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The characteristics of motion and time study in Taiwan's electronics industry and their relationship to business size

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THE CHARACTERISTICS OF MOTION AND TIME STUDY

IN TAIWAN'S ELECTRONICS INDUSTRY

AND THEIR RELATIONSHIP TO BUSINESS SIZE

A Dissertation Submitted

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Industrial Technology

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ABSTRACT

This research was conducted to investigate the characteristics of motion and time study implementation in Taiwan's electronics industry, as perceived by industrial engineers, and the relationships of these perceptions to business sizes of the firms. The questionnaires were mailed to 252 industrial engineers in the general firms group. A total of 206 (81.75%) instruments were returned. The questionnaires were then mailed to another 15 industrial engineers in the highly productive firms group. All the instruments (100%) were returned from the highly productive firm group. Telephone interviews were later conducted with six selected highly productive electronics firms to investigate their successful implementation of motion and time study. The Statistical Package for Social Sciences (SPSS) computer program was used to perform the statistical analysis. Statistical analysis involved frequencies, crosstabs, chi-square analysis, and Spearman's rank correlation coefficients.

The major findings drawn from the analysis of data was that motion and time study practices were different by business size in Taiwan's electronics industry regarding usage of time standards, application of time standards on indirect personnel and problems with conducting motion and time study. In addition, motion and time study training practices in Taiwan's electronics industry were also

different by business size regarding current practices and perceived ideal practices.

Business size was found to have positive correlations related to: (a) the use of work measurement techniques such as MTM-1, MTM-2, and computerized work measurement systems; (b) the application of time standards on department functions such as cost estimation and cost accounting; as well as (c) person-hours involved conducting motion and time study. Negative correlation, however, was found between business size and the application of time standards on production planning/scheduling. Concerning the differences in motion and time study practices and related training practices in highly productive electronics firms compared with other electronics firms, highly productive firms tended to use time standards more often than general electronics firms in the manufacturing process area. Chi-square values revealed no significant differences regarding all the other implementation characteristics used in this study.

Major recommendations of this study were: (a) motion and time study related training programs of various types, content and length of time should be provided to meet the demands of motion and time study personnel in Taiwan's electronics industry, and (b) the concept of applying time standards to various company departments and functions should be disseminated in order to promote the implementation of motion and time study.

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CHAPTER I

INTRODUCTION

The Council for Economic Planning and Development (1992) of Taiwan reported that the electronics industry is the largest manufacturer in Taiwan in terms of export volume and its contribution to the Gross National Product (GNP). The Industrial Development Bureau of the Republic of China (1990) also stated that electronic components such as semiconductors, capacitors, and resistors have been the most prevalent exported products since 1983. The production level and export volume, however, have been affected by labor shortages and rising labor costs in recent years (Chou, 1990; Hung, 1993). With its importance in the economy of Taiwan, the need for productivity improvement in the electronics industry has become substantial.

Motion and time study is an effective technique for improving productivity (May & Jackson, 1989; Meyers, 1992; Sakamoto, 1987). According to Meyers (1992), the work performance in manufacturing plants can be improved up to 42% by setting time standards, and then incentive wage systems tied to these standards can result in another 42% increase in productivity.

In Taiwan, some motion and time study promotion organizations, as well as educational and training organizations focus on fostering motion and time study analysts and developing motion and time study programs. These organizations regularly provide curricula and programs for industry. Many of the programs, however, have not been changed in 15 years. Only a few colleges and time and motion study promotion organizations offer programs about newly developed time and motion study techniques such as 4M and ADAM. Nevertheless, not many enterprises have adopted them (Chang, 1993; Shih, 1984).

A limited research has been done on the present use of motion and time study in the electronics industry in Taiwan. This research will investigate the extent of adoption of motion and time studies in the electronics industry. The findings of this study may help the industry, promotion organizations, colleges, and training centers to improve not only their work productivity, but also curricula and training programs for the electronics industry in Taiwan.

Statement of Problem

The major problem of this study was to investigate the relationship of selected motion and time study characteristics to the size of electronics companies in Taiwan. The secondary problem was to determine the differences in motion and time study practices, problems currently experienced, and training practices in highly productive small, medium, and large Taiwan electronics firms as compared with other electronics firms in these categories. The characteristics involved in this research included: (a) types of work measurement techniques employed; (b) company functions for which time standards applied; (c) employment of incentive wage systems; (d) person-hours involved conducting motion and time study; and (e) use of motion and time study on indirect labor.

Statement of Purpose

The purpose of this study was to investigate the characteristics of motion and time study implementation in the electronics industry in Taiwan, and the relationships of these characteristics to the size of enterprises. It was expected that the findings would contribute to the body of knowledge in motion and time study and help industry, motion and time study promotion organizations and educational and training organizations that train motion and time study analysts and develop motion and time study programs to provide curricula and programs that fit the demand of the electronics industry in Taiwan.

Statement of Need

The need for this study was based on the following information:

Taiwan has made great progress in terms of economics, industry, and social establishments in the past decades. It is now considered a "newly industrialized country" (NIC). Therefore, both the government and manufacturers hope to find ways to upgrade industry in Taiwan, particularly in the field of productivity improvement and production process design (The State of Small Business, Ministry of Economic Affairs, R. O. C., 1993). Many of the large electronics manufacturers in Taiwan have improved significantly in the areas of productivity, the working environment, and scientific management. On the other hand, a large portion of small businesses remain in traditional production conditions with very few improvements in their equipment, operation methods, and management styles. As a consequence, the Industrial Development Bureau of the Republic of China has strong concerns about improving the production and management styles of small businesses.

Cost reduction and productivity improvement are two emergent goals of the electronic industry in Taiwan (Hung, 1993). Because of the increase in direct labor cost, some of Taiwan's electronic plants have planned to transfer their operations to other countries such as the People's Republic of China and Thailand (Chou, 1990). In the period between 1972 to 1982, foreign investment in the electronics industry in Taiwan had an average growth of 6.37%. The average annual business amount of the electronics industry between 1985 to 1988 was 15.2 billion in United States dollars, which was 11.37% of the total GNP of Taiwan (Industrial Development Bureau of the Republic of China, 1990). The average growth rate of foreign investment in the electronics industry in Taiwan, however, decreased by -3.28% during 1989 to 1991 (Industrial Development and Investment Center of R.O.C., 1992).

Taiwan has been a country with limited natural resources. Therefore, human resources are a very important element for Taiwan industry. Many of the industries in Taiwan are labor-intensive operations (Council for Economic Planning and Development, 1992). Industrial production accounted for 46% of the Gross Domestic Product (GDP) in 1987, and 43.6% in 1989 (Industrial Development Bureau of R. O. C., 1990). Export is an important source of GNP in Taiwan and electronic products accounted for 25.6% of the total export amount in 1991 (Statistics Institute, 1992).

Motion and time study is a fundamental tool for industrial management. It has been applied in industry all over the world (Niebel, 1993). It is an economical way of increasing productivity compared to buying new equipment (Meyers, 1992). The outcomes obtained through motion and time study can make a significant contributions to productivity improvement. According to Sakamoto (1987), manufacturing plants applying motion and time study can reach 14% higher productivity than those without motion and time study. The electronics industry is among the three largest industries in Taiwan in terms of its contribution to the Gross National Product. It is a labor intensive industry in which many manual operations are needed. Consequently, it is particularly suitable to apply motion and time study techniques in the electronics industry (Chen, Chou, Chen, & Fu, 1991).

The electronics industry has the highest percentage of use of motion and time study among industries in Taiwan (Chen, 1992). Other researchers have shown the importance of motion and time study on the electronics industry in Taiwan. For instance, in a study involving the application of management techniques in small business in Taiwan, Chien (1988) concluded that application of motion and time study is an approach for management improvement for the electronics industry.

Five of the characteristics applied in this study were identified through a review of literature as important factors which have significant influence on the use of motion and time study in the electronics industry. These characteristics include: (a) types of work measurement techniques employed; (b) company functions for which time standards applied; (c) employment of incentive wage systems; (d) person-hours conducting motion and time study; and (e) use of motion and time study on indirect labor. The other two characteristics which were used to investigate the demand related to motion and time study in the electronics industry in Taiwan were: (a) problems with conducting motion and time study and (b) training practices and needs.

Work Measurement Systems

May and Jackson (1989) divided work measurement into two major systems; the direct measurement approach, and the standard data approach. With the direct measurement approach, the time and motion study analysts need to observe the entire operation process at the work station and measure it. Stopwatch time studies, predetermined time standard systems such as Work Factor and Method Time Measurement (MTM), as well as work sampling, are examples of direct measurement. May and Jackson (1989) further stated that direct measurement is usually applied in settings in which production occurs in high volume or a small number of operations are involved. They also indicated the standard data approach as another popularly used system. With this approach, the time and motion study analysts separate the whole operation process into smaller tasks, then they measure each different activity unit performed by workers. Each activity unit is called a standard data element. While setting time standards, industrial engineers assemble those standard data elements with varying frequencies. According to May and Jackson (1989), the standard data approach has many advantages, it is easy to use and has consistency. Furthermore, it is economical for setting standards of many different operations.

Most manufacturing plants in the U.S. and European countries use the direct measurement approach. Among the businesses that use predetermined time systems, most of those in Japan use the Work Factor system, while most of those in the U.S. and European countries use the MTM system, with simplified approaches of MTM being preferred (Sakamoto, 1987).

Company Functions for Which Time Standards are Applied

Establishing time standards is one of the most important tasks in motion and time study. Time standards have a wide usage. According to a study conducted by The Joint Working Party of the International MTM Directorate and European Federation of Productivity Services (1990), time standards can be used in planning areas such as production planning, process planning and capacity planning; they can also be used in financial areas such as cost estimation, budget control and cost accounting. Furthermore, time standards can be used in other areas such as production efficiency management and incentive wage systems.

Incentive Wage System

The establishment of incentive wage systems or payment systems is one of the most popular uses of motion and time study (The Joint Working Party of the International MTM Directorate and European Federation of Productivity Services, 1990; Niebel, 1993; Sakamoto, 1987). When time standards are set, the productivity improvement can be as high as a 42% increase from the original performance; incentive systems can improve performance with another 42% increase in productivity (Meyers, 1992).

Person-hours Involved Conducting Motion and Time Study

Motion and time study is a good approach in establishing time standards and promoting working efficiency. Some industries, however, do not use it extensively because it is costly and time consuming (Chen et al., 1991). For example, consider MTM-1, it takes 300 to 350 minutes of time to set up the time standard for each minute of performance time (Smith, 1978). Therefore, person-hours spent in conducting motion and time study have a direct affect on the successful application of motion and time study. Business size is a factor influencing person-hours spent in motion and time study with large industries tending to hire more personnel to work in this area (Chou, 1980).

Application of Motion and Time Study to Indirect Labor

The techniques of time standards can be applied to improve the efficiency of indirect labor (The Joint Working Party of the International MTM Directorate and European Federation of Productivity Services, 1990; Niebel, 1993;

Shin, Riel, & Sink, 1988). According to the study conducted by The Joint Working Party of the International MTM Directorate and European Federation of Productivity Services (1990), application to indirect labor is an important request for work measurement. Meyers (1992) further stated that motion and time study is particularly suitable for the following fields in the manufacturing plants:

> (1) material control department: time and motion study can be used to eliminate or automate moves, combine operations, reduce transporting empty, move machines closer together, etc. For instance, move part manufacturing station next to assembly line is a good example of how to eliminate moves.
> (2) quality control department: many line inspectors are usually assigned to work on assembly lines, they have tools and work stations just like other workers on line, therefore, time and motion study can be used to establish time standards for them too. (Meyers, 1992, pp. 269,270)

There are usually many employees in material control departments in manufacturing plants. In most manufacturing plant systems in Taiwan, warehouse and shipping divisions are also a part of the material control department. Therefore, the time and motion study technique can also be conducted on the indirect labor of the above departments (the material control department and the quality control department).

Research Questions

The following research questions were utilized for guiding this study:

1. How do motion and time study practices (applications and problems currently experienced) differ by business size in Taiwan's electronics industry?

2. How do motion and time study training practices (programs and needs) differ by business size in Taiwan's electronics industry?

3. What relationship, if any, exists between business size and the motion and time study practices in Taiwan's electronics industry?

4. What are the differences in motion and time study practices and related training practices in highly productive small, medium, and large Taiwan electronics firms as compared with other electronics firms in these categories?

Null Hypotheses

The following null hypotheses were formulated for this study:

1. Motion and time study practices and problems currently experienced do not significantly differ by business size in Taiwan's electronics industry.

2. Motion and time study training practices and needs do not significantly differ by business size in Taiwan's electronics industry.

3. There is no significant relationship between business size and the motion and time study practices in Taiwan's electronics industry.

4. There are no significant differences in motion and time study practices (techniques, applications, and training practices) in highly productive small, medium, and large Taiwan electronics firms as compared with other electronics firms in these categories.

Assumptions

This study was conducted with the assumptions as follows:

1. The experienced industrial engineers in the panel were capable of judging the validity of the questionnaires.

2. The Industrial Engineering Association of the Republic of China had an accurate and current listing of members.

3. The industrial engineers in the population gave honest answers on the questionnaires.

4. The language translation of the questionnaire did not affect validity and reliability.

Delimitations

The following delimitations were made with respect to this study:

1. In this study, the business size of electronics companies was classified by number of employees. The amount of capital, assets, and annual sales were not used in classification of the business size.

2. The characteristics of the use of motion and time study utilized in this study were limited to: (a) types of work measurement techniques employed; (b) company functions for which time standards applied; (c) employment of incentive wage systems; (d) person-hours involved conducting motion and time study; and (e) use of motion and time study on indirect labor.

3. The types of work measurement techniques included in this study consisted of stopwatch time study, MTM-1, MTM-2, Work Factor, standard data method and computerized predetermined time system only.

4. The categories of indirect labor included in this study involves: (a) in process quality control personnel, (b) quality control personnel other than quality control personnel, (c) material handling personnel, (d) material control personnel other than material handling personnel, (e) clerical personnel, and (f) management only.

5. Only members of the Industrial Engineering Association of the Republic of China were included in the survey to the general electronics firms group.

6. The population for the survey to the general electronics firms group in this study consisted of members of the Industrial Engineering Association of the Republic of China whose present job was in the field of motion and time study in the electronics industry in Taiwan.

7. Only electronics firms on the list of The Top 1000 Manufacturers in Taiwan, which was in the July 1993 issue of Business Weekly (Taiwan), were included in the telephone interview and the survey to the highly productive electronics firms group.

8. This study was limited to the implementation of motion and time study in Taiwan's electronics industry.

Limitations

1. The questionnaire and telephone interview depended upon self-reported and subjective perceived information.

2. The results of this study were limited in use to the Taiwan area or areas with similar economic environment and culture background.

Definition of Terms

The following terms are defined to clarify their use throughout this study:

Cost estimation: "A cost estimation is a forecast of direct labor and direct material required for a design" (Salvendy, 1982, p. 9.2.1).

Incentive wages: "Incentive wages are a means of automatic financial supervision for both labor and management. They tend to reward the more productive workers in proportion to their output" (Mundel, 1985, p. 52-53).

Line balancing: "The balancing of operations in terms of equal times and in terms of the time required to meet the desired rate of production" (Muther, 1971, p. 11.96).

Method study: "Method study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs" (International Labour Office, 1979, p. 79).

Methods-time measurement (also refereed to MTM or MTM-1): Methods-time measurement is a procedure which analyzes any manual operation or method into the basic motions required to perform it and assigns to each motion a predetermined time standard which is determined by the nature of the motion and the conditions under which it is made. (Schwab, 1971, p. 5.21)

Motion and time study: Motion and time study is the systematic study of work systems with the purposes of (1) developing the preferred system and method--usually the one with the lowest cost; (2) standardizing this system and method; (3) determining the time required by a qualified and properly trained person working at a normal pace to do a specific task or operation; and (4) assisting in training the worker in the preferred method. (Barnes, 1980, p. 6)

Motion study: The motion study aspect consists of a wide variety of procedures for the description, systematic analysis, and improvement of work methods, considering (a) the raw materials; (b) the design of the outputs; (c) the process or order of work; (d) the tools, workplace, and equipment for each step in the process; and (e) the human activity used to perform each step. The aim is to determine a preferable work method. (Mundel, 1985, p. 2)

MTM-2: "A system of synthesized first-level MTM data" (Mattern, Knott, & McDonald, 1971, p. 5.115).

Work Factor: "Work Factor is an elemental time system for compiling time standards to establish the expected productivity of the human when performing useful manual and mental work" (Quick, Duncan, & Malcolm, 1971, p. 5.65).

Work measurement: "Work measurement is the application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance" (International Labour Office, 1979, p. 33).

> Predetermined time system (PTS): A predetermined time system (PTS) is a set of organized data for first-order work-unit standard times, representing some consistent and known concept of standard performance, together with the rules and conventions for computing and documenting a task standard time from these data. (Mundel, 1985, p. 396)

Standard data: "A list of the elements of work required to perform an activity and allowed times for performing them" (Crossan & Nance, 1972, p. 137).

> Standard time: A standard time is a function of the amount of time necessary to accomplish a unit of work:
> (1) Using a given method and equipment.
> (2) Under given conditions of work.
> (3) By a worker possessing a specified amount of skill on the job and a specified aptitude for the job.
> (4) When working at a pace that will utilize, within a given period of time, the maximum physical exertion such a worker could expend on such a job without harmful effects. (Mundel, 1985, p. 68)

> Stopwatch time study: A stopwatch time study is a work measurement technique for recording the times measured by a stopwatch and rates of working for the elements of a specified job carried out under specified conditions, and for analyzing the data so as to obtain the time necessary for carrying out the job at a defined level of performance. (International Labour Office, 1979, p. 205)

> Time study: Time study is often referred to as work measurement. It involves the technique of establishing an allowed time standard to perform a given task, based on measurement of the work content of the prescribed method, with due allowance for fatigue and for personal and unavoidable delays. (Niebel, 1993, p. 7)

The operational definitions used in this study were:

Highly productive firms: Highly productive firms in this research were selected from the list of "The Top 1000 Manufacturers in Taiwan" which was in the July 1993 issue of Business Weekly (Taiwan). The criteria this writer used to select the productive firms were dependent on the amount of total sales divided by the number of employees. The firms being selected were on the top half of the "Sales/number of employees" list.

Large electronics companies: Electronics companies with more than 1000 employees.

Medium size electronics companies: Electronics companies with an amount of employees between 200 to 999.

Small electronics companies: Electronics companies with less than 200 employees.

