchers of having to relate specific dimensions of technology (Hickson, et al, 1969) to other variables, such as size and structure.

Child and Mansfield's (1972) graphic portrayal of their findings can be interpreted as showing that technology is industry specific. If this is true, then the approach taken here is very likely the best way to approach an investigation of technology as it relates to other variables. That is, technology can be used as a classificatory device, rather than a scalar or vector quantity.

Effects of Contextual Variables

Other Than Size and Technology

Despite the fact that considerable thought went into the selection of firms included in this study, there is evidence of the existence of several potentially confounding factors. Unionization, dispersal of facilities, degree of

sub-contracting and dilution of ownership were found to be related to several structural variables. In some instances these relationships were stronger than the relationships of size to structure. Clearly, these contextual variables, and perhaps other unidentified contextual variables confound attempts to examine size-technology-structure relationships. This may be a partial explanation for the variation in findings of studies (Table 2-1) that use samples that vary in product, ownership makeup, affiliation with other organizations or other contextual variables.

Discussion of Specific Structural Dimensions

Each structural dimension was found to be related to a different set of contextual variables (Table 4-1, 4-2). The intercorrelations among structure (Tables 5-2, 5-3) were also lower in this study than in others (Grinyer and Yasai-Ardekani 1980, Marsh and Mannari 1981, Pugh, et al. 1968, Inkson, et al. 1969). One explanation for the low intercorrelations is that each structural dimension is a function of a different set of explanatory contextual variables. These two findings indicate that an understanding of structure may be enhanced by considering each structural element separately.

Table 5-2

Construction Firm Structure Intercorrelations
n = 15

	<u>Formalization</u>	<u>Specialization</u>	<u>Decentralization</u>	<u>C. E. O. Span</u>	<u>Levels</u>
Formalization	1.00 (.00) *				
Specialization	.46 (.0957)	1.00 (.00)			
Decentralization	.22 (.4389)	.42 (.1179)	1.00 (.00)		
C. E. O. Span	.51 (.0547)	.18 (.5246)	.19 (.5051)	1.00 (.00)	
Levels	.56 (.0301)	.43 (.1057)	.29 (.2976)	.67 (.0068)	1.00 (.00)

*Significance level

Table 5-3

Machinery Firm Structure Intercorrelations
n = 21

	<u>Formalization</u>	<u>Specialization</u>	<u>Decentralization</u>	<u>C. E. O. Span</u>	<u>Levels</u>
Formalization	1.00 (.00)*				
Specialization	.72 (.0003)	1.00 (.00)			
Decentralization	.39 (.0773)	.20 (.3732)	1.00 (.00)		
C. E. O. Span	.27 (.2324)	.29 (.2090)	-.02 (.9370)	1.00 (.00)	
Levels	.58 (.0062)	.44 (.0462)	.02 (.9380)	.22 (.3280)	1.00 (.00)

*Significance level

Formalization

The findings of this study reveal that formalization is strongly linked to size. These results also support studies by Hickson, et al. (1968), Child and Mansfield (1972) and Marsh and Mannari (1981). The finding that formalization is also linked to technology also supports Woodward (1958), Harvey (1968) and Marsh and Mannari (1981), but is contrary to findings by Hickson, et al. and Marsh and Mannari.

For custom-technology firms and mass-technology firms, then, formalization is firmly linked to both size and technology. The natures of the relationships are as follows. For small firms no difference in formalization is found between the two categories of technology. This means that size and technology are related, but that formalization is related to technology only among large firms. (See Appendix 3, 4.) This relationship is opposite to Hickson, et al.'s hypothesis that technology affects structure of small firms more than large. The findings of this study indicate that small firms possess little formalization, but formalization increases with measures of size. The rate at which firms add formalization is modified by their technology. (See Figure 4-1.)

C. E. O. Span of Control

The findings generated by this study reveal no relationships among C. E. O. span of control, size and

technology. These findings contradict virtually all earlier studies. (See Table 2-1.) Marsh and Mannari (1981) found that C. E. O. span of control is more a function of technology than size. This could lead to the expectation that regression of C. E. O. span versus size as in this study might be expected to yield negative results. A difference in means of C. E. O. span of control between the two samples could indicate a link to technology, neglecting size. However, a comparison of C. E. O. span of control means (Table 5-1) also failed to show a significant difference between technologies. So, no assertion can be made that C. E. O. span of control is related to either size or technology.

The studies cited in Table 2-1 neglected other potentially explanatory variables. If dispersal of facilities was ignored in this study, a significant link between size and C. E. O. span of control would have been found for custom technology. (See chapter four.) However, based on the data, the dispersal of facilities could not be ignored. As stated above, the most tenable conclusion is that C. E. O. span of control is not related to either size or technology.

Specialization

The findings regarding specialization appear to be more clear cut than those of the other variables in this study. Specialization is clearly related to both technology and size. Additionally, mass-technology firms exhibit greater

specialization than custom-technology firms. Structural specialization increases with measures of size at approximately the same rate for both technology categories. There appear to be no significant effects due to other contextual variables for either category of technology.

Decentralization of Authority

The literature cited (Table 2-1) prior to 1973 consistently revealed a strong relationship between decentralization of authority and size. However, Marsh and Mannari (1981) found no such linkage, which is consistent with the results of this study. Additionally, this study found no relationship to technology. A possible explanation is that the earlier cited studies did not control for contextual variables other than size and technology. If decentralization of authority and size are considered without reference to controls, then the earlier studies are supported. That is, in this study decentralization of authority is linked to size among companies in the mass-technology sample. However, in this study no linkage was found between size and decentralization of authority among companies in the custom-technology sample.