Indirect labor: The categories of indirect labor included in this study involves: (a) in process quality control personnel, (b) quality control personnel other than quality control personnel, (c) material handling personnel, (d) material control personnel other than material handling personnel, (e) clerical personnel, and (f) management only.

Statement of Methodology

The methodology used for this study was as follows:

1. The nature of the research was correlational research.

2. The data collection of this study contains three parts: (a) the first step survey on general firms--questionnaire survey on the members of the Industrial Engineering Association of the Republic of China, (b) the second step survey--questionnaire survey on 15 highly productive electronics firms, five in each of the large, medium and small firms categories, and (c) telephone interviews on six highly productive Taiwan electronics firms, two in each of the large, medium and small firms categories.

3. The population of the first step survey was members of the Industrial Engineering Association of the Republic of China whose present position was in the field of motion and time study in the electronics industry. The population contained 252 industrial engineers, and the entire population was included as subjects.

4. A two-part questionnaire was designed. Part one was designed to investigate the characteristics in use of motion and time study and the problems with conducting motion and time study. The selected characteristics included (a) types of work measurement techniques employed;

(b) company functions for which time standards applied; (c) employment of incentive wage systems; (d) person-hours involved conducting motion and time study; and (e) use of motion and time study on indirect labor. Part two was intended to obtain information about training practices and needs related to motion and time study.

5. The questionnaire was designed and translated into Chinese, and then sent to five experienced industrial engineers for pilot testing. These five experienced engineers reviewed the questionnaire for correctness in translation and appropriate content, then the questionnaire was revised according to their opinions. After the revision, the questionnaires were sent back to these five industrial engineers for a second review.

6. After completing the pilot tests, the questionnaires were sent to members of the Industrial Engineering Association of the Republic of China, who were currently working in the motion and time study area in the electronics industry.

7. Two weeks later, a follow-up letter was sent to those who did not respond.

8. The following statistical processes were used to analyze the data collected:

a. Chi-square test was used to analyze the group frequencies.

b. Spearman's correlation coefficients were used to determine the relationship of the characteristics of the use of time and motion study to the business size.

9. The population of the second step survey contains industrial engineers of 15 highly productive electronics firms in Taiwan. Five of the highly productive firms in each of the small, medium, and large Taiwan electronics firms categories were selected from the electronics firms on the list of The Top 1000 Manufacturers in Taiwan, which was published in the July 1993 issue of Business Weekly (Taiwan) (1993). The total number of the selected highly productive firms was 15. A letter was sent to each of the 15 firms to inquire if it would like to be included in the survey of the implementation of motion and time study of the highly productive electronics firms. If there were any firms responding that it did not wish to be included in this survey, another highly productive firm in that exact category (small, medium, or large firms) was selected.

10. The questionnaires of the same form as the first survey were sent to each of the 15 firms to investigate the implementation of motion and time study in highly productive small, medium, and large Taiwan electronics firms.

11. The results of the survey on highly productive electronics firms were compared with the results of the

first step survey on the Industrial Engineering Association members who were working for the general electronics firms to determine the differences in motion and time study practices and related training practices.

12. Two of the highly productive firms in each of the small, medium, and large Taiwan electronics firms categories were selected from a list of nominations made by the China Productivity Center, Metal Industry Development Center, Taipei Institute of Technology and Taiwan Industrial Technology College. A telephone interview was conducted on each of the six electronics companies focusing on their motion and time study practices and related training practices.

Subsequent Chapters

This dissertation contains five chapters. Chapter two involves a review of the literature related to research methodology and the motion and time study. The research procedures of this study are included in chapter three. Chapter four reports the findings of the study. The summary, conclusions, and recommendations are contained in chapter five.

CHAPTER II

REVIEW OF LITERATURE

This review of literature emphasized the development and implementation of motion and time study techniques. The background of Taiwan's electronics industry is also included. Content presented in this chapter provides an overview regarding: (a) an introduction of motion and time study, (b) the development of motion and time study, (c) the electronics industry in Taiwan, (d) related research, (e) characteristics related to motion and time study implementation, and (f) research procedures.

Introduction of Motion and Time Study

Motion and time study deals with all the operational tasks (Chen, 1976). It is the foundation of industrial management programs and is being used by industries all over the world to decide the method and the time needed to reach optimum productivity and efficiency (Czajkiewicz & Issa, 1987). Lambert (1987) also indicated the importance of motion and time study in the future for maximizing productivity and competitiveness.

The purpose of motion and time study is to look for the most economical, effective and pleasant methods and time for conducting a task to ensure optimum utilization of manpower, material, and other resources in order to increase productivity and lower the cost (Chen et al., 1991; Rae, 1966). It can create a cost consciousness which provides engineers and managers a competitive advantage over all other engineers and managers in their industries (Meyers, 1992). Meyers (1992) further stated that the goals for motion and time study include:

> 1. to set fair and equitable time standards for the company and the employees.
> 2. to have full time standards coverage
> 3. to promote productivity
> 4. to develop motion economy and cost consciousness in all employees, both labor and management.
> 5. to develop time standards for indirect labor such as set-up , material handling, quality control, rework, distribution, data processing , filing, etc.
> 6. to develop standard data. Because standard data is faster, more accurate, and easier to explain than any other method of setting time standards.
> 7. to teach employees and supervisors techniques of motion and time study.
> 8. to prepare technologists for supervisory positions.
> 9. to continually expand ones knowledge of company's technology and to become the expert in manufacturing methods, machines, techniques, and time standards.
> 10. to be ready to serve whenever asked and to be ready with the answer in ones area of expertise. (p. 289)

In many countries other than the United States, the term "work study" is also used to identify motion and time study. The International Labour Office (1979) reported that work study was known as "time and motion study" for many years, but with the development of work study technique and its application to a very wide range of activities, many people felt that the term "time and motion study" was too narrow and insufficiently descriptive. "The term 'work study' entered the English language only after the Second World War, but it is now generally accepted; 'motion and time study' is, however, still used in the United States" (International Labour Office, 1979, p. 36).

Development of Motion and Time Study--Some Important Individuals

In the period since the nineteenth century to the early twentieth century, many pioneers such as Frederick W. Taylor, Frank and Lillian Gilbreth, Henry L. Gantt and Harrington Emerson introduced and developed the concepts and many principles in scientific management (Karger & Bayha, 1987; Nadler, 1955; Polk, 1984; Wang, 1964). One of their important achievements was the establishment of the bases for motion and time study.

The first time study was conducted on the manufacture of No. 6 common pins by Jean Rodolphe Perronet, a French engineer, in 1760. Then, in 1820, Charles W. Babbage, an English economist, also made time studies on No. 11 common pins (Niebel, 1993). The most famous figure, however, in the historical development of motion and time study was Frederick Winslow Taylor. Taylor is generally referred to as the father of time study. In 1881, Taylor began to measure his worker's performance with a stopwatch at Midvale Steel Company in Philadelphia (Karger & Bayha, 1987; Lee, 1971; Meyers, 1992; Nadler, 1955). He also set up standard production times from performance records in the past. He believed that the operator's best effort could be acquired only with "wages based on output" (Polk, 1984, p. 6). He carried out a number of experiments involving improving work efficiency and advocated incentive and piece rate wage systems (Fogarty, Hoffmann, & Stonebraker, 1989; Taylor, 1967). Moreover, he presented and published many of his findings. Taylor made a great contribution to the area of time study, but his greatest achievement was publicizing the concepts of scientific management. He is unquestionably the most prominent historical character in the development of time study (Barnes, 1980; Chang, 1993; Niebel, 1993).

Henry Laurence Gantt had experience working together with Taylor at Midvale and Bethlehem Steel Companies. Their cooperation, however, did not last long because Henry L. Gantt did not agree with Taylor's approaches to industrial management. Then Gantt developed a concept emphasizing the major importance of the human element. He is remembered for originating the concept of the task and bonus wage system (Niebel, 1993; Polk, 1984). Gantt's and Taylor's viewpoints on management were similar in many respects. Taylor, however, paid primary attention to the "analysis and organization of the work in solving problems" (Polk, 1984, p. 9) while Gantt emphasized the persons who were doing the work.

Frank B. Gilbreth and his wife Lillian M. Gilbreth have been the most well known people in the history of motion study. The Gilbreths generated many principles and techniques in the field of motion study, which were widely accepted and utilized by industry all over the world (Chang, 1972; Meyers, 1992). They are known as the founders of motion study. The two important theories they developed were: (a) the seventeen basic elements common to all human operations, which were named "therbligs" and (b) the principles of motion economy. The original 17 therbligs developed by the Gilbreths include (a) Search, (b) Select, (c) Grasp, (d) Transport Empty, (e) Transport Loaded, (f) Hold, (g) Release Load, (h) Position, (i) Pre-Position, (j) Inspect, (k) Assemble, (l) Dissemble, (m) Use, (n) Unavoidable Delay, (o) Avoidable Delay, (p) Plan, and (q) Rest for Overcoming Fatigue (Karger & Bayha, 1987, p. 8).

The foundation of motion economy includes "eliminating the movement, or reducing the extent of the movement, and combining movements in the most economic sequences" (Holmes, 1940, p. 63). The principles of motion economy the Gilbreths specified concerned hand motions (Niebel, 1993). Additionally, other researchers in the field of motion and time study also had contributions which expanded the list that the Gilbreths initiated (Barnes, 1980; Close, 1960). Those principles of motion economy which evolved were:

> 1. Both hands should begin and end their basic divisions of accomplishment simultaneously and should not be idle at the same instant, except during rest periods.
> 2. The motions made by the hands should be made symmetrically and simultaneously away from and toward the center of the body.
> 3. Momentum should be employed to assist the worker wherever possible, and it should be reduced to a minimum if it must be overcome by muscular effort.
> 4. Continuous curved motions are preferable to straight-line motions involving sudden and sharp changes in direction.
> 5. The least number of basic divisions should be used, and these should be confined to the lowest practicable classifications. These classifications, summarized in ascending order of the time and fatigue expended in their performance, are:
>   a. Finger motions.
>   b. Finger and wrist motions.
>   c. Finger, wrist, and lower arm motions.
>   d. Finger, wrist, lower arm and upper arm motions.
>   e. Finger, wrist, lower arm, upper arm and body motions.
> 6. Work that can be done by the feet should be arranged so that it is done simultaneously with work being done by the hands. It should be recognized, however, that it is difficult to move the hand and foot simultaneously.
> 7. The middle finger and the thumb are the strongest working fingers. The index finger, fourth finger and little finger are not capable of handling heavy loads over extended periods.
> 8. The feet are not capable of efficiently operating pedals when the operator is in a standing position.
> 9. Twisting motions should be performed with the elbows bent.
> 10. To grip tools, the segments of the fingers closest to the palm of the hand should be used.
> 11. Fixed locations should be provided for all tools and material so as to permit the best sequence and to eliminate or reduce the therbligs search and select.

12. Gravity bins and drop delivery should be used to reduce reach and move times; also, wherever possible, ejectors to remove finished parts automatically should be provided.

13. All materials and tools should be located within the normal working area in both the vertical and the horizontal plane.

14. A comfortable chair should be provided for the operator and the height so arranged that the work can be efficiently performed by the operator alternately standing and sitting.

15. Proper illumination, ventilation, and temperature should be provided.

16. The visual requirements of the workplace should be considered so that eye fixation demands are minimized.

17. Rhythm is essential to the smooth and automatic performance of an operation, and the work should be arranged to permit an easy and natural rhythm wherever possible.

18. Multiple cuts should be taken whenever possible by combining two or more tools in one, or by arranging simultaneous cuts from both feeding devices, if available.

19. All levers, handles, wheels, and other control devices should be readily accessible to the operator and should be designed so as to give the best possible mechanical advantage and to utilize the strongest available muscle group.

20. Parts should be held in position by fixtures.

21. The use of powered or semiautomatic tools, such as power nut and screwdrivers and speed wrenches, should always be investigated. (Niebel, 1993, p. 206-207)

The Gilbreths' studies addressed the influence of equipment, tools, material and human factors and also undertook the study of fatigue as well as assisting the handicapped in becoming more mobile (Lee, 1971). Furthermore, they developed motion study techniques such as the process chart, micromotion study, cyclegraphic analysis, and chronocyclegraphic analysis techniques (Chen et al., 1991; Niebel, 1993). The predetermined time standard system we use today is built on the work of the Gilbreths.

In the early 20th century, Harrington Emerson successfully applied the rules of scientific working methods to operations when he worked for Santa Fe Railroad Company. Emerson's philosophy was "efficiency everywhere and in everything" (Niebel, 1993, p. 14). In 1911, he expanded his ideas and wrote a book, Twelve Principles of Efficiency, which became a good guide to management at that time (Karger & Bayha, 1987; Niebel, 1993).

During the Second World War period, Franklin D. Roosevelt advocated implementing motion and time study and establishing time standards through the Department of Labor (Niebel, 1993). This, just as expected, increased productivity. It also popularized the application of motion and time study.

Related Research

Sakamoto Study

In 1987, Sakamoto completed an international study to investigate the use of motion and time study in industries in the United States, European countries, Japan and some Asian countries. The major factors in Sakamoto's model included the uses of time standards, business size of industries, work measurement techniques being used, incentive wage systems, effective planning for productivity improvement and industrial engineering activities.

The relationship between the business size and the application of motion and time study was one of the factors in Sakamoto's study. Results of this study demonstrated a significant positive correlation between the business size and the application of motion and time study. The percentage of the application of motion and time study in industries in the United States and European countries was reported to be higher than those of Japanese industries with the same business size. An average of 79% of European and American industries involved in the study applied motion and time study while only 39% of Japanese industries employed it. It was reported that the percentage of companies applying motion and time study was increasing compared with 1975.

Sakamoto indicated that the application of time standards in various areas in a company--such as manufacturing schedule, cost estimation and performance control areas--was one of the reasons for the employment of motion and time study. Nevertheless, it is common in Japan that different departments in industries use different standards, and this phenomenon obstructs the application of motion and time study.

Sakamoto reported the uses of time standards as follows:

1. In the planning area, 67% of the respondents in Japan, and 57% in Europe/U.S.A. applied time standards to capacity planning; 62% of the respondents in Japan, and 57% in Europe/U.S.A. applied time standards to production planning; while 44% of the respondents in Japan, and 41% in Europe/U.S.A. applied time standards to manufacturing process planning.

2. In the financial area, 72% of the respondents in Europe/U.S.A. and 67% in Japan applied time standards to cost accounting; 55% of the respondents in Japan, and 36% in Europe/U.S.A. applied time standards to cost estimation; while 50% of the respondents in Europe/U.S.A. and 35% in Japan applied time standards to budget control.

3. Forty percent of the respondents in Europe/U.S.A. and 4% in Japan applied time standards to incentive wage systems.

Sakamoto indicated that one third of the companies in European countries and the United States regard "adoption of proper productivity measurement techniques" as an important factor affecting productivity improvement. Other factors that were reported affecting productivity improvement included cooperation between labor and management, making workers understand productivity improvement measures, design improvement and adoption of proper new technology. It was also reported that there was an enormous difference between Japan and Europe/U.S.A. in employment of incentive wage systems. Ninety eight percent of the industries in European countries and the United States employed incentive wage systems, while only 7% of the Japanese industries involved in this study employed them.

Sakamoto's study was an international survey covering industries in countries in Europe, North America, and Asia. In addition, Taiwan had a similar background to Japan in regard to social and industrial development (Chou, 1990). Sakamoto's model should be suitable for use with industries in Taiwan.

Cozens Study

Cozens (1988), a senior lecturer in management studies in Nene College in the United Kingdom, conducted a study in the Northamptonshire area to investigate the trend of motion and time study in private and public industries in order to plan future course strategy. The 12 industries involved in the study include electronics, engineering, shoes, furniture, local government, water, gas, electricity and the health service. The three techniques primarily used in both private and public industry sectors were stopwatch time study, activity sampling, and synthesis. This study indicated that stopwatch time study was the most popular technique for measuring direct labor in the past, while stopwatch time study and synthesis were equally being used in 1988. The use of stopwatch time study had decreased "because the measurement of direct work has reached the point where only maintenance time study is necessary, but the use of synthesis has increased and this is seen as a logical movement because a mass of time study elemental data is available together with the wider use of computers . . . " (Cozens, 1988, p. 21). It was reported that the predetermined time system was another significant work measurement technique utilized by the public industries involved in the study.

Cozens reported that the rapid growth of the computer had increased the application of motion and time study. Public industries plan to carry out more indirect labor work measurement on office work in the future than private industries. On the other hand, economic pressure was the main reason for the industries to use motion and time study. Union pressures were also an important reason, but principally for public industries involved in the study. This study concluded that work measurement would continue to make significant contributions to productivity in industries in Northamptonshire area.

Study by the Joint Working Party of the International MTM Directorate and European Federation of Productivity Services

A study was conceived and commissioned by the Joint Working Party of the International MTM Directorate (IMD) and European Federation of Productivity Services (EFPS) (1990). The purpose of the study was to investigate the present use of work measurement and assess the possible future development corresponding to the rapid change in technology. EFPS and IMD sent questionnaires to 58 companies in the United States, European and Asian countries. Visits to a small number of companies were undertaken after the questionnaire survey. Significant results included:

1. Most of the companies responded that work measurement was an effective technique to provide information for the purposes of planning and control.

2. As manufacturing technology moved toward computer-aided and flexible manufacturing systems, as well as the need for preproduction planning, the work measurement systems needed to be correspondingly flexible, and extended to new products.

3. Much of the respondents expressed their need for work measurement which could deal with the indirect work.

4. Every country in the survey declared the necessity of computerized systems, so they could apply and update measurement data easier and faster.

5. A number of the companies responded that some managers were not aware of the range and nature of work measurement techniques currently available.

6. Many companies in Sweden replied that labor turnover was a big problem.

7. The United Kingdom had a broad application of motion and time study for manual workers. A large portion of the development of measurement systems in the United Kingdom were in the field of clerical systems and the computerization of measurement techniques.

8. Work measurement systems needed to be improved to meet the needs of the practitioners. Managers needed to be required to realize the benefits from a good work measurement program.

Most companies involved in this survey hoped time study could provide information about productivity management, development of production system, planning of production and material, cost control, as well as capacity management and planning. It was reported that many companies responded that managers needed to be educated to comprehend the real benefits that could be acquired from a good motion and time study program. They also expressed the hope that managers would have the ability to evaluate their needs for particular types of work measurement systems.

In summary, all of the three studies reported that motion and time study was widely utilized and would continue to make meaningful contributions to productivity in industry. The studies also indicated the trends of motion and time study such as the use of computerized work measurement techniques and the application of motion and time study on indirect labor. The results of Sakamoto's study revealed a significant positive correlation between the business size and the application of motion and time study. Moreover, he stated that the application of time standards in various areas in a company, such as manufacturing schedule and cost estimation, is one of the reasons for the employment of motion and time study.

Characteristics Related to Motion and Time Study Implementation

The literature regarding characteristics related to motion and time study implementation is reviewed in this section. It consists of (a) work measurement techniques which include stopwatch time study, predetermined time systems (Methods-Time Measurement system and Work Factor system), computerized work measurement systems, and standard data system), (b) application of time standards to indirect labor, (c) incentive wage system, (d) usage of time standards, and (e) person-hours involved conducting motion and time study.

Work Measurement Techniques

Stopwatch Time Study

Stopwatch time study had been historically one of the most popular techniques used for establishing time standards (Rotroff, 1959). The procedures by which an industrial engineer using to conduct a stopwatch time study would be as follows:

1. Divide the standard operation into several units of activities.

2. Measure the time taken to perform the task with a stopwatch and record it.

3. Make a rating of the worker's performance according to his/her working pace.

4. Transform the observed times to "normal times" by the calculation:

$$\text{Normal Time} = \text{Average observed Time} \times \frac{\text{Average Rating}}{100}$$

5. Determine the allowances for the normal time for the operation, allowances include personal time, delays, and fatigue.

6. Compute the standard time by the following calculation:

Standard Time = Normal Time + Time for allowances (International Labour Office, 1979; Lu, 1983)

Performance rating is likely the most difficult and the most critical part of a stopwatch time study. Therefore, Das (1982) recommended training programs for time study analysts to improve the consistency and accuracy in rating operators' performance. Smith (1978) stated two points to be noticed while stopwatch time studying: (a) the analyst must judge if the operation is in a stable situation; (b) the analyst must validate that the workers who are being studied know the proper working method and "have sufficient skill, ability, and practice for the job" (p. 48). The International Labour Office (1979) further indicated that a good relationship between time study analysts and the management, the foremen, as well as the workers must be established before the time study is conducted.

Predetermined Time Systems

The first mention of Predetermined Time Systems was in Manufacturing Industry, by Segur in 1927. Neale (1967) stated the basic concept of all predetermined time systems: with sufficient practice, every single worker can perform the same motion in a constant period of time; the variations in the time required are very small for different workers.

This concept has led to the developments of various predetermined time systems. Predetermined time systems have great utility in repetitive short-cycle operations (Hicks, 1977).

The Work-Factor system and Method-Time Measurement are among the most popularly used predetermined time systems (Lu, 1983; Polk, 1984). According to Mundel (1985), the publication of the Method-Time Measurement system by H. B. Maynard, G. J. Stegemerten, and J. L. Schwab in 1948 was the first general disclosure of predetermined motion time data. After 1970, the MTM family which included MTM-2, MTM-3, MTM-C and MTM-V were presented (Ramcharan & Martin, 1988). Sakamoto (1987) found from his study that Work Factor was the most popularly used predetermined time system technique in European countries while MTM prevailed in the United States.

Methods-Time Measurement System. The Methods-Time Measurement (MTM) system was generated from motion picture studies of industrial operations (Barnes, 1980). It is "a technique that breaks any manual task into the basic motions required to perform it and judges the conditions under which each motion will occur, then sums the appropriate predetermined times for all of the basic motions involved" (Dilworth, 1983, p. 573). MTM has significant value not only for improving existing manufacturing methods, but also when setting up operation process before production is started (Rotroff, 1959). The unit of time used in MTM system is referred to as a time-measurement unit (TMU). One TMU equals 0.00001 hour, or 0.0006 minute (Polk, 1984). Polk further stated that the motions used in operation were classified into different categories. The classification of motions and their notations are as follows:

> 1. Reach (R): Reach is the movement of the hand to a desired destination.
> 2. Move (M): Move is the movement of the hand when the purpose is to transport an object to a desired destination.
> 3. Turn (T): Turn is the path traced by the hand either empty or loaded with an object by a movement that rotates the hand, wrist, and forearm around the long axis of the forearm.
> 4. Apply Pressure (AP): Apply pressure is the application of muscular force not greater than the object's resistance to motion.
> 5. Grasp (G): Grasp includes the movements required to sufficiently secure control of an object so that it may be held or moved as intended.
> 6. Position (P): Position movements are those required to bring objects into an exact relation with an environment.
> 7. Release (RL): Release is the basic movement required to relinquish control of an object by the fingers or hand.
> 8. Disengage (D): Disengage is the basic movement required to break contact between two objects.
> 9. Eye Travel (ET) and Eye Focus (EF): Eye travel is the movement of the eyes between two points of focus; eye focus involves using the eyes to direct the movement of a body member or to check the characteristics of an object without moving the eyes from the object.
> 10. Body, Leg, and Foot Motions. (Polk, 1984, p. 192, 193, 196)

Karger and Bayha (1987) noted that the operation methods can be described accurately and time standards will be consistent for different jobs if the MTM system is being employed; the engineers have to design equipments and operation methods on a scientific basis, and the importance of operation methods is stressed. Engineers can set up the time standards before production; it therefore makes possible the development of more accurate cost estimation and production planning. Moreover, grievance cases can be judged on a fact basis.

Genaidy, Agrawal, and Mital (1990) indicated that the steps in the application of MTM-1, MTM-2, and MTM-3 are as follows:

> 1. observe the operation;
> 2. document detailed information about the operation;
> 3. analyze the operation to identify and classify all the motions or motion sequences required for performing the operation and to account for right and left motions made simultaneously; in case of simultaneous motions the greater time of the two is used;
> 4. record the motions using the proper MTM conventions for the system being used and document them on the MTM activity analysis form;
> 5. assign time values to the motions by entering the proper times from the MTM data card;
> 6. add up the time values to obtain the total time required for the operation studied;
> 7. add the required allowances;
> 8. validate and apply the standard. (p. 572)

MTM was designed for measuring repetitive short cycle time operations. According to Smith (1978), MTM-1 is seldom applied for operations with cycle times much longer than one minute. It takes 300 to 350 minutes of time to set up the time standard for one minute operation time in using MTM-1. MTM-2 and MTM-3 are for applications which need less precision. MTM-2 uses only nine categories of motions which are combinations of MTM elements. The application times of MTM-2 are about 150 minutes per minute of operation time.

Work Factor System. The Work Factor System was developed by Quick and Shea, and released to the public in 1945; it was one of the first developed predetermined time systems, which was widely utilized by industries (Barnes, 1980; Neale, 1967). Neale indicated that the majority of the data was obtained by using stopwatches reading in one thousandth of a minute. Those very short and complex motions they studied were taken by 16mm cameras and photo-electric timers. Barnes further stated that four primary variables used in the Work-Factor System were: (a) body member used; (b) distance moved (in inches); (c) the manual control required; and (d) the weight or resistance involved (in pounds). Standard elements recognized in Work-Factor system included "Transport (Reach and Move)(TRP), Grasp (GR), Pre-position (PP), Assemble (ASY), Use (Manual, Process, or Machine Time)(US), Disassemble (DSY), Mental Process (MP), and Release (RL)" (Barnes, 1980, p. 367, p. 373). Barnes also indicated other notations employed by Work-Factor System as follows:

1. Symbols for body members include F (Finger), H (Hand), A (Arm), FS (Forearm Swivel), T (Trunk), FT (Foot), L (Leg), and HT (Head Turn).

2. Symbols for Work-Factors include W (Weight or Resistance), S (Directional Control or Steer), P (Care or Precaution), U (Change Direction), and D (Definite Stop).

Computerized Work Measurement Systems

The Joint Working Party of the International MTM Directorate and the European Federation of Productivity Services (1990) indicated that the current application of most computerized work measurement systems serves as a tool to speed up the formerly manual processes. Today, there are mainframe computers suitable for multidivision organizations, minicomputers for single plant organizations, and microcomputers of which the storage capacity is adequate for handling extensive standard data work measurement systems (Karger & Hancock, 1982). The Joint Working Party of the International MTM Directorate and the European Federation of Productivity Services (1990) further stated that with the great achievements being made on data storage and processing capability, computers can provide innovative approaches to solve the problems in the field of motion and time study, and also much more information which was unavailable previously (The Joint Working Party of the

International MTM Directorate and the European Federation of Productivity Services, 1990, p. 632).

The computerized work measurement systems were being developed as the computer grew rapidly in the past decades. Today, there are a variety of sizes and complexities of computers to fit different demands of industries since the advancement of technology (Karger & Hancock, 1982). The available computerized work measurement systems include 4M (Micro-Matic Methods and Measurement, a computerized version of MTM-1), ADAM (Automated Data Application and Maintenance), Computer MOST (Maynard Operation Sequence Technique), WOCOM II, and MODAPTS (Modular Arrangement of Predetermined Time Standards) (Genaidy et al., 1990). Karger and Hancock (1982) indicated the features of some of the computerized work measurement systems, among these, the MOST work measurement system can be used for any cycle length and repetitiveness; the WOCOM system provides automated application of both MTM and Work Factor predetermined time standard systems, WOCOM can meet needs of different companies, while previous experience in computer is not required; the ADAM system, which was the first predetermined time system developed for the microcomputer, can increase the speed of application and the accuracy of the work measurement technique can be maintained at the same time.

The use of computerized work measurement will be the trend in the coming decade (Niebel, 1993). All countries involved in the study conducted by the Joint Working Party of the International MTM Directorate and European Federation of Productivity Services (1990) expressed the need for computerized systems to make the application of measurement data easier and faster. The application of computerized work measurements make it feasible to increase the coverage of measured work in manufacturing plants because it is much more rapid to develop standards with computers than manually (Niebel, 1993). Other advantages of using computers to develop standards are that it can offer more accurate standards, and improve standards maintenance. Niebel further stated that the computer-based systems operate as follows:

> 1. Methods engineering develops a workstation layout and motion pattern.
> 2. Methods engineering also identifies the proposed methods in detail by an elemental breakdown.
> 3. A computer program retrieves the description of each element, identifies the normal elemental times, extends the elemental times by frequencies, applies allowances, and computes the allowed time for the operation.
> 4. The system prepares all associated reports.
> 5. A computer operator enters the operation time and description into a permanent file for future use and maintenance. (Niebel, 1993, p. 710-711)

Standard Data System

Standard data is generally referred to "a list of the elements of work required to perform an activity and allowed times for performing them" (Crossan & Nance, 1972, p. 137). The motion and time study analysts need not undergo time study for each operation if they use the standard data method. Therefore, many industries choose to use this approach because it is economical. Developing standard data involves an eight-step procedure as follows: (a) conduct activity analysis, (b) establish elements, (c) develop and/or collect elemental standard times, (d) design work sheet, (e) develop task times, (f) test and refine data, (g) develop allowances, and (h) prepare a work management manual (Mason, 1992, p. 4.119-4.120).

There are two kinds of standard data which are commonly used, namely universal standard data and standard data for job families (Buffa, 1983). Universal standard data offer time values for basic types of motions; therefore, a motion and time study analyst can break down a task into motions needed to perform the operation, and then sum up all the time value to determine the time required to perform the task. Generally, universal standard data are applied together with other work measurement techniques such as stopwatch time study. Standard data for job families, on the other hand, offer normal time values for all the major elements of tasks. While using this standard data method, the analysts add the normal cycle time derived from the standard data, plus the allowances for fatigue, delays and personal time to obtain final operation standard times (Buffa, 1983; Mason, 1992).

Application of Time Standards to Indirect Labor

It is possible for the work measurement system "to be able to cope with the indirect work associated with the manufacturing system" (The Joint Working Party of the International MTM Directorate and the European Federation of Productivity Services, 1990, p. 632). For example, Sink and Rossler (1987) reported that TOPS (The One Page Management System) is a measurement system useful in white collar settings. On the other hand, Niebel (1993) stated that it is hard to study and determine time standards for most indirect labor operations because of their nonrepetitive tasks characteristic. The indirect labor area, however, usually offers a great potential for reducing costs through motion and time study since "a much greater proportion of workers today perform servicing or monitoring functions as equipment designs reach higher and higher levels of automation" (Hicks, 1977, p. 74). There are many advantages for application of motion and time study and establishment of time standards to indirect labor area. The working methods must be standardized and improved before the employment of motion and time study, and needless procedures can be eliminated in this stage (Hodson & Mayo, 1992). The labor loads can be estimated and the efficiency of different indirect labor work can be concluded through motion and time study. Moreover, employees in various industries will need less supervision and it will become possible to set up an incentive wage systems on indirect labor, because the nature of work standards programs tends to enforce itself (Niebel, 1993).

Standard data were more suitable for indirect work such as maintenance and office work than for production operations, in view of the diversification of indirect labor operations (Meyers 1992; Niebel, 1993). Developing standard data to preprice all indirect operations is very costly where maintenance and other indirect operations are numerous and diversified. Therefore, some engineers have sought to develop universal indirect standards. The three principal considerations in introducing a universal indirect labor system are:

> 1. Determination of the number of standards to do a satisfactory job.
> 2. Determination of the numerical standard representative of each group of operations contained in each slot.
> 3. Assignment to the appropriate slot of indirect labor work as it occurs. (Niebel, 1993, p. 695)

Lambert (1987) predicted that motion and time study may move into some new fields--measuring the activities and efficiencies of indirect labor and management as well as examining service functions.

Incentive Wage System

An incentive wage system is designed to encourage employees to perform above standard (Evans, Anderson, Sweeney, & Williams, 1990). In other words, employees will be rewarded if their performance exceeds the standard. Evans et al. (1990) also indicated that incentive wage systems are ways "to improve productivity without high capital investment, reduce costs, increase morale, and improve supervisory effectiveness" (Evans et al., 1990, p. 464). Meyers (1992) indicated that the goals of incentive wage systems are to: (a) reduce cost, need of supervision, as well as delays and waiting time; (b) increase productivity, employee earnings, as well as plant and machine utilization; (c) improve employee morale, labor/management relations or customer service; and (d) develop motion consciousness and cost consciousness.

An incentive wage system is an effective tool to improve productivity. Consequently, it can help industries to maintain competition in the world market. According to Smith (1978), the employees who are paid day work usually perform at approximately 60% to 90% rate of time standard. Today, in the United States, for example, only approximately 25% of manufacturing employees are on incentive wage system. The improvement in productivity could be remarkable if the percentage of employees on incentive were doubled in the next decade. Hicks (1977) also indicated that if a manufacturing plant applied an incentive plan, the output would increase 30% to 35%.

Motion and time study--especially the work measurement part--can strongly influence the application of incentive wage plans (Krick, 1962). Therefore, the consistencies of the time standards should be focused.

The incentive wage systems include both individual incentive plans and group plans. In individual plans, the compensation is decided according to each employee's performance, while group plans are applicable to two or more operators working as a team. Industry prefers to use individual incentive plans because (a) they are more effective as an incentive for high individual effort than group plans; (b) if a group incentive plan is used, the group of people will get the same pay while different persons have different level of efficiency, and this may therefore cause personnel problems; and (c) it is difficult to justify base rate differentials for people in the same group (Karger & Bayha, 1987; Niebel, 1993).

On the other hand, group incentive plans also have advantages. It is easy to measure group output rather than individual output; group incentive plans will cause less paperwork and cost in administration than individual plans, it will also reduce variation of inventory in process, and in-process inspection (Niebel, 1993). Group incentive plans are effective in obtaining the best performance of a group of operators because of the expectation and motivation from the team (Karger & Bayha, 1987). Celley (1992) stated that the advantages of the group system include:

> 1. Individual operators cooperate better.
> 2. Less supervision may be required.
> 3. New employees can be trained by experienced employees.
> 4. Nonproductive labor is reduced.
> 5. More accurate total costs prevail.
> 6. Product costing is simplified.
> 7. Timekeeping is simplified.
> 8. Employees work more conscientiously.
> 9. Earnings are more equitably shared.
> 10. Wages do not fluctuate greatly.
> 11. Operators are assigned work for which they are best suited.
> 12. The working environment is made more pleasant.
> (Celley, 1992, p. 6.33)

Generally speaking, individual incentive plans can promote higher rates of production and reduce the unit cost of products. In some of the working areas, however, if individual work is changeable, employees have to cooperate with other people, or it is hard to measure individual output, then group incentive plans will be very useful tools.

The most popular individual plans include the following two types:

1. Employees partake of all the gain above standard: the representative plans in this classification include piecework, the standard hour plan, the Taylor differential

piece rate, the Merrich multiple piece rate, measured daywork, etc.

2. Employees share the gain with employer. The systems in this category include the Halsey plan, the Bedaux point system, the Rowan plan, the Emerson plan, productivity sharing plans, profit sharing, etc. (Celley, 1992; Meyers, 1992; Niebel, 1993).

<u>Usage of Time Standards</u>

The range of the employment of time standards, which is the outcome of time and motion study, may influence the application of time and motion study in business (The Joint Working Party of the International MTM Directorate and European Federation of Productivity Services, 1990; Sakamoto, 1987). As a matter of fact, time standards have a wide usage in various areas in industries. They can be used in the areas of (a) product design, (b) equipment evaluation of alternatives, (c) production planning and scheduling, (d) cost estimation and control, (e) plant layout and material handling, (f) incentive plans and (g) performance control (Chen et al., 1991; Genaidy et al., 1990). Meyers (1992) further indicated that motion and time study can also influence the fields of production and inventory control, quality, industrial safety, materials and process.

The duties of the production planning and control sections in industries include scheduling, production processing, dispatching and follow up (Fogarty, Blackstone, & Hoffmann, 1991; Jacobs & Mabert, 1986; Vollmann, Berry, & Whybark, 1984). Their final purpose is output on schedule. The basis of production planning and control is capacity estimation, which includes capacity estimation of machines, of different departments or of a whole plant. Capacity estimation, however, is based on time standards. Therefore, time standards should be used as the foundation of production planning and control.

Industries need to accurately estimate and control the cost of their products. The cost of the products includes material cost and labor cost. Generally industries estimate material cost by calculating the standard amount of material. The labor cost, which is the harder part, is based on time standards (Dudley, 1968). Time standards are therefore the basis of cost accounting and budgetary control (Chen et al., 1991).

Time standards can be used to evaluate alternatives of different equipment and decide what and how many equipments are most suitable. When plant layout and material handling equipment are set, time standards are also an important component to consider for more effective operation or assembly.

Experienced engineers who design products generally take time standards for reference in order to devise products which are easier for operators to manufacture. Time standards can also be used for controlling employees' performance, raising productivity, or person-power planning.