However, when unionization is controlled for, no size effects are found for either sample. A test of means (Table 5-1) shows no difference between decentralization of authority between the two samples. The conclusion is that firms

included in the survey in both technology categories exhibit no significant differences in decentralization of authority. Therefore, it is concluded that decentralization of authority is linked to neither size nor technology.

Number of Hierarchical Levels

Number of hierarchical levels appears to be related to size for firms in the mass-technology samples but not for firms in the custom-technology sample. These findings strongly support that technology is related to the number of hierarchical levels at least for the two technology categories of this study. Number of hierarchical levels appears to be related to dispersal of facilities for the custom-technology category. Dispersal of facilities did not occur to a significant degree for the mass-technology category sample. (See Appendix 4.) Possibly, if there were more data available that included mass-technology firms with dispersal facilities, similar findings would have been obtained for both technology-category samples.

Secondary Findings

Several observations that are not central to this study appear to be in order. First, each element or dimension of structure investigated in this study appears to be related to a different set of contextual variables (Tables 4-1, 4-2). Also, the intercorrelations of structural elements

(Tables 5-2, 5-3) are lower than in earlier studies (Gringer and Yasai-Ardekani 1980, Marsh and Mannari 1981, Pugh, et al. 1968, Hickson, et al. 1969), indicating that the variables are related to different sets of contextual variables.

Second, the strong relationship ($r = .67$, $P < .007$) between number of hierarchical levels and C. E. O. span of control for the custom-technology sample (Table 5-2) appears to hinge on dispersal of facilities. This supports Grinyer and Yasai-Ardekani (1980). They defined a "shape" variable related to both span of control and number of hierarchical levels and found it to be related to number of operating sites.

Decentralization of authority was not clearly linked to size in this study. However, decentralization of authority was found to be linked to unionization for the mass-technology sample ($r = .54$, $P < .01$). This partially supports the Aston group findings (Pugh, et al. 1969), which revealed a relationship between decentralization of authority and dependence. They defined dependence as a relationship between the firm and parent organizations and trade unions. Parent organizations were not relevant in the samples of this study since the samples included firms that are independent organizations.

Implications for Future Research

Several directions for research are indicated by this study. The first is that regression analysis more effectively demonstrates the nature of interrelationships of variables than correlation analysis.

The second implication is that Gillespie and Mileti's (1979) suggestion to use technology as a control variable appears to be a fruitful approach. This study compared only two technology categories. Other categories are implied in Figure 2-2. If firms employing technologies representative of other cells in Figure 2-2 are studied, additional relationships among size, technology and dimensions of structure are likely to appear. The findings of this study are limited due to the controls imposed on the samples.

A third avenue for research is that a regression model building approach may be fruitful in exploring the relationship of structure to contextual variables. For example, a model could be investigated such as

$$S = A_0 + B_1S + B_2U + \dots B_nN$$

where

S = structural dimension under investigation

A_0 = intercept

$B_1, B_2 \dots B_n$ = regression coefficients

S = size variable

U = unionization variable

N = additional representative contextual variables.

An approach such as this would give simultaneous consideration to contextual variables rather than the piecemeal approach commonly used.

Conclusions

It appears that investigations of this nature are needed to bring some coherence to the field of organization theory. Hopefully this study is a beginning. Structure and its correlates have been demonstrated to be complex in this and earlier studies. Researchers have apparently compounded the problem by mixing levels of analysis, using incomplete measures of technology and using terminology inconsistently.

An effort was made in this dissertation to avoid adding any complexity by using terminology established by earlier researchers. Also size measures, technology classifications and structural dimensions were used that appeared to be appropriate to the organization as the unit of analysis. The effort to consistently use organizational-level measures may have resulted in the apparent bridging of earlier studies that disagreed. Continued research is needed to examine the relationships as found in this study and to search for similar types of relationships among other technology classifications.

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AN ANALYSIS OF RELATIONSHIPS AMONG SIZE,
TECHNOLOGY AND STRUCTURE IN A
CONTEXTUALLY LIMITED SETTING

by

Joel K. Worley

(ABSTRACT)

For several years organization theorists have debated the magnitude of the impact of size and technology on dimensions of organization structure. Also, management theorists have shown the importance of structure on organization goal attainment. However, no consensus has been reached concerning the interrelationship among size, structure and technology.

Apparently much of the disagreement among theorists is a result of mixing levels of analysis, inadequate specification of variables, use of inadequate or inappropriate research tools and lack of controls for potentially confounding variables.

The purposes of this dissertation were: (a) to provide a better understanding of the complex interrelationships among size, technology and structure; (b) to use regression analysis in an effort to better depict the relationships among those variables; and (c) to attempt to bridge some of

the findings of other researchers that disagree among themselves.

The study used carefully selected variables that appear to be appropriate to the level of analysis (the organization) used, and careful selection of sample organizations in order to control for some potentially confounding variables. Other potentially confounding variables were measured and their effects on size, technology and structure controlled for.

The central hypotheses of the study were: (a) that technology would cause structure to differ for small firms; and (b) that the difference in structure would disappear among large firms.

The findings were mixed, with some of the structural dimensions being related to both size and technology and others to neither size nor technology.

The structural dimensions of formalization, specialization and number of hierarchical levels appear to be functions of organizational size, with the effects of size moderated by technology. The structural dimensions of decentralization of authority and Chief Executive Officer's span of control do not appear to be related to either size or technology. Additionally, it appears that the differences in structure attributable to technology are greater

for large firms than for small firms. This finding was contrary to the hypothesized relationship.

An additional significant finding of this research was that it appears to be more appropriate to refer to the relationship among given dimensions of structure and other variables rather than structure as a monolithic concept.