Person-Hours Involved Conducting Motion and Time Study

Raising the production amount in order to increase profits is the purpose most business pursue. Generally, the ways industries utilize to raise the production amount include increasing equipment, employees, working hours, or enhancement in management and supervision. As a matter of fact, there are a lot of ineffective work and ineffective time wasted in people's daily work, and this type of work is time consuming and lacks efficiency (International Labour Office, 1979). Chou (1980) indicated that method improvements should be the first consideration for raising the production amount: current working methods should be examined regularly and all the factors of waste should be eliminated, which include time wasted and all the other sources wasted. Method improvements are in the area of motion and time study.

Generally speaking, motion and time study is not employed broadly in Taiwan's industries, especially small business (Chou, 1980). In the motion and time study field, time study is a time consuming task. On the other hand, it takes time for business to train motion and time study personnel (Clark, 1974; Das, 1982). A large portion of small businesses in Taiwan do not have good training programs for employees (Chou, 1980). The Taiwanese government extensively promoted productivity raising activities two times in the past decades, but this promotion did not achieve as a successful result as had been expected (Shih, 1984). On the other hand, Chou (1980) reported that the number of personnel who were conducting motion and time study was proportional to business size; they further stated that businesses which spent more time in conducting motion and time study tended to have more effective implementation of it, no matter what work measurement technique they used.

The Electronics Industry in Taiwan

The growth of the electronics industry in Taiwan has been very rapid in the last decade. The total electronics production amount grew from 267,585 millions in New Taiwanese dollars in 1981 to 720,805 millions in New Taiwanese dollars in 1990 and the average annual growth rate for the 10 years was 10.4% (Chou, 1990). In 1981, the electronics production amount was 10.6% of the total national industrial manufacturing amount. The percentage, however, grew to 17.3% when the electronics industry became the largest industry in Taiwan in 1990 (Wang, 1992). Chen (1991) stated that the rapid growth of the electronics industry is due to the Taiwan government's policies of encouraging foreign investment, the establishment of Export Processing Zones, and successful technology transfer from Japan. Taiwan's government also established protection policies to help the development of the electronics industry. The improvements of television media technology have contributed to the increase of domestic needs of consumers' electronics products such as TV sets and video cassette recorders (Chen, 1991; Hung, 1993).

Since 1986, the growth rate of the electronics industry has been getting decreasing each year and the annual growth rate became 0.3% in 1990 (Yeh, 1992). Some of the reasons for the decrease are as follows:

1. The rapid rise of labor costs--labors' wages rise as Taiwan's GNP increase. The rate of wages' rise in Taiwan was even higher than that of other southeastern Asian countries.

2. Shortage of labor--the service industry hired more and more human resources as it grew; this fact caused a labor shortage in most of the manufacturing industries in Taiwan.

3. The keen competition among newly industrialized Asian countries--Taiwan's electronics industry used to be second place in Asia. No other countries except Japan were able to manufacture more and better electronics products than Taiwan. The electronics industries in Korea, Singapore

and Hong Kong, however, became prosperous and more competitive in recent years, and threatened Taiwan's electronics industry in the international market (Hung, 1993; Lu, 1990).

More than 80% of Taiwan's electronics products are for export. Therefore, the trends in the international market have a direct influence on Taiwan. The Economic Establishment Committee of the Executive Yuan, the Republic of China (1991) forecasted that consumers' electronics industry of Taiwan will have an annual growth rate of 5% in the coming years, and the production amount will be 9,150 millions in United States dollars in 1996 (9% of world market). Taiwan's integrated circuits industry will grow 19% annually and the production amount will be 4,600 millions in United States dollars in 1996 (5.5% of world market). Chen and Wang (1992) also forecasted that the production of computer related equipment would still be the mainstream around the globe in the coming decade, that total production amount of electronics products all over the world will total 2,565 billions United States Dollars in 2000, and that the total production amount of electronics products of Japan and other Asian countries would be 37% of the total world production in 2000, which would be equal to U.S.$ 949.1 billions.

It has been predicted that computer technology will be developed more rapidly in the coming decade than the past ten years (Chou, 1990). Pung (1993), Tsai (1993) and Chou (1990) forecast the trend of Taiwan's electronics industries as follows:

1. The trend for computer will be better function, more rapid processing, and smaller size products.

2. Integrated circuits will be the main products in semiconductor industry in the coming years.

3. FAX machines and computer network system products will still be popular. Therefore, the manufacturing technology in this field needs to be further improved.

4. Printed circuit boards will be Taiwan's major products in the electronics parts market.

Chen (1991) suggested Taiwan's electronics industries develop technology transfer from other countries, technologist training programs, and productivity improvements such as application of motion and time study techniques on automation and capacity planning to respond to the trends in the near future.

Research Procedures

The review of research procedures related literature has been further divided into two categories: (a) research design and (b) data analysis. Three sections has been included in the research design category. They were questionnaire survey, instrument design, and telephone interview.

Research Design

Questionnaire Survey

Survey research is a popularly used technique for conducting studies (Anderson, 1990; White, 1987). Mail questionnaires are an effective and economic technique to collect data which also permits collection of data from a large sample (Clover & Balsley, 1984; Gay, 1992). Balian (1982) further stated that the questions in the survey instrument should be able to answer the research problem. Clover and Balsley (1984) indicated that a mail questionnaire has the following advantages:

> 1. Mail questionnaires can be sent to persons in widely scattered locations covering a large geographical area.
> 2. Prospective respondents can be reached at relatively low cost.
> 3. Respondents can be reached in their homes or offices, where they read and answer the questionnaire.
> 4. Mail questionnaires can be answered more carefully than personal or telephone questionnaires because more time can be allowed for thinking through the answer.
> 5. No interviewer is present to bias the answers or to make mistakes in recording information. (p. 125)

Follow-up is a necessary procedure for any mail questionnaire study because it is an effective way to increase response rate (Berdie, Anderson, & Niebuhr, 1986; Dillman, 1978). In order to enhance response, researchers should contact the respondents before the questionnaires are being mailed (Wiersma, 1991).

Instrument Design

The format of mail questionnaires is very important because "it is a major factor in determining whether the questionnaire will be completed" (Anderson, 1990, p. 215). For example, colored paper looks more pleasing than white paper and stands out over white paper; light colors such as ivory, gray, and yellow are better than dark ones (Draves, 1988). Anderson (1990) further suggested to use the first page as a cover and have a suitable title and an introductory paragraph. It will increase the response rates to indicate the name of the sponsoring group at the top of the first page of the questionnaire (Berdie et al., 1986). Bradburn, Sudman, and Associates (1980) further suggested a "detailed, informative, and truthful introduction" for the respondents (Bradburn et al., 1980, p. 132). The researcher should explain to the subjects that they are carefully selected and their response is important for the study (Dillman, 1978). Interesting yet nonthreatening questions are suggested to be arranged at the beginning part of the questionnaires (Berdie et al., 1986; Dillman, 1978). In addition, items on questionnaires should not be crowded together (Berdie et al., 1986). Dillman (1978) recommended a mailing date on an early week day. A pretest of the questionnaire is necessary before starting the main survey (Borg, Gall, & Gall, 1993).

Dealing with only one concept in each question is a major principle of question wording (Labaw, 1981). Labaw (1981) further indicated that a questionnaire should be designed around systematic and theoretic principles. On the other hand, the request for a signature affects the response rate to the questionnaire (Bradburn et al., 1980).

Telephone Interview

The interview may produce more accurate and honest responses because the interviewer has chances to explain and clarify the questions being asked as well as the purpose of the study (Anderson, 1990; Best & Kahn, 1986; Gay, 1992). In addition, the interviewer can "follow up on incomplete or unclear responses by asking additional probing questions" (Gay, 1992, p. 231). With the interview technique, the researcher can collect in-depth data, which are not possible with a questionnaire (Anderson, 1990; Gay, 1992). There is a type of interview called an "elite" interview (Anderson, 1990). In this type of interview, the interviewer investigates the opinions of a small number of elite individuals. It is "one directed at a respondent who has particular experience or knowledge about the subject being discussed" (Anderson, 1990, p. 223). In an elite interview, the interviewer should have some knowledge of the interview subject. The elite interview is "a teaching situation in which the respondent teaches the interviewer about events and personal perspectives" (Anderson, 1990, p. 223-224). Preparation is an important procedure for conducting a successful interview (Best & Kahn, 1986; Frey, 1983), and "interviewers must have a clear conception of just what information they need" (Best & Kahn, 1986, p. 186). Fowler (1984) also indicated that a key point in increasing interviewer consistency was using standardized questions.

Telephone interviews can be conducted at a low cost compared with personal interviews (Borg & Gall, 1989; Clover & Balsley, 1984; Lavrakas, 1987). With the telephone interview technique, data can be gathered faster than using face-to-face interviews. "In a week or less one can gather data via telephone that might take a month or more using in-person interviews" (Lavrakas, 1987, p. 12). Bradburn et al. (1980) indicated that there are no significant differences in response bias between telephone and in-person surveys. Telephone survey is particular suitable for open-ended questions; and a well trained telephone interviewer can "often overcome a respondent's reluctance to answer particular questions" (Dillman, 1978, p. 205).

With telephone interview technique, the researcher can select subjects from a broader accessible population than a personal interview in which case interviewers would travel to the location of each respondent (Borg & Gall, 1989; Frey, 1983). Business people are easier to reach by telephone than by personal visits. Borg and Gall (1989) also stated that telephone calls are suitable for dealing with sensitive topics. Telephone interviews can be used to supplement other survey techniques and to collect information in a relatively short period of time (Clover & Balsley, 1984).

In the procedure of conducting a telephone interview, a preliminary phone call is sometimes used for introduction (Frey, 1983). A preliminary call is not to request information, but "to inform respondents of their selection for the survey and of how the selection was made" (Frey, 1983, p. 94). In addition, recording interviews on tape is preferred by many interviewers (Best & Kahn, 1986), because "interviews recorded on tape may be replayed as often as necessary for complete and objective analysis at a later time" (Best & Kahn, 1986, p. 187).

Data Analysis

It is appropriate to use chi-square tests when characteristics of one or more population distributions were concerned (Hamburg, 1983; Hays, 1973). Researchers can compare several populations in some particular ways, or contrast population values with research hypotheses. With chi-square tests, researchers can deal with "value of population mean, the differences among two or more population means, the equality of two population variances, the value of a population regression coefficient, and so on" (Hays, 1973, p. 717).

Clover and Balsley (1984) suggested converting the raw numbers to percentages, because it would permit ease in making comparisons, a more distinguishable presentation of the differences in various populations, and a more thorough analysis for the researchers. Correlation coefficients can be used to measure the degree of relationship between variables (Matre & Gilbreath, 1980). Hurlburt (1994) further stated that Spearman's rank-order correlation coefficient is suitable to describe "the degree of relationship between ordinal variables or a pair of variables where one is ordinal and the other is interval/ratio" (p. 366) because it depends on the ordering of the data within each variable.

CHAPTER III

METHODOLOGY

The purpose of this study was to investigate the characteristics of motion and time study implementation in the electronics industry in Taiwan, and the relationships of these characteristics to the size of enterprises. A description of methodology used is contained in this chapter. It is divided into four sections: (a) research instrument, (b) pilot test, (c) data collection, and (d) data analysis.

Research Instrument

A questionnaire survey technique was used in this study. Since no survey instruments that deal with the exact topic of this research were found, a questionnaire was developed to obtain the data needed. The questionnaire was designed by the author according to the principles stated in "Asking Questions" (Sudman & Bradburn, 1982). Sakamoto's international study concerning the use of motion and time study served as part of the conceptual basis for this study. The questionnaire was also based on the problems identified from other literature sources. Variables measured in the survey instrument included:

1. Types of work measurement techniques employed.

2. Company functions for which time standards applied.

3. Employment of incentive systems.

4. Person-hours involved conducting motion and time study.

5. Use of motion and time study on indirect labor.

6. Problems with conducting motion and time study.

7. Training practices and needs.

The questionnaire contained two parts. Part one (question 1 to 13) was designed to investigate the characteristics in the use of motion and time study; namely, the types of work measurement techniques employed, company functions for which time standards were applied, the employment of incentive wage systems, person-hours involved in conducting motion and time study, and the use of motion and time study on indirect labor. Industrial engineers' perceptions about problems with conducting motion and time study were also obtained from this part. Questions about the amount of employees and the electronics industry classification were at the beginning of the questionnaire.

Part two (question 14 to 24) of the questionnaire was intended to obtain information about training practices and needs related to motion and time study. Questions about the working years of the respondents were at the beginning of this part. The variables related to "types of work measurement techniques employed" and "company functions for which time standards applied" were measured by a six-point percentage scale; other variables related to the application of motion and time study were measured by frequencies.

Pilot Test

The questionnaire was sent to five experienced industrial engineers for a pilot test after it was designed and translated into Chinese. The purpose of the pilot test was to improve the validity of the questionnaire in order to obtain appropriate responses needed for the research. The five experienced industrial engineers who participated in the pilot test were recommended by the China Productivity Center. The criteria for the industrial engineers who were recommended to participate in the pilot test included the following:

1. They had more than three years working experience in the motion and time study area.

2. They were currently working in electronics industry.

This writer contacted each of the experienced industrial engineers by telephone first to obtain their permission to participate in the validation procedure. Then a questionnaire and a cover letter were sent to each of the five industrial engineers who agreed to participate in the pilot test. These five validators were asked to answer all the questions on the questionnaire and give comments about the appropriateness and clarity of the content.

Some modifications in the wording used and the format of the questionnaire were made according to the validators' suggestions. The modified questionnaire was sent to each of the five validators for a second review after the revision to confirm the modification was appropriate. All of the five validators expressed their satisfaction about the new revision.

Data Collection

The data collection of this study involves three parts: (a) the first step survey on general firms--questionnaire survey on the members of the Industrial Engineering Association of the Republic of China, (b) the second step survey--questionnaire survey on 15 highly productive electronics firms, five in each of the large, medium and small firms categories, and (c) telephone interview on six highly productive Taiwan electronics firms, two in each of the large, medium and small firms categories.

First Step Survey

The population for the first step survey were the 259 members of the Industrial Engineering Association, who were working in the motion and time study area in the electronics industry. Three of them were found to be working in the same company as three other engineers; these three engineers who were on the lower part of the list were excluded from the survey population. Another four engineers were found working in companies which were on the possible list of the second-step survey companies (a list contained the top eight electronics companies in each of the employee categories: less than 100, 100-199, 200-299, 300-499, 500-999, and more than 1000 categories). These four engineers were also excluded from the first step survey population to avoid repetition of the respondents in both of the two populations which were compared in a later procedure. Therefore, the total population for the first step population accordingly became 252.

The writer asked the Industrial Engineering Association to support this study in order to increase responses, and permission was granted to use the letterhead of the Industrial Engineering Association. The questionnaires were mailed to each of the industrial engineers on November 6th, 1993 with a cover letter. The questionnaires were number coded in order to identify non-respondents. A self-addressed, stamped envelope was enclosed with each questionnaire.

Two weeks later, a follow-up letter was sent to industrial engineers whose responses had not been received.

By December 4th, 1993, a total of 206 questionnaires had been returned. The response rate was 81.75%.

Second Step Survey

After the first step of the survey from Industrial Engineering Association members was completed, another survey with a smaller population was conducted in order to pursue answers to research question four. The questionnaires used in the second step survey were the same as those used in the first step survey. The population of the second step survey, however, included 15 engineers or chief engineers in 15 highly productive electronics firms, five in each of the large, medium and small firms categories.

The list of The Top 1000 Manufacturers in Taiwan, which was published in the July, 1993 issue of Business Weekly (Taiwan), was used as the base to decide the second step survey population. All the firms on the list of The Top 1000 Manufacturers in Taiwan were classified into small, medium, and large firm categories according to their business size. Manufacturers with less than 200 employees were classified into the small firm category, while those with 200 to 999 employees and 1000 employees or more were classified into the medium and large firm categories, respectively.

Industries which were ranked as the top ten electronics companies in each of the small, medium, and large firms categories were then selected as the reference group to receive a telephone request to participate in the second step survey. The ranking the writer used was based on the sales over number of employees of each company from the list of The Top 1000 Manufacturers in Taiwan.

Industries which were ranked as the top five electronics companies in each of the small, medium, and large firms categories were the first choices for telephone request. The writer contacted each of the 15 highly productive firms selected from the list by telephone to request their participation in the second step survey. All of the five companies in the large firms category agreed to take part in the second step survey, while one company in the medium firms category and two in the small firms category declined. Therefore, the writer contacted the firm which was ranked as the sixth in the medium firms category and the firms that were ranked as the sixth and seventh in the small firms category. All of these three companies agreed to participate in the survey. Consequently, the total number of participants in the second survey was 15.

On December 4th, 1993, questionnaires for the second step survey on the 15 highly productive electronics firms were sent to either the industrial engineer or chief industrial engineer who was responsible for motion and time study in these firms. A follow-up telephone call was made ten days later to remind those non-respondents. By December 21st, 1993, all the 15 questionnaires were returned. The response rate for the second step survey was 100%.

Telephone Interview

The writer requested each of the China Productivity Center, Metal Industry Development Center, Taipei Institute of Technology and Taiwan Industrial Technology College to recommend one highly productive firm with successful implementation of motion and time study in each of the small, medium, and large Taiwan electronics firms categories to form the nomination list for telephone interview. From the synthesis of all the recommendation forms collected, the writer found there were four highly productive firms in the large Taiwan electronics firms category, three in the medium firm category and three in the small firm category. Two highly productive firms were selected from each category on the list for a telephone interview regarding their implementation of motion and time study. Therefore totally six highly productive firms were included.

The writer contacted each of the six highly productive firms selected from the list by telephone to ask if they would willing to be telephone interviewed. All of the firms agreed. The writer also arranged the date and time for the telephone interview with each of the chief industrial engineers at their convenience. The telephone interview date was arranged for the following week after the telephone request. A list of all the possible telephone interview topics was sent to each of the chief industrial engineers before the telephone interview. Each of the telephone interviews was limited to about 30 minutes. The content of the telephone interview was recorded on a cassette tape for the purpose of an objective report and analysis.

Data Analysis

After the returned questionnaires were organized, the person-hours per week conducting motion and time study were calculated for each respondent's company. The calculated person-hours and all other data were then loaded into the computer system. The Statistical Package for Social Sciences (SPSS) computer program was used to accomplish the statistical analysis. The research questions of this study were analyzed as follows with a probability level of 0.05 set for statistical significance.

Research Question One

"How do motion and time study practices (applications, and problems currently experienced) differ by business size in Taiwan's electronics industry?" Chi-square was used to measure the differences in motion and time study practices among small, medium and large firms. Frequencies and crosstabs were also performed to analyze the motion and time study practices of small, medium and large firms in first step survey population (general firms group).

Research Question Two

"How do motion and time study training practices (programs and needs) differ by business size in Taiwan's electronics industry?" Chi-square was used to examine the differences in motion and time study training practices among small, medium and large firms. Frequencies and crosstabs were also developed to analyze the motion and time study training practices of small, medium and large firms in first step survey population (general firms group).

Research Question Three

"What relationship, if any, exists between business size and the motion and time study practices in Taiwan's electronics industry?" Spearman's correlation coefficients were analyzed to determine the degree of relationship between business size and selected characteristics of motion and time study implementation (Kvanli, Guynes, & Pavur, 1989), namely, types of work measurement techniques employed, company functions for which time standards applied, the employment of incentive wage systems and person-hours involved conducting motion and time study.

Research Question Four

"What are the differences in motion and time study practices and related training practices in highly productive small, medium, and large Taiwan electronics firms as compared with other electronics firms in these categories?" Frequencies and crosstabs were used to analyze motion and time study practices and related training practices of plants in the general firms group and the highly productive firms group. Chi-square was also used to measure the differences in motion and time study practices and related training practices between firms of these two groups.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

This chapter is divided into three sections in order to facilitate the presentation of the findings for this study. In the first section, the demographic data is reported. The second section deals with statistical analysis of data. While the third section reports the results of the telephone interviews with selected highly productive firms regarding their implementation of motion and time study.

Demographic Information

The survey to the Industrial Engineering Association members consisted of 252 questionnaires sent to each of the industrial engineers who were working in motion and time study in Taiwan's electronics firms. A total of 206 (81.75%) questionnaires had been returned. Among these returned questionnaires, 201 were usable for data analysis. Demographic data were collected to gain information regarding the (a) number of employees at the plant, (b) type of industry, (c) use of time standards, (d) establishment of time standards as routine work, (e) respondent's working years on his/her current/related job in each firm, (f) respondent's total working years on motion and time study, and (g) need of training. These results were summarized in Tables 1-7.

The Number of Employees in Plant

The numbers of employees for the respondents' plants were summarized in Table 1. Approximately 42.3% of the respondents indicated that there were 200 to 999 employees in their plants. About 30.3% of the respondents worked for firms with less than 200 employees while 27% of the respondents worked for firms with 1000 or more employees.

Table 1

The Number of Employees in Plant

Number of employees	N = 201	%
Less than 200	61	30.3
200-999	85	42.3
1000 or more	55	27.4
Total	201	100.0

Type of Industry

The type of industry of the respondents' plants was reported in Table 2. Approximately 46.8% of the respondents indicated that their plants were electronics parts manufacturers, about 31.8% of the respondents' plants were dealing with electronics assembly, and 17.9% were dealing with sub-assembly.

Table 2

Type of Industry

Type of industry	N = 201	%
Electronics parts	94	46.8
Electronics assembly	64	31.8
Sub-assembly	36	17.9
Other	7	3.5
Total	201	100.0

Use of Time Standards

Table 3 indicated the total number of electronics companies that used time standards (96.0%).

Table 3

Use of Time Standards

Use of time standards	N = 201	%
Yes	193	96.0
No	8	4.0
Total	201	100.0

Establishment of Time Standards as Routine Work

Table 4 contained the total number of electronics companies where the establishment of time standards was part of their routine work (87.6%).

Table 4

Establishment of Time Standards as Routine Work

Establishment of time standards as routine work	N = 201	%
Yes	176	87.6
No	25	12.4
Total	201	100.0

Working Years on Current/Related Job in Each Firm

In Table 5, the respondent's working years were summarized in current/related job in each firm. About 46.8% of the respondents had worked in their current firm for more than four years and 37.3% of the respondents had been employed for 2-4 years. Thirty-seven percent of the respondents had worked in their current firm less than two years.

Table 5

Working Years on Current/Related Job in Each Firm

Working years	N = 201	%
Less than 2 years	75	37.3
2-4 years	32	15.9
More than 4 years	94	46.8
Total	201	100.0

Total Working Years on Motion and Time Study

Table 6 represented the respondent's total working years in motion and time study. The majority (52.7%) of the respondents had worked in motion and time study for more than four years. About 33.8% of the respondents had been employed in motion and time study for less than two years while 13.4% of the respondents had worked for 2-4 years.

Table 6

Total Working Years on Motion and Time Study

Working years	N = 201	%
Less than 2 years	68	33.8
2-4 years	27	13.4
More than 4 years	106	52.7
Total	201	100.0

Need for Training

Table 7 contained the total number of respondents who perceived the need for training related to motion and time study (89.6%).

Table 7

Need of Training

Need of training	N = 201	%
Yes	180	89.6
No	21	10.4
Total	201	100.0

Statistical Analysis of the Study Findings

This section of the findings is directed at the research questions of the study. Wynne (1982) indicated that:

> The significance level of a statistical test refers to the probability level at which the investigator is prepared to reject the null hypothesis as being a very unlikely statement and to favor the alternative hypothesis instead. . . . Generally speaking, if the test statistic yields a value so extreme that it would occur only five times or less out of 100, then the investigator is prepared to reject the null hypothesis in favor of the alternative hypothesis. (p. 134)

All of the chi-square values and Spearman's correlation coefficients in this study were tested for statistical significance at $p \leq 0.05$ level.

Research Question One

How do motion and time study practices (applications, and problems currently experienced) differ by business size in Taiwan's electronics industry?

The frequencies for usage of time standards, application of time standards on indirect personnel, and problems with conducting motion and time study from the response from small, medium, and large electronics firms in the first step survey (general firms) group are presented in Table 8. The differences were examined by the chi-square statistic (Table 8) and the critical value was 5.99 (df = 2). In the area of usage of time standards, the chi-square values were found to be statistically significant for manufacturing processes ($x^2 = 8.49$), and cost estimation ($x^2 = 6.69$), suggesting significant differences among small, medium and large electronics firms regarding their usage of time standards in these two fields. Medium and large size electronics firms tend to apply time standards in cost estimation area more often than small electronics firms. Small size electronics firms, however, tend to apply time standards in the manufacturing process field more often than medium and large size electronics firms.

Table 8

Frequency and Chi-square Analysis for Characteristics and Problems of Motion and Time Study Applications in General Firms Group

	Small N = 61	Frequency Medium N = 85	Large N = 55	N	Chi Square x^2	p
Usage of Time Standards						
Incentive system	17	39	24	80	5.27	.07
Manufacturing processes	46	45	30	121	8.49*	.01
Cost estimation	49	80	49	178	6.69*	.04
Production planning/scheduling	54	64	42	160	4.32	.12
Application of Time Standards on Indirect Personnel						
In process QC (IPQC)	15	21	19	55	1.96	.37
Non-IPQC Quality Control personnel	0	7	0	7	--	
Material handling personnel	7	15	0	22	10.96*	.01
Non-material handling MC personnel	0	0	14	14	--	
Clerical personnel	0	6	6	12	--	
Management	0	8	17	25	26.61*	.01
Problems with Conducting Motion and Time Study						
Personnel shortage	31	42	17	90	5.92	.05
Costly/time-consuming	6	8	37	51	70.21*	.01
Lack of skills	30	34	7	71	18.23*	.01
Top management not support	5	0	0	5	--	
Cause labor conflict	11	22	6	39	4.89	.09

Note. * statistically significant values
-- Expected value less than minimum amount in cells
In the case in Table 8, x^2 could not properly be analyzed when $N \leq 18$.
Critical value = 5.99 for chi-square values.

In the area of the application of time standards to indirect personnel, the chi-square values were found to be statistically significant for material handling personnel (x^2 = 10.96) and management (x^2 = 26.61), suggesting significant differences among different sizes of electronics firms regarding application of time standards to indirect personnel in the above fields. Generally, the larger the electronics firm, the more often they apply time standards to management. On the other hand, small and medium size electronics firms tend to apply time standards to material handling personnel more often than large size electronics firms. According to Gravetter and Wallnau (1992), a requirement of the valid use of chi-square test is that the expected frequency of each cell must be five or more. Consequently, the chi-square values for non-IPQC quality control personnel, non-material handling material control personnel and clerical personnel could not properly be analyzed because of insufficient data.

In the area of problems with conducting motion and time study, the chi-square values were found to be significant for the items of too costly/time consuming (x^2 = 70.21) and lack of skill (x^2 = 18.23), suggesting significant differences among small, medium and large electronics firms related to the problems with conducting motion and time study in these two fields. Generally, the smaller the electronics firm, the more often they responded "lack of skill" as a problem with conducting motion and time study. On the other hand, large size electronics firms tend to respond "costly/time-consuming" as a problem with conducting motion and time study more often than small and medium size electronics firms.

Research Question Two

How do motion and time study training practices (programs and needs) differ by business size in Taiwan's electronics industry?

The frequencies for current motion and time study training practices from the responses from small, medium, and large electronics firms in the general firms (1st step survey) group are presented in Table 9. The differences were examined by chi-square (Table 9) and the critical value was 5.99 (df = 2). In the area of type of current training program, the chi-square values were found to be statistically significant for on-site training (x^2 = 84.16), extensive courses (x^2 = 19.86), and certificate courses (x^2 = 25.84), suggesting significant differences among small, medium and large electronics firms regarding the type of current training programs. Generally, the larger the electronics firms, the more often they used extensive courses and certificate courses as current training program types. In addition, large and small size electronics firms tended to use an on-site training program and medium size electronics firms did not. Actually, a higher percentage of medium electronics firms did not have a formal training program.

In regard to length of current training period, as shown in Table 9, the chi-square values were found to be

Table 9

Frequency and Chi-square Analysis for Current Motion and Time Study Training Practices in General Firms Group

	Frequency Small N = 61	Medium N = 85	Large N = 55	N	Chi Square x^2	p
Type of Current Training Program						
On-site training	25	8	48	81	84.16*	.01
Extensive courses	0	6	13	19	19.86*	.01
Certificate courses	11	20	32	63	25.84*	.01
Workshops	0	9	5	14	--	
Length of Current Training Period						
1-4 days	19	13	23	55	12.45*	.01
1-2 weeks	10	0	14	24	22.23*	.01
More than 2 weeks	5	8	0	13	--	
Current Training Content						
Work Simplification skills	36	14	36	86	42.16*	.01
MTM skills	0	13	13	26	15.08*	.01
Computerized work measurement skills	5	7	8	20	1.78	.41
Rating skills	21	15	18	54	6.41*	.04
Line Balancing skills	24	20	42	86	38.50*	.01
Current Training Funding						
Government	0	0	0	0	--	
Company	56	35	55	146	74.32*	.01
Government & company share	0	0	0	0	--	
Other agent	0	0	0	0	--	

Note. * statistically significant values
-- Expected value less than minimum amount in cells
In the case in Table 9, x^2 could not properly be analyzed when $N \leq 18$.
Critical value = 5.99 for chi-square values.

statistically significant for 1-4 days ($x^2 = 12.45$) and 1-2 weeks ($x^2 = 22.23$), suggesting significant differences among different sizes of electronics firms regarding length of current training periods. Large and small size electronics firms tended to offer training programs with the length of periods of 1-4 days and 1-2 weeks and medium size electronics firms did not.

In regard to current training content, as presented in Table 9, the chi-square values were found to be statistically significant for all of the items except computerized work measurement skills. Among these are work simplification skills (x^2 = 42.16), MTM skills (x^2 = 15.08), rating skills (x^2 = 6.41), and line balancing skills (x^2 = 38.50), suggesting significant differences among small, medium and large electronics firms related to their current training content. Generally speaking, the larger the electronics firm, the more often they included MTM skills in their current training content. In addition, large and small size electronics firms tended to include work simplification skills, rating skills and line balancing skills in their current training content more often than medium size electronics firms.

Concerning current training funding, the chi-square value was found to be statistically significant for company funding (x^2 = 74.32). Again, large and small size electronics firms tended to offer company funding while medium electronics firms did not.

The frequencies for perceived ideal motion and time study training practices from small, medium, and large electronics firms in the first step survey (general) group are presented in Table 10. The differences were examined by chi-square (Table 10) and the critical value was 5.99 (df = 2). Regarding the ideal training program, the chi-square value was found to be statistically significant for on-site training (x^2 = 9.90), suggesting significant differences among small, medium and large electronics firms related to the type of perceived ideal training program. A higher percentage of industrial engineers from large and small size electronics firms perceived on-site training as a type of ideal training program than did industrial engineers from medium size electronics firms.

In the field of length of an ideal training period, as shown in Table 10, the chi-square value was found to be statistically significant for 1-4 days (x^2 = 12.65), suggesting significant differences among different sizes of electronics firms regarding the length of ideal training period. A higher percentage of respondents from large and small size electronics firms perceived 1-4 days as length of an ideal training period than did respondents from medium size electronics firms.

In the area of ideal training content, as presented in Table 11, the chi-square values were found to be statistically significant for MTM skills (x^2 = 9.91), rating skills (x^2 = 38.76) and line balancing skills (x^2 = 12.61),

Table 10

Frequency and Chi-square Analysis for Perceived Ideal Motion and Time Study Training Practices in General Firms Group

	Frequency Small N = 61	Medium N = 85	Large N = 55	N	Chi Square x^2	p
Type of Ideal Training Program						
On-site training	37	44	43	124	9.90*	.01
Extensive courses	14	28	17	59	1.80	.41
Certificate courses	20	41	20	81	4.01	.13
Workshops	0	13	0	13	--	
Length of Ideal Training Period						
1-4 days	46	44	42	132	12.65*	.01
1-2 weeks	15	20	6	41	4.22	.12
More than 2 weeks	0	8	7	15	--	
Ideal Training Content						
Work Simplification skills	51	63	36	150	5.05	.08
MTM skills	16	43	18	77	9.91*	.01
Computerized work measurement skills	29	49	38	116	5.50	.06
Rating skills	30	64	12	106	38.76*	.01
Line Balancing skills	47	82	47	176	12.61*	.01
Ideal Training Funding						
Government	0	0	0	0	--	
Company	21	49	12	82	19.22*	.01
Government & company share	40	51	31	122	1.06	.59
Other agent	0	0	12	12	--	

Note. * statistically significant values
-- Expected value less than minimum amount in cells
In the case in Table 10, x^2 could not properly be analyzed when $N \leq 18$.
Critical value = 5.99 for chi-square values.

suggesting significant differences among small, medium and large electronics firms related to their perceived ideal training content. A higher percentage of industrial engineers from medium size electronics firms responded MTM skills, rating skills and line balancing skills as ideal training contents than did those from large and small size electronics firms.

Concerning ideal training funding, the chi-square value was found to be statistically significant for company funding (x^2 = 19.22). Again, higher percentage of respondents from medium size electronics firms than respondents from large and small size electronics firms perceived company funding as an ideal training funding. Four tables (Appendix H) were developed in order to compare the current and the perceived ideal training practices.

Research Question Three

What relationship, if any, exists between business size and the motion and time study practices in Taiwan's electronics industry?

In order to determine the extent to which business size and selected characteristics of the motion and time study practices are related to each other, a Spearman's rank correlation analysis was performed among all of the above variables (Table 11).

The variables used for the selected characteristics of motion and time study practices included: (a) person-hours involved in conducting motion and time study; (b) employment

Table 11

Correlations Among Business Size and Selected Motion and Time Study Characteristics

	Spearman's r_s	p
Person-hours	.34*	.01
Incentive system	.11	.11
Stopwatch	.04	.57
MTM-1	.22*	.01
MTM-2	.26*	.01
Work Factor	.12	.08
Standard data method	-.05	.44
Computerized work measurement system	.27*	.01
Material planning	.03	.64
Production planning/ scheduling	-.22*	.01
Capacity planning	.13	.06
Process planning	-.06	.40
Purchase planning	.06	.42
Cost estimation	.17*	.02
Budget control	.05	.48
Cost accounting	.29*	.01

Note. N = 201. p = probability
Critical value = .138 for Spearman's correlation coefficient
* statistically significant values

of incentive wage systems; (c) stopwatch, MTM-1, MTM-2, Work Factor, standard data method, and computerized work measurement systems which were in the area of types of work measurement techniques employed; and (d) material planning, production planning/scheduling, capacity planning, process planning, purchase planning, cost estimation, budget control, and cost accounting, which were in the area of company functions for which time standards applied.

Cohen (1977) indicated the definitions of correlational effect size as follows:

small effect size: $r = .10$

medium effect size: $r = .30$

large effect size: $r = .50$

where r stands for product-moment correlation coefficient.

According to Kvanli, Guynes, and Pavur (1989), it appeared that a significant relationship exists between the variables if $|r_s| >$ critical value. In this case critical value equals to .138 when $\underline{N} = 201$, at the .05 level of significance. As shown in Table 12, the results indicated the following:

1. The correlation between business size and person-hours involved conducting motion and time study was statistically significant at the .01 level of significance. The Spearman's correlation coefficient ($r_s = .34$) indicated

that the larger the business size, the more person-hours they spent conducting motion and time study, a medium effect size.

2. In the area of types of work measurement techniques employed, business size correlated with MTM-1 (r_s = .22), MTM-2 (r_s = .26), and computerized work measurement systems (r_s = .27) all significant at the .01 level of significance. Generally, the larger the business size, the more often they used MTM-1, MTM-2 and computerized work measurement systems, in the small to medium effect size range. The correlations between (a) business size and MTM-2 (r_s = .26), as well as (b) business size and computerized work measurement systems (r_s = .27) were close to medium effect size. Nevertheless, no correlations existed between business size and the use of any of the following work measurement techniques: (a) stopwatch method, (b) Work Factor and (c) standard data method.

3. In the area of company functions for which time standards applied, there was a negative correlation between business size and production planning/scheduling beyond the .01 level of significance. The Spearman's correlation coefficient (r_s = -.22) indicated that the smaller the business size, the more often time standards were applied to production planning and scheduling function, a small to medium effect size. There were positive correlations

between business size and cost estimation (r_s = .17, p = .02), and cost accounting (r_s = .29, p = .01). Generally, the larger the business size, the more often time standards were applied to cost estimation and cost accounting. All of these correlations reflected small to medium effect size. The correlation between business size and accounting (r_s = .29) was very close to medium size.

4. The correlations between business size and incentive systems (r_s = .11) were not significant at the .05 level of significance. The Spearman's correlation coefficient indicated there did not appear to be any relationships between the size of the companies and the use of incentive system. In the area of types of work measurement techniques employed, business size did not significantly correlate with stopwatch (r_s = .04), Work Factor (r_s = .12), and standard data method (r_s = -.05) at the .05 level of significance.

5. In the area of company functions for which time standards applied, business size did not correlate significantly with material planning (r_s = .03), capacity planning (r_s = .13), process planning (r_s = -.06), purchase planning (r_s = .06), and budget control (r_s = .05) at the .05 level of significance. No correlations existed between business size and the application of time standards on any of the following characteristics: (a) material planning,

(b) capacity planning, (c) process planning, (d) purchase planning and (e) budget control.

Research Question Four

What are the differences in motion and time study practices and related training practices in highly productive small, medium, and large Taiwan electronics firms as compared with other electronics firms in these categories?

The frequencies for usage of time standards, application of time standards to indirect personnel, and problems with conducting motion and time study from the responses from electronics firms in general firms (the first step survey) group and the highly productive firms (the second step survey) group are presented in Table 12. The differences were examined by chi-square (Table 12) and the critical value was 3.84 (df = 1). In the area of usage of time standards, the chi-square value was found to be statistically significant for manufacturing processes (x^2 = 4.15), suggesting significant differences between general firms and highly productive electronics firms regarding the use of time standards in the manufacturing process area. All other chi-square values in the area of usage of time standards (incentive system, cost estimation, production

Table 12

Frequency and Chi-square Analysis for Characteristics and Problems of Motion and Time Study Applications Comparing General Firms Group to Highly Productive Firms Group

	Frequency General N = 201	HP N = 15	N	Chi Square x^2	p
Usage of Time Standards					
Incentive system	80	8	88	1.06	.30
Manufacturing processes	121	13	134	4.15*	.04
Cost estimation	178	15	193	1.92	.17
Production planning/scheduling	160	13	173	0.44	.51
Application of Time Standards on Indirect Personnel					
In process QC (IPQC)	55	4	59	--	
Non-IPQC Quality Control personnel	7	2	9	--	
Material handling personnel	22	1	23	--	
Non-material handling MC personnel	14	0	14	--	
Clerical personnel	12	1	13	--	
Management	25	2	27	--	
Problems with Conducting Motion and Time Study					
Personnel shortage	90	6	96	0.13	.72
Costly/time-consuming	51	4	55	--	
Lack of skills	71	2	73	3.02	.08
Top management not support	5	0	5	--	
Cause labor conflict	39	2	41	--	

Note. HP: highly productive firms group
-- Expected value less than minimum amount in cells
In the case in Table 12, x^2 could not properly be analyzed when $N \leq 71$.
Critical value = 3.84 for chi-square values

planning/scheduling) revealed no significant differences regarding usage of time standards.

Concerning the application of time standards on indirect personnel, all of the chi-square values (in process quality control personnel, other quality control personnel, material handling personnel, other material control personnel, clerical personnel, management) were not appropriate to be analyzed because of insufficient data. In regard to problems with conducting motion and time study, the chi-square values for "personnel shortage" and "lack of skill" were not found to be significant. All other chi-square values (costly/time-consuming, top management does not support, causes labor conflict) in this section could not properly be analyzed because of insufficient data.

The frequencies for current motion and time study training practices from the responses from electronics firms in the general firms (the first step survey) group and the highly productive firms group are presented in Table 13. The differences were examined by chi-square (Table 13) and the critical value was 3.84 (df = 1). Concerning current motion and time study training practices, from the responses from electronics firms in the above two groups (general firms group and highly productive firms group), chi-square values for the following characteristics revealed no significant differences: (a) "on-site training" and "certificate courses" which were in the field of type of current training program, (b) "work simplification skills" and "line balancing skills" which were regarding current

Table 13

Frequency and Chi-square Analysis for Current Motion and Time Study Training Practices Comparing General Firms Group to Highly Productive Firms Group

	Frequency General N = 201	HP N = 15	N	Chi Square x^2	p
Type of Current Training Program					
On-site training	81	6	87	0.01	.98
Extensive courses	19	1	20	--	
Certificate courses	63	5	68	0.03	.87
Workshops	14	1	15	--	
Length of Current Training Period					
1-4 days	55	5	60	--	
1-2 weeks	24	3	27	--	
More than 2 weeks	13	2	15	--	
Current Training Content					
Work Simplification skills	86	9	95	1.68	.20
MTM skills	26	3	29	--	
Computerized work measurement skills	20	3	23	--	
Rating skills	54	6	60	--	
Line Balancing skills	86	7	93	0.09	.77
Current Training Funding					
Government	0	0	0	--	
Company	146	11	157	0.01	.95
Government & company share	0	0	0	--	
Other agent	0	0	0	--	

Note. HP: highly productive firms group
-- Expected value less than minimum amount in cells
In the case in Table 13, x^2 could not properly be analyzed when $N \leq 71$.
Critical value = 3.84 for chi-square values

training content, and (c) "company funding" that was in the area of current training funding.

Regarding current motion and time study training practices from the responses from electronics firms in the general firms (the first step survey) group and highly productive firms group, chi-square values for the following characteristics were not appropriate to be analyzed because of insufficient data: (a) "extensive courses" and "workshops" which were in the field of type of current training program, (b) all of the chi-square values ("1-4 days," "1-2 weeks," and "more than two weeks") which were related to length of current training period, (c) "MTM skills," "computerized work measurement skills," and "rating skills" that were regarding current training content, and (d) "government," "government and company share," and "other agent" which were in the area of current training funding.

The frequencies for perceived ideal motion and time study training practices from the response from electronics firms in general firms (the first step survey) group and highly productive firms group are presented in Table 14. The differences were examined by chi-square (Table 14) and the critical value was 3.84 (df = 1). Concerning perceived ideal motion and time study training practices from the responses from electronics firms in the above two groups (general firms group and highly productive firms group), chi-square values for the following characteristics revealed no significant differences: (a) "on-site training" and "certificate courses" which were in the area of type of

Table 14

Frequency and Chi-square Analysis for Perceived Ideal Motion and Time Study Training Practices Comparing General Firms Group to Highly Productive Firms Group

	Frequency General N = 201	HP N = 15	N	Chi Square x^2	p
Type of Ideal Training Program					
On-site training	124	8	132	0.41	.52
Extensive courses	59	4	63	--	
Certificate courses	81	6	87	0.01	.98
Workshops	13	1	14	--	
Length of Ideal Training Period					
1-4 days	132	8	140	0.93	.33
1-2 weeks	41	2	43	--	
More than 2 weeks	15	2	17	--	
Ideal Training Content					
Work Simplification skills	150	13	163	1.09	.30
MTM skills	77	9	86	2.74	.10
Computerized work measurement skills	116	10	126	0.46	.50
Rating skills	106	10	116	1.09	.30
Line Balancing skills	176	12	188	0.71	.40
Ideal Training Funding					
Government	0	0	0	--	
Company	82	7	89	0.20	.66
Government & company share	122	8	130	0.32	.57
Other agent	12	0	12	--	

Note. HP: highly productive firms group
-- Expected value less than minimum amount in cells
In the case in Table 14, x^2 could not properly be analyzed when $N \leq 71$.
Critical value = 3.84 for chi-square values

ideal training program, (b) "1-4 days" which was concerning the length of ideal training period, (c) all of the chi-square values ("work simplification skills," "MTM skills," "computerized work measurement skills," "rating skills," "line balancing skills") that were in the area of ideal training content, as well as (d) "company" and "government and company share" which were related to ideal training funding.

Regarding perceived ideal motion and time study training practices from the responses from electronics firms in the general firms (the first step survey) group and the highly productive firms group, chi-square values for the following characteristics could not appropriately be analyzed because of insufficient data: (a) "extensive courses" and "workshops" which were in the area of type of ideal training program, (b) "1-2 weeks" and "more than two weeks" that were in regard to length of ideal training period, as well as (c) "government" and "other agent" which were related to ideal training funding.

Report of Telephone Interviews

Telephone interviews were conducted by this writer after the questionnaire survey. The purpose of the telephone interview was to obtain additional information about the motion and time study implementation in Taiwan's highly productive electronics firms for research question four of this study. Consequently, six highly productive Taiwan electronics firms were involved in the telephone interview, two in each of the large, medium and small firms categories. This part of report of telephone interviews was divided into four sections regarding: (a) large electronics firms, (b) medium electronics firms, (c) small electronics firms, and (d) summary.

Large Electronics Firms

P Company

P Company was in second place of the 1992 net sales rank list of the electronics industry. The industrial engineering group leader the writer interviewed by telephone was working for P Company's Chung-li plant. It has been operated for about a 16 year history, and its' main products were monitors. In this plant, the Industrial Engineering section was under the organization and efficiency department. The objective of this department was to improve the efficiency of not only the shop-floor, but also the whole company. Besides the industrial engineering section, there were other sections responsible for company wide quality control and production cost reduction.

In Chung-li plant of P Company, there were 12 industrial engineers responsible for motion and time study related affairs. In general, they had two foci, one was product evaluation and the other was process evaluation. In the product evaluation procedure, industrial engineering personnel needed to join in and evaluate the product design in order to offer suggestions for easier assembly in the new product design period. In this way, the research and development department could consider changing the design before mass production if changes are necessary.

Process evaluation focused on efficiency improvements, time standard maintenance and related tasks such as the application of automation, production line balance and work simplification. Setting time standards as the base of manufacturing process was focused on in early years. Now they turned their focus to time standard maintenance, efficiency improvements, and so on.

The electronics industry is a labor-intensive industry. Therefore, production line balance was treated as a focus of this plant, because it had a direct influence on production output and person-power efficiency. In other words, motion and time study was often used as a tool to improve line balance and the production process. In the Chung-li plant, every department was asked to list their improvement plan regularly. In addition, they arranged at least two days a month to do routine production improvement activities. In these two days, the production department manager, organization and efficiency department manager, industrial engineering section leader and other related personnel worked together to identify what could be done to improve productivity. People in various areas such as electrical engineers, maintenance engineers and production department supervisors assisted and supported the improvement activity if necessary.

In 1989, the Chung-li plant had successfully saved 30% direct labor cost through a productivity improving activity. Another example of the successful result of Chung-li plant's improvement occurred on a production line. The production line equipment supplier estimated that the maximum production rate of that production line was 500 per day, but the Chung-li plant had increased the productivity to 1250 per day through their efforts in work simplification and production process improvements. In 1994, the Chung-li plant set a plan with a target of a 30% labor reduction starting from indirect labor such as quality control personnel. The Industrial Engineering section was also responsible for the evaluation of all of the general equipment investment company-wide.

In the future, the company's production direction will be high value-added products. Therefore the evaluation of new equipment needed, and the setting of the suitable plant layout, working stations and working process will be a focus of the Industrial Engineering section in the near future. All these tasks mentioned above need to use time standards as fundamental.

As promoted by the Industrial Engineering section and Production department, a shop-floor wide highly efficient productivity was obtained. The industrial engineering section leader of P Company indicated their plant's operators' working pace averaged 30% faster than operators in other electronics factories in the Chung-li area.

Currently, the Industrial Engineering group leader and senior engineers offered training programs for new personnel in the area of motion and time study. In addition, the Industrial Engineering group leader and senior engineers also offered training programs for engineers and supervisors in the production department in order to disseminate the idea of work simplification.

S Company

S Company was a highly productive electronics manufacturer in Taiwan in the second place of the 1992 net sales rank list of local invested electronics industry. This plant had a 30 year history. Its' main products were television sets and video cassette recorders.

Motion and time study has been highly emphasized in S Company. There were four industrial engineers and four technicians responsible for motion and time study. These four technicians spent 70% of their working time on motion and time study. The Industrial Engineering department manager of S Company indicated that the tasks of their department covered a very wide area. Besides motion and time study, their industrial engineers also handled many other tasks such as the automation plan, evaluation of equipment and some industrial engineering related computer programming. S Company has emphasized industrial engineering functions a great deal. Many of their managers in various departments previously worked in the industrial engineering department. Whenever they set a new plant layout or a new production line, there needed to be industrial engineers in the work team. S Company also had overseas plants in other countries such as the United States.

S Company had time standards for each product style. All the manufacturing cost estimations were based on time standards which were set by the Industrial Engineering section. Therefore, time standards had to be carefully set and also be precise. For example, estimated time standards for a new product needed to be set before mass production. In addition, maintenance of time standards was also needed after regular production.

The industrial engineering department manager believed that high quality, high productivity and low cost were the reasons for the high net sales in this company. He also mentioned that motion and time study was important because it related to productivity and cost. The annual target of the industrial engineering department was a 10% reduction in labor costs. Some of the approaches which were found to reduce labor cost included production line balancing technique, as well as the utilization of automation machinery and testing equipment to reduce defects. In 1993, they had reduced labor costs by 20 million New Taiwanese dollars by using the approaches mentioned above.

In the early stages of the company, S Company used a "master table" for setting time standards, which contained time standards for every motion unit such as obtaining a screw, securing the driver, etc. Now, however, they have developed a "sub-table" which offered time standards of a "task" (such as "driving a screw") which combined several motion units together. In this way, motion and time study has been applied more efficiently.

Stopwatch time study, MTM-1, Work Factor, standard data method and computerized work measurement techniques were all employed as time study techniques in S Company. For example, industrial engineers set the manufacturing process based on standard data which was developed with the Work Factor technique. Stopwatch time study technique was usually applied to "tuning" operation; MTM technique was applied in the case of operation simulation whenever new time standards were needed. Some of time standards were calculated through computer programming. Production lines were networked with offices and bar code readers were used on certain production lines to record production amount and defective amount. Therefore, top management instantly became aware of these amounts in their offices through their computer network.

In S Company, time standards were used for capacity planning, manufacturing process planning, cost estimation, budget control, production planning and scheduling. The industrial engineering section had very close relationship with the manufacturing department as well as the research and development department. In conclusion, motion and time study implementation, as well as other industrial engineering practices, were highly focused in S Company.

Medium Electronics Firms

C Company

C Company was in the first place of the 1992 net sales rank list of Taiwan's medium size electronics industry. It was a plant of a famous computer manufacturing group. Its' main products were monitors. In C Company, motion and time study tasks were handled by the Production Technology Department. Most of motion and time study practices were applied on the line balance function. Stopwatch time study was the only work measurement technique being used in C Company. Time standards were, however, widely applied in C Company; they were applied not only as the basis for setting manufacturing process, production planning and scheduling, but also on an incentive wage system and cost estimation.

One of the special points on the implication of motion and time study in C Company was the combination of motion and time study and company-wide quality improvement functions. The purpose of this combination was to improve production quantity and quality.

C Company had several plans for establishing new plants or new plant layouts in the next few years. Therefore, the production technology department devoted a great deal of attention to tasks related to new plant setting. The production technology department had professional personnel not only in motion and time study but also in the areas of monitor auto-tuning skills, making jigs and fixtures, and the application of new equipments. The department manager viewed motion and time study as an important function because it was the basis of line balance and productivity improvements.

Since the stopwatch time study technique was widely used in C Company, rating skills were considered of high importance. Their industrial engineering personnel hoped to include rating skills and work simplification skills in the training programs.

There were four engineers in the industrial engineering section of the Production Technology Department; each engineer was responsible for different production lines. Setting the manufacturing process and preparing manufacturing process information were among important routine tasks of their industrial engineers.

Research and development was one of the focuses of C Company; it was also considered as one of the reasons for good sales. Industrial engineers need to participate and support the research and development department for the manufacturing related affairs beginning with the early pilot run period. The industrial engineering section also closely cooperated with other departments such as the material control department, the electrical engineering department and the production department. Industrial engineers helped the material control department with process flow, warehouse layout and material planning, cooperated with the electrical engineering department for setting the manufacturing process for production, and supported the human resource department by offering time standards for capacity planning. In addition, their industrial personnel assisted the production department in improving the production process in order to have a smooth production and also supported the financial department by offering time standards for cost accounting.

H Company

H Company was an electronic company with more than a 20 year history. It had two different plants which are both located in an Export Processing Zone in Taiwan. One of them was a semiconductor manufacturing plant, and the other was a plant producing printed circuit boards assembly for computers. H Company was an original equipment manufacture company. The plant representative this writer interviewed by telephone was the printed circuit boards assembly plant.

There were five persons in the Industrial Engineering division of H Company. Top management assigned the authority to this division to decide what to do. In addition, they also provided sufficient support to the industrial engineering division. For example, they had increased industrial engineering personnel by 30% in the last two years in order to respond to the acquirement of personnel expansion from the supervisor of the industrial engineering division.

The supervisor of the industrial engineering division in H Company emphasized the importance of motion and time study, and stated that they would put more focus on it in the future. He also indicated that motion and time study was an important basis for person-power planning. In the past two years, H Company had developed their own computerized work measurement system. Another thing which should be noted was that H Company indicated a high percentage standard time application in various planning and financial areas. For example, the industrial engineering division supervisor of H Company indicated that time standards were always employed for planning and financial functions such as budget control, material planning, production planning and scheduling.

The supervisor of the industrial engineering division stated that, since the electrical and mechanical design of a new product could influence the ease of manufacture, industrial engineers should cooperate with design personnel and offer suggestions to them in order to design easy-to-manufacture products. With the idea of work simplification, industrial engineers often offered suggestions to product design personnel about easier production as well as the deletion or combination of parts. Besides, industrial engineers have had to handle the evaluation of equipment and have helped with manufacturing affairs on production lines.

The industrial engineering division supervisor of H Company indicated the importance for industrial engineering personnel to adequately communicate with production line supervisors to assist them in completely understanding the industrial engineering personnel's ideas. Therefore, manufacturing personnel accepted industrial engineers' ideas and cooperated with them while the industrial engineering section had plans about raising productivity by the way of production line balancing, labor reduction or buying new equipments which would be applied to the production line.

Small Electronics Firms

W Company

W Company was in the first place of the 1992 net sales rank list of Taiwan's small size electronics industry. It has had a 12 year history. It's main products were monitors.

Motion and time study was highly regarded by the top management of W Company. One engineer and one technician were responsible for setting and maintaining time standards currently. Other tasks that industrial engineers were responsible for included setting manufacturing processes and plant layout. In W Company, time standards were also used for other industrial engineering functions such as line balancing and plant layout.

In establishing time standards, W Company used three different approaches--stopwatch time study, work factors and standard data method--and then compared to see if there were obvious differences in time standards obtained by these three approaches. When time standards were applied on a new production line, they usually allowed some extra tolerance for the first three to six months manufacturing. These extra tolerance times would be gradually reduced after the first three to six months period.

W Company emphasized applying time standards to indirect labor. Time standards were now applied on material handling personnel, product repair operators, in process quality control personnel and other quality control inspectors.

In W Company, most of the motion and time study related training programs were offered by senior engineers. The advantages of this kind of training programs was that it focused on the special needs and the specific working environment in this plant. On the other hand, industrial engineering personnel also had opportunities to attend outside training programs if approved by management. Usually, evening or weekend training programs were preferred because industrial engineering personnel did not have to ask for leave regularly. Productivity raising and production method improvements were thought to be the focuses of the industrial engineering section. The current objective of the industrial engineering section was a 10% annual productivity improvement. Considering the possibilities of labor conflict, industrial engineers usually applied a step-by-step approach for productivity raising and labor reduction. Generally, motion and time study was applied to new products. The computerized work measurement system used in their company was programmed by the industrial engineering personnel.

Individual and group incentive wage systems were both employed in W Company. All of the working stations in W company were covered in the incentive wage system. An individual incentive system was applied to jobs which produced eye strain, such as monitor adjusting and to heavy jobs such as packing. A group incentive system was applied on all the other work stations.

The chief industrial engineer of W Company indicated that their industrial engineering personnel always cooperated with other departments. Particularly, when a new product was designed, industrial engineers and personnel of other departments such as quality control, mechanical engineering and purchasing worked together in order to determine if this new design would accommodate for manufacturing in the future, and offer their opinions.

Time standards were used by the financial department for cost estimation, budget control, and cost accounting. In addition, time standards were also used by manufacturing process engineers for setting manufacturing processes, by the purchasing department for purchasing planning, and by the production control department for capacity planning, production planning and scheduling.

A Company

A Company was a highly productive small size electronics industry in Taiwan. It had a seven year history of operation. Its' main products were personal computers (notebook and desktop). There were three industrial engineers handling motion and time study tasks. This was a comparatively high amount of motion and time study personnel compared with other similar size electronics factories in Taiwan. Besides motion and time study, these three engineers were also responsible for manufacturing process and all the flow of production line, line balance, etc. The industrial engineering section leader stated that motion and time study practices were the basis of all the other industrial engineering functions. The industrial engineering section leader emphasized that the major qualification for the industrial engineers in their company was a college major in industrial engineering.

The industrial engineering section leader believed that the implementation of motion and time study was closely related to the high productivity and high net sales of the company. He indicated another reason for their high productivity was the cooperation between the industrial engineering section and other departments such as Material Control, Purchasing, and Production Control.

In discussing the plan of the industrial engineering section for the near future, the industrial engineering section leader of A Company indicated they would apply computerized work measurement techniques so they could maintain time standards easier. Regarding work measurement techniques applied, A Company employed MTM, Work Factor and stopwatch time study techniques. Industrial engineers could apply any work measurement technique they were familiar with. The only objective they focused on was obtaining reasonable and useful time standard data.

Concerning the characteristics of small size electronics company, the industrial engineering section leader of A Company indicated that production on schedule and smooth manufacturing condition on production lines were the most important points in manufacturing. This needed effective management and the cooperation among all related departments such as purchasing, material control, production control, manufacturing, and quality control. Motion and time study was therefore considered important because it produced time standards which were part of the basis applied by the above departments.

The industrial engineering section leader stated that time standards were particularly important for production lines in A Company. Time standards were also applied on indirect labor such as in process quality control (IPQC) personnel and material handling personnel. In addition, time standards were used by industrial engineering personnel for manufacturing processes, line balancing and method improvements; and furthermore they were used by production control personnel for capacity planning, and were used by financial department for cost estimation.

In A Company, all of the industrial engineers were industrial engineering majors. Actually, only industrial engineering majors were considered for work as industrial engineers to handle motion and time study practices. Therefore, they did not offer training programs about very basic industrial engineering related knowledge and techniques. At present, senior industrial engineers offered regular on-site Industrial Engineering training programs focusing on the affairs related to manufacturing and operation in this plant. The industrial engineers were more interested in training programs offered by other organizations regarding new knowledge and techniques in the industrial engineering field.

Summary

Telephone interviews were conducted by the writer to acquire information about the motion and time study practices in Taiwan's highly productive electronics firms. Since most of the questions in the telephone interviews were open ended questions, the interviewees had chances to express their perceptions and describe the details of their motion and time study implementation. Consequently, the writer obtained in-depth information from highly productive Taiwan electronics firms related to their implementation of motion and time study. For example, the writer identified how some firms employed three or more work measurement techniques and the advantages of the application. The writer also recognized the features of small size electronics firms. The industrial engineers of some firms mentioned that company-wide improvements and product evaluation were the traits of their motion and time study sections. A few interviewees indicated that their high productivity and the cooperation among different departments were the reasons for their high sales.

As presented in Table 15, among the six highly productive electronics firms which participated in the telephone interviews, five (83.3%) firms responded the application of time standards for many department functions and line balancing. Four (66.7%) of the firms mentioned about their emphasis on plant layout design and the cooperation with other departments. Three out of the six (50%) firms had similarity about the following events: product evaluation, method/efficiency improvements, productivity improvements, equipment evaluation, on-site training, computerized work measurements, application of time standards on cost estimation, time standard maintenance, and use of more than three work measurement techniques.

Synthesizing the reports of the six highly productive electronics firms being interviewed by telephone, the following results were found:

Table 15

Comparison of Similarities of Interviewed Firms

	Large		Medium		Small	
	P	S	C	H	W	A
Company-wide improvements	V		V			
Product evaluation	V		V	V		
Method/efficiency improvement	V				V	V
Automation	V	V				
Line balancing	V	V	V	V		V
Productivity improvements	V				V	V
Labor reduction	V	V				
Equipment evaluation	V	V		V		
On-site training	V			V		V
MTS idea dissemination	V			V		
Computerized WM		V		V	V	
Plant layout design	V	V	V	V		
Cost estimation		V	V		V	
T.S. maintenance	V	V			V	
Use more than three WM techniques		V			V	V
Use TS for many department functions		V	V	V	V	V
Cooperation with other department		V	V		V	V
Apply TS on indirect labor					V	V

Note. MTS--motion and time study
TS--time standard(s)
WM--work measurement

1. The "application of time standards for many department functions" and "line balancing" were adopted by majority of the firms (83.3%), regardless of the business size.

2. The "automation" and "labor reduction" were emphasized by the two (100%) large firms. It did not appear, however, that the small and medium size firms used them.

3. "Equipment evaluation" and "time standards maintenance" were completely emphasized by both (100%) of the two large firms while only few firms in small and medium categories adopted them.

4. All of the large and medium firms this writer interviewed by telephone focused on plant layout design, but no small firms did.

5. Both (100%) of the medium firms implemented product evaluation, but only one large firm and no small firms did.

6. It appeared that small firms tended to apply time standards on indirect labor. Both (100%) of the small firms adopted it while no firms in other categories (large and medium) did.

7. Small firms tended to focus on method/efficiency improvements, productivity improvements, cooperation with other departments and use of more than three work

measurement techniques. Nevertheless, only few firms in small and medium categories did.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to provide data for industry, motion and time study promotion organizations, as well as educational and training organizations in Taiwan. Specifically, it was to identify and analyze selected characteristics of motion and time study implementation in Taiwan's electronics industry. Furthermore, this study was conducted to investigate the relationships of these characteristics to the size of the electronics enterprises.

This study focused on the relationships of characteristics of motion and time study implementation in the electronics industry in Taiwan to the size of the enterprises. Four research questions were developed to guide the study:

1. How do motion and time study practices (techniques, applications, and problems currently experienced) differ by business size in Taiwan's electronics industry?

2. How do motion and time study training practices (programs and needs) differ by business size in Taiwan's electronics industry?

3. What relationship, if any, exists between business size and the motion and time study practices and related training practices in Taiwan's electronics industry?

4. What are the differences in motion and time study practices and related training practices in highly productive small, medium, and large Taiwan electronics firms as compared with other electronics firms in these categories?

The data collection of this study contains three parts: (a) the first step survey on general firms; (b) the second step survey on 15 highly productive electronics firms, five in each of the large, medium, and small firms categories; and (c) telephone interview on six highly productive Taiwan electronics firms, two in each of the large, medium, and small firms categories.

The population of the first step survey was members of the Industrial Engineering Association of the Republic of China whose present position was in the field of motion and time study in the electronics industry. The population contained 252 industrial engineers, and the entire population was included as subjects.

A questionnaire was designed to investigate the characteristics in use of motion and time study and the problems with conducting motion and time study, as well as to obtain information about training practices and needs related to motion and time study. The selected characteristics in this study included: (a) types of work measurement techniques employed, (b) company functions for which time standards applied, (c) employment of incentive wage systems, (d) person-hours involved conducting motion and time study, and (e) use of motion and time study on indirect labor.

The questionnaire was sent to five experienced industrial engineers for a pilot test after it was designed and translated into Chinese. The purpose of the pilot test was to improve the validity of the questionnaire in order to obtain appropriate responses needed for the research.

The questionnaires were mailed to the 252 members of the Industrial Engineering Association of the Republic of China, who were currently working in the motion and time study area in the electronics industry. A total of 206 questionnaires were returned. The response rate was 81.75%. Among these returned questionnaires, 201 were usable.

The second step survey on 15 highly productive electronics firm industrial engineers were conducted after the first step survey on 252 Industrial Engineering Association members. The 15 highly productive firms were selected from the Top 1000 Manufacturers in Taiwan, which was published in the July, 1993 issue of Business Weekly (Taiwan).

The telephone interviews were conducted on six highly productive electronics firms, two in each of the large, medium and small categories to investigate their successful implementation of motion and time study. These six highly productive firms were recommended by China Productivity, Metal Industry Development Center, Taipei Institute of Technology and Taiwan Industrial Technology College.

The Statistical Package for Social Sciences (SPSS) computer program was used to accomplish the statistical analysis. Analysis involved frequencies, crosstabs, chi-square analysis and Spearman's correlation coefficients. Research question one and two were analyzed by chi-square values among different business size electronics firms. Research question three was analyzed by Spearman's correlation coefficients. Chi-square values and the information obtained from telephone interviews were used to analyze question four.

Findings of the Study

Demographic Information

1. Approximately 42.3% of the respondents indicated that there were 200 to 999 employees in their plants. About 30.3% of the respondents worked for firms with less than 200 employees while 27% of the respondents worked for firms with 1000 or more employees.

2. A large number (46.8%) of the respondents indicated that their plants were electronics parts manufacturers. About 31.8% of the respondents' plants dealt with

electronics assembly, and 17.9% were dealing with sub-assembly.

3. The overwhelming majority (96.0%) of the electronics companies used time standards.

4. The majority (87.6%) of the respondents indicated the establishment of time standards as their routine work.

5. A large number (46.8%) of the respondents had worked on the current or related job in their firm for more than four years; while 37.3% of the respondents had been employed for 2-4 years and 27% of the respondents had worked for less than two years.

6. The majority (52.7%) of the respondents had worked in the motion and time study area for more than four years. About 33.8% of the respondents had been employed for less than two years and 13.4% of the respondents had worked for 2-4 years.

7. The majority (89.6%) of respondents perceived the need of motion and time study related training.

Findings Related to Research Questions

Research Question One: How do motion and time study practices (techniques, applications, and problems currently experienced) differ by business size in Taiwan's electronics industry?

1. A statistically significant difference was found among the motion and time study practices of small, medium

and large electronics firms in Taiwan. In the area of usage of time standards, a higher percentage of medium and large size electronics firms applied time standards in the area of cost estimation than did small electronics firms. Small size electronics firms tended to apply time standards in the manufacturing process field more often than medium and large size electronics firms.

2. Concerning the application of time standards to indirect personnel, the larger the electronics firms, the more often they applied time standards to management. On the other hand, small and medium size electronics firms tended to apply time standards to material handling personnel, while the large size electronics firms did not.

3. Regarding problems with conducting motion and time study, the smaller the electronics firm, the more often they responded that "lack of skill" was a problem with conducting motion and time study. On the other hand, large size electronics firms tended to say that "costly/time-consuming" was a problem more often than did small and medium size electronics firms.

Research Question Two: How do motion and time study training practices (programs and needs) differ by business size in Taiwan's electronics industry?

1. In general, the larger the electronics firm, the more often they used extensive courses and certificate courses as current training program types.

2. Large and small size electronics firms tended to use on-site training programs while medium size electronics firms did not.

3. A higher percentage of industrial engineers from large and small size electronics firms responded that their companies currently tended to offer training programs with lengths of 1-4 days and 1-2 weeks than did industrial engineers from medium size electronics firms.

4. Large and small size electronics firms tended to include rating skills and line balancing skills in their current training content but medium size electronics firms did not.

5. Concerning current funding, large and small size electronics firms tended to offer company funding but medium size electronics firms did not.

6. Large and small size electronics firms tended to perceive on-site training as a type of ideal training program but medium size electronics firms did not.

7. A higher percentage of respondents from large and small size electronics firms perceived 1-4 days as the ideal length for a training period than did respondents from medium size electronics firms.

8. Medium size electronics firms tended to perceive rating skills and line balancing skills as ideal training content while large and small size electronics firms did not.

9. Medium size electronics firms tended to believe company funding was the ideal source for training funding while large and small size electronics firms did not.

Research Question Three: What relationship, if any, exists between business size and the motion and time study practices in Taiwan's electronics industry?

1. Business size was significantly correlated with person-hours involved in conducting motion and time study. The Spearman's correlation coefficient revealed that the larger the business size, the more person-hours were spent conducting motion and time study.

2. Concerning types of work measurement techniques employed, business size was found to relate significantly to MTM-1, MTM-2, and computerized work measurement systems. Generally, the larger the business size, the more often they used MTM-1, MTM-2 and computerized work measurement systems.

3. In the area of company functions for which time standards applied, there was a negative correlation between business size and production planning/scheduling. The smaller the business size, the more often they applied time standards to production planning and the scheduling

function. In addition, business size was found to be significantly associated with cost estimation and cost accounting. The Spearman's correlation coefficients revealed that the larger the business size, the more often they applied time standards to cost estimation and cost accounting.

Research Question Four: What are the differences in motion and time study practices and related training practices in highly productive small, medium, and large Taiwan electronics firms as compared with other electronics firms in these categories?

Findings derived from questionnaire survey included:

1. Highly productive electronics firms tended to use time standards more often than general electronics firms in the manufacturing process area.

2. No statistically significant differences were found between the general electronics firms group and highly productive electronics firms group in the use of time standards in any of incentive systems, cost estimation and production planning/scheduling areas.

3. In the area of application of time standards on indirect personnel, all of the chi-square values (in process quality control (IPQC) personnel, non-IPQC quality control personnel, material handling personnel, non-material handling material control personnel, clerical personnel,

management) could not appropriately be analyzed because of insufficient data. This was caused by the totally low frequencies (less than 33.3%) in the combination of the general electronics firm group and the highly productive electronics firm group together.

4. No statistically significant differences were observed in the perceptions of industrial engineers in the general electronics firms and highly productive electronics firms regarding either "personnel shortage" or "lack of skill" as a problem with conducting motion and time study.

5. In the area of problems with conducting motion and time study, the chi-square values for the factors "costly/time-consuming,""top management does not support," and "causes labor conflict" could not appropriately be analyzed because of insufficient data. This was caused by the totally low frequencies (less than 33.3%) in the combination of the general electronics firm group and the highly productive electronics firm group together.

6. No statistically significant differences were found in the perceptions of industrial engineers in general electronics firms and highly productive electronics firms regarding either "on-site training" or "certificate courses" as a current training program.

7. Regarding the type of current training program, chi-square values for either "extensive courses" or

"workshops" could not appropriately be analyzed because of insufficient data. In other words, low frequencies (totally less than 33.3%) were observed in the combination of the general electronics firm group and the highly productive electronics firm group together.

8. All chi-square values in the area of length of current training period (1-4 days, 1-2 weeks, more than two weeks) could not appropriately be analyzed because of insufficient data. This was caused by the totally low frequencies (less than 33.3%) in the combination of the general electronics firm group and the highly productive electronics firm group together.

9. No statistically significant differences were observed in the perceptions of industrial engineers in general electronics firms and highly productive electronics firms regarding either "work simplification skills" or "line balancing skills" as a current training content.

10. In regard to current training content, chi-square values for any of MTM skills, computerized work measurement skills and rating skills could not appropriately be analyzed because of insufficient data. This was caused by the totally low frequencies (less than 33.3%) in the combination of the general electronics firm group and the highly productive electronics firm group together.

11. No statistically significant differences were found in the perceptions of industrial engineers in general

electronics firms and highly productive electronics firms regarding company funding.

12. In the area of current training funding, chi-square values for either "government" or "government and company share" could not appropriately be analyzed because of insufficient data.

13. No statistically significant differences were observed in the perceptions of industrial engineers in general electronics firms and highly productive electronics firms regarding either of "on-site training" and "certificate courses" as an ideal training program.

14. In regard to type of ideal training program, chi-square values for either extensive courses or workshops could not appropriately be analyzed because of insufficient data.

15. Concerning length of ideal training period, chi-square value for 1-4 days revealed no significant differences. All other chi-square values (1-2 weeks, more than two weeks) in the area of length of ideal training period could not appropriately be analyzed because of insufficient data.

16. In the field of ideal training content, all the chi-square values (work simplification skills, MTM skills, computerized work measurement skills, rating skills, line balancing skills) revealed no significant differences.

17. Regarding ideal training funding, chi-square values for "company" and "government and company share" revealed no significant differences. All other chi-square values (government, other agent) in this area could not appropriately be analyzed because of insufficient data.

18. Concerning the telephone interviews the writer conducted on six highly productive electronics firms, there were a great deal of similarities among these firms. Five (83.3%) firms responded the application of time standards on many department functions and line balancing. Four (66.7%) of the firms mentioned about their emphasis on plant layout design and the cooperation with other departments. Three out of the six (50%) firms had similarities about the following events: product evaluation, method/efficiency improvements, productivity improvements, equipment evaluation, on-site training, computerized work measurements, application of time standards on cost estimation, time standard maintenance, and use of more than three work measurement techniques.

Conclusions

The conclusions of this study were based on the data reported in Chapter IV. After the analysis of the data, the following conclusions were made:

Conclusions Related to Research Question One

Taiwan electronics firms of different sizes have different usages of motion and time study. In addition, large, medium and small electronics firms apply time standards to indirect labor area differently. Moreover, industrial engineers of large, medium and small electronics firms perceived different problems with conducting motion and time study. Generally, the smaller the electronics firms, the more often they responded that "lack of skill" was a problem with conducting motion and time study. On the other hand, large size electronics firms tended to respond that "costly/time-consuming" was a problem more often than did small and medium size electronics firms. In large firms with many more work stations of different operations than medium and small firms, tasks of motion and time study did require a significant amount of person-hours. In other words, it was costly and time-consuming. On the other hand, more motion and time study personnel in small and medium firms lacked related skills because less training opportunities were offered.

Conclusions Related to Research Question Two

Large and small size electronics firms tended to use on-site training program while medium size electronics firms did not. Moreover, large and small size electronics firms tended to perceive on-site training as a type of ideal training program but medium size electronics firms did not. It appeared that the firms of the business size categories that currently have regular use of on-site training tended to perceive it as a type of ideal training program. In other words, those who have experienced on-site training programs were likely to regard it as a good program for them.

A higher percentage of industrial engineers from large and small size electronics firms responded that their companies tended to offer training programs with lengths of 1-4 days and 1-2 weeks than did industrial engineers from medium size electronics firms. Moreover, a higher percentage of respondents from large and small size electronics firms perceived 1-4 days as the ideal length for a training period than did respondents from medium size electronics firms. It appeared that the firms of the business size categories with current usage of 1-4 days training programs tended to perceive it as an ideal length for a training period. The length of "1-4 days" likely to be a suitable training period for electronics plant industrial engineers.

Large and small size electronics firms tended to include rating skills and line balancing skills in their current training content but medium size electronics firms did not. Medium size electronics firms, however, tended to perceive rating skills and line balancing skills as ideal training contents while large and small size electronics firms did not. The industrial engineers of medium firms, which had less training content in the field of rating skills and line balancing skills, may need rating and line balancing skills urgently. The industrial engineers of large and small firms, who already had training content of rating skills and line balancing skills, may need training content of other fields, such as computerized work measurement skills or work simplification skills.

Concerning current funding, large and small size electronics firms tended to offer company funding but medium electronics firms did not. Medium size electronics firms, however, tended to perceive company funding as an ideal training funding while large and small size electronics firms did not. It is likely that industrial engineers from medium size electronics firms desired their companies to offer more funding for training programs. Nevertheless, the highest percentage of all the small, medium and large firms categories (65.6%, 60.0%, and 56.4% respectively) desired the government to share training funding with their companies.

Conclusions Related to Research Question Three

Positive correlations existed between business size and person-hours involved in conducting motion and time study (in the medium effect size). The larger the business size, the more person-hours they spent conducting motion and time study. Larger electronics firms meant more operators, and usually more work stations. The larger the business size, the more person-hours it required to conduct motion and time study. Generally, larger electronics firms tended to hire comparatively more motion and time study personnel; in other words, there were more persons spending their time in motion and time study.

In the area of types of work measurement techniques employed, positive correlations existed between: (a) business size and MTM-1, (b) business size and MTM-2, as well as (c) business size and computerized work measurement systems (small to medium effect size range). The correlations revealed that the larger the business size, the more often MTM-1, MTM-2 and computerized work measurement systems were used. Both MTM-1 and MTM-2 were very time-consuming. In other words, it required a substantial number of person-hours to conduct them. Computerized work measurement techniques, on the other hand, were modern approaches which required more funds for equipment and programming. It was possible for these work measurement techniques to be used by larger electronics firms which had a larger budget and more motion and time study personnel.

A negative correlation (in the small to medium effect size range) existed between business size and the application of time standards in the area of production planning/scheduling. Generally, the smaller the business size, the more often they applied time standards to production planning and scheduling function. In smaller firms, production on schedule is crucial for making profits. Therefore, production planning and scheduling were particularly emphasized by smaller firms.

In the area of company functions for which time standards applied, positive correlations existed between: (a) business size and cost estimation, as well as (b) business size and cost accounting. The correlations revealed that the larger the business size, the more often they applied time standards to cost estimation and cost accounting. (All these correlations were between small to medium effect size range.) In Taiwan's electronics companies, it was not popular for time standards to be employed. For those companies which adopted them, cost estimation and cost accounting were likely to be their first choices for application, because using time standards in the areas of cost estimation and cost accounting would produce precise calculation of labor cost. On the other hand, no correlations existed between business size and incentive systems because incentive systems were not popularly employed in any of the large, medium and small Taiwan electronics firms.

No correlations existed between business size and the use of any of stopwatch, Work Factor, and standard data method. Stopwatch was the most popularly used work measurement technique in industry (Rotroff, 1959), and this was true of Taiwan's electronics firms also, regardless of their business size. Work Factor and standard data method, however, were rarely used in Taiwan's large, medium and small electronics firms.

No correlations existed between business size and the application of time standards on any of the following characteristics: (a) material planning, (b) capacity planning, (c) process planning, (d) purchase planning and (e) budget control. Crosstabs revealed that time standards were seldom used in company departments regarding material planning, process planning, purchase planning and budget control. On the other hand, time standards were frequently applied in capacity planning, regardless of the size of the business.

Conclusions Related to Research Question Four

Chi-square values for all the motion and time study implementation characteristics except the item of use time standards in the "manufacturing process" area revealed either no statistically significant differences between the general electronics firms group and highly productive electronics firms group or were not appropriate to be analyzed because of insufficient data. Those chi-square values which were not appropriate to be analyzed because of insufficient data (Table 12, Table 13, and Table 14) were caused by the totally low frequencies (less than 33.3%) in the combination of the general electronics firm group and the highly productive electronics firm group together. In short, the data gathered in this study indicated that there were only minor differences in motion and time study practices and related training practices between highly productive Taiwan electronics firms and other Taiwan electronics firms.

The report of telephone interviews, which including six highly productive electronics firms, revealed that many of the six firms had some similarities. They were likely the attributes of Taiwan's highly productive electronics firms. The following tasks which were related to motion and time study were emphasized by 50% or more of the six firms interviewed by this writer: (a) line balancing, (b) application of time standards on many department functions, (c) plant layout design, (d) the cooperation with other departments, (e) product evaluation, (f) method/efficiency improvements, (g) productivity improvements, (h) equipment evaluation, (i) on-site training, (j) computerized work measurements, (k) application of time standards on cost estimation, (l) time standard maintenance, and (m) use of more than three work measurement techniques.

Recommendations Based on the Study

1. Motion and time study related training programs of various types, content and length of time should be provided to meet the demands of motion and time study personnel in Taiwan's electronics industry.

2. The concept of applying time standards to various company departments and functions should be disseminated in order to promote the implementation of motion and time study.

3. Taiwan's electronics firms should offer more flexible training opportunities, both on-site and out-site, for their motion and time study personnel in order to enhance their skills in the area of motion and time study. In addition, these firms should consider hiring more motion and time study personnel in order to facilitate the implementation of motion and time study.

4. Taiwan's electronics firms should offer funding to support training programs related to motion and time study in addition to government support.

5. Consultant systems should be established to offer motion and time study projects for Taiwan's small electronics firms. This can solve small firms' problem of

lack of personnel and skills in motion and time study implementation.

6. The application of time standards on both of incentive wage systems and indirect labor areas should be fostered to broaden the usage of motion and time study.

7. Techniques of both computerized work measurement and standard data method should be promoted to enhance the application of motion and time study in Taiwan's electronics industry.

8. Instructors, educators and administrators of higher education, training organizations and continuing education in the field of motion and time study should examine the findings of this study to determine if current learning activities focus on the demands of industry.

Recommendations for Future Study

It is recommended that further research in the following fields be conducted:

1. Experimental studies should be conducted to assess the effects of motion and time study on production efficiencies in different production types of the electronics industry.

2. A study should be conducted to determine if there is any significant statistical difference in motion and time study implementation in Taiwan's electronics industry for

different product/production type categories and different geographical areas.

3. A study should be conducted to assess Taiwan's electronics industry's needs about techniques, information and training, which are related to motion and time study, and to gather data from motion and time study personnel, management and investors.

4. This study should be replicated using a broader population which would include all of the electronics firms in Taiwan.

5. A study should be conducted to investigate what factors inhibit the implementation of motion and time study.

6. A study should be conducted to assess the trends and future usage regarding motion and time study in Taiwan's electronics industry.

REFERENCES

Anderson, G. (1990). Fundamentals of educational research. London, UK: The Falmer Press.

Balian, E. S. (1982). How to design, analyze, and write doctoral research: The practical guidebook. New York: University Press of America.

Barnes, R. M. (1980). Motion and time study: Design and measurement of work. New York: John Wiley & Sons.

Berdie, D. R., Anderson, J. F., & Niebuhr, M. A. (1986). Questionnaires: Design and use (2nd ed.). Metuchen, NJ: Scarecrow Press, Inc.

Best, J. W., & Kahn, J. V. (1986). Research in education (5th ed.). Englewood Cliffs, NJ: Prentice-Hall.

Borg, W. R., & Gall, M. D. (1989). Educational research: An introduction (5th ed.). New York: Longman Publishing Group.

Borg, W. R., Gall, J. P., & Gall, M. D. (1993). Applying educational research: A practical guide (3rd ed.). New York: Longman Publishing Group.

Bradburn, N. M., Sudman, S., & Associates. (1980). Improving interview method and questionnaire design. San Francisco: Jossey-Bass Publishers.

Buffa, E. S. (1983). Modern production/operations management. New York: John Wiley & Sons.

Business Weekly Editors Committee. (1993, July). Top 1000 manufacturers in Taiwan. Business Weekly (Taiwan), pp. 38-85

Celley, A. F. (1992). Conventional wage incentives. In W. K. Hodson (Ed.), Maynard's industrial engineering handbook (4th ed., pp. 6.17-6.42). New York: McGraw-Hill Book Company.

Chang, L. (1972). Business administration for the new age. Taipei, Taiwan: Li Ming Publications, Inc.

Chang, P. T. (1993, July). Trends in motion and time study. Industrial Managers (Taiwan), pp. 21-25.

Chen, L. (1992, July). Implementation of work study. Industrial Managers (Taiwan), pp. 14-19.

Chen, T. J., & Wang, W. T. (1992). Globalization of Taiwan's electronics industry. Proceedings of economic development and prospects of the Republic of China (pp. 81.1-81.25). Taipei, Taiwan: Board of Foreign Trade, Ministry of Economic Affairs, R.O.C.

Chen, W. C. (1976). Industrial management. Taipei, Taiwan: Chung Hsing Company.

Chen, W. C., Chou, T., Chen, S. N., & Fu, W. H. (1991). Work study. Taipei, Taiwan: Chung Hsing Company.

Chen, Y. T. (1991). Restart of Taiwan's consumers' electronics products industry. Taiwan Economics Research Monthly, 14(12), 63-68.

Chien, S. (1988). Application of industrial management techniques on small business. Taipei, Taiwan: Li Ming Book Company.

Chou, T. (1980). Work simplification, work study, motion and time study. Taipei, Taiwan: China Business Administration Development Center.

Chou, Y. S. (1990). Analysis of the current situation of electronics industry. Industry and Finance, 71(1), 40-54.

Clark, T. B. (1974). Expectations and perceptions of industrial engineers concerning the accuracy and precision of work measurement techniques (Doctoral dissertation, Georgia State University, 1974). Dissertation Abstracts International, 35, 3975A

Close, G. C. (1960). Work improvement. New York: John Wiley & Sons, Inc.

Clover, V. T., & Balsley, H. L. (1984). Business research methods (3rd ed.). Columbia, OH: Grid Publishing, Inc.

Cohen, J. (1977). Statistical power analysis for the behavioral sciences. New York: Academic Press, Inc.

Council for Economic Planning and Development. (1992). Industry of Free China. Taipei, Taiwan: Council for Economic Planning and Development, Executive Yuan, R.O.C.

Cozens, A. C. (1988). The future of work measurement in Northamptonshire. Management Services, 32(9), 20-22.

Crossan, R. M., & Nance, H. W. (1972). Master standard data. New York: McGraw-Hill Book Company.

Czajkiewicz, Z. J., & Issa, T. N. (1987). Productivity improvement and management: Part six--task-related techniques. MTM Journal of Methods-Time Measurement, 13(1), 32-36.

Das, B. (1982). Performance rating training in industry: using Das's programmed learning method. 1982 Annual Industrial Engineering Conference Proceedings (pp. 687-693). Norcross, GA: Industrial Engineering and Management Press, Institute of Industrial Engineers.

Dillman, D. A. (1978). Mail and telephone surveys. New York: John Wiley & Sons, Inc.

Dilworth, J. B. (1983). Production and operations management. New York: Random House, Inc.

Draves, W. A. (1988). High response surveys. Manhattan, KS: Learning Resources Network.

Dudley, N. A. (1968). Work measurement: Some research studies. London: Macmillan and Company Limited.

Economic Establishment Committee of the Executive Yuan, R. O. C. (1991). Six years plan for national establishment. Taipei, Taiwan: Author.

Evans, J. R., Anderson, D. R., Sweeney, D. J., & Williams, T. A. (1990). Applied production and operations management. St. Paul, MN: West Publishing Company.

Fogarty, D. W., Blackstone, J. H., & Hoffmann, T. R. (1991). Production and inventory management. Cincinnati, OH: South-Western Publishing Co.

Fogarty, D. W., Hoffmann, T. R., & Stonebraker, P. W. (1989). Production and operations management. Cincinnati, OH: South-Western Publishing Co.

Fowler, F. J. (1984). Survey research methods. Beverly Hills, CA: Sage Publication, Inc.

Frey, J. H. (1983). Survey research by telephone. Beverly Hills, CA: Sage Publications, Inc.

Gay, L. R. (1992). Educational research: Competencies for analysis and application (4th ed.). New York: Macmillan Publishing Company.

Genaidy, A. M., Agrawal, A., & Mital, A. (1990). Computerized predetermined motion-time systems in manufacturing industries. Computers and Industrial Engineering, 18(4), 571-584.

Gravetter, F. J., & Wallnau, L. B. (1992). Statistics for the behavioral sciences: A first course for students of psychology and education (3rd ed.). St. Paul, MN: West Publishing Company.

Hamburg, M. (1983). Statistical analysis for decision making. New York: Harcourt Brace Jovanovich, Inc.

Hays, W. L. (1973). Statistics for the social sciences. New York: Holt, Rinehart and Wilston, Inc.

Hicks, P. E. (1977). Introduction to industrial engineering and management science. New York: McGraw-Hill Book Company.

Hodson, W. K., & Mayo, W. E. (1992). Fundamentals of indirect labor measurement and labor forecasting. In W. K. Hodson (Ed.), Maynard's industrial engineering handbook (4th ed., pp. 5.69-5.96). New York: McGraw-Hill Book Company.

Holmes, W. G. (1940). Applied time and motion study. New York: The Ronald Press Company.

Hung, C. H. (1993). Consumers' electronics products industry. In Industry Bureau of R.O.C. (Eds.), Republic of China 1992 Industrial Development Annual Report (pp. 260-286). Taipei, Taiwan: Industry Bureau of R.O.C.

Hurlburt, R. T. (1994). Comprehending behavioral statistics. Pacific Grove, CA: Brooks/Cole Publishing Company.

Industrial Development and Investment Center of R.O.C. (1992). A brief introduction to the investment climate in Taiwan, Republic of China. Taipei, Taiwan: Author.

Industrial Development Bureau of the Republic of China. (1990). Annual report of ROC industry. Taipei, Taiwan: Industrial Development Bureau of R.O.C.

International Labour Office. (1979). Introduction to work study. Geneva: Author.

Jacobs, F. R., & Mabert, V. A. (1986). Production planning, scheduling, and inventory control: Concepts, techniques, and systems. Norcross, GA: Industrial Engineering and Management Press, Institute of Industrial Engineers.

The Joint Working Party of the International MTM Directorate and the European Federation of Productivity Services. (1990). The future of work measurement. 1990 International Industrial Engineering Conference Proceedings (pp. 630-637). Norcross, GA: Industrial Engineering and Management Press, Institute of Industrial Engineers.

Karger, D. W., & Bayha, F. H. (1987). Engineered work measurement. New York: Industrial Press Inc.

Karger, D. W., & Hancock, W. M. (1982). Advanced work measurement. New York: Industrial Press Inc.

Krick, E. V. (1962). Methods engineering-design and measurement of work methods. New York: John Wiley & Sons, Inc.

Kvanli, A. H., Guynes, C. S., & Pavur, R. J. (1989). Introduction to business statistics: A computer integrated approach. St. Paul, MN: West Publishing Co.

Labaw, P. J. (1981). Advanced questionnaire design. Cambridge, MA: Abt Books.

Lambert, K. (1987). Work study--what relevance has it in today's and tomorrow's industry? Management Services, 31(1), 16-21.

Lavrakas, P. J. (1987). Telephone survey methods: Sampling, selection, and supervision. Newbury Park, CA: Sage Publications, Inc.

Lee, S. F. (1971). Industrial engineering and operational management. Taipei, Taiwan: Mei Ya Publications, Inc.

Lu, C. Y. (1990). The retrospection and the outlook of electronics technology and industry. Science Monthly, 21(1), 67-70.

Lu, Y. Y. (1983). Introduction to modern industrial engineering. Taipei, Taiwan: Hua Tai Book Company.

Mason, J. W. (1992). Standard data concepts and development. In W. K. Hodson (Ed.), Maynard's Industrial Engineering Handbook (4th ed., pp. 3.121-3.189). New York: McGraw-Hill Book Company.

Matre, J. G., & Gilbreath, G. H. (1980). Statistics for business and economics. Dallas, TX: Business Publications, Inc.

Mattern, W. J., Knott, K., & McDonald, R. W. (1971). MTM-GPD and other second generation data. In H. B. Maynard (Ed.), Maynard's Industrial Engineering Handbook (3rd ed., pp. 5.102-5.121). New York: McGraw-Hill Book Company.

May, J. E., & Jackson R. (1989, June). Industrial engineering philosophies and practices can increase shop floor productivity . . . and our own. Journal of Industrial Engineering, pp. 39-43.

Meyers, F. E. (1992). Motion and time study: Improving work methods and management. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Mundel, M. E. (1985). Motion and time study: Improving productivity. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Muther, R. (1971). Production line techniques. In H. B. Maynard (Ed.), Maynard's Industrial Engineering Handbook (3rd ed., pp. 11.90-11.114). New York: McGraw-Hill Book Company.

Nadler, G. (1955). Motion and time study. New York: McGraw-Hill Book Company.

Neale, F. J. (1967). Primary standard data. London, U. K.: McGraw-Hill Publishing Company Limited.

Niebel, B. W. (1993). Motion and time study. Boston, MA: Richard D. Irwin, Inc.

Polk, E. J. (1984). Methods analysis and work measurement. New York: McGraw-Hill Book Company.

Pung, S. C. (1993). Passive electronics parts industry. In Industry Bureau of R.O.C. (Eds.), Republic of China 1992 Industrial Development Annual Report (pp. 287-309). Taipei, Taiwan: Industry Bureau of R.O.C.

Quick, J. H., Duncan, J. H., & Malcolm, J. A. (1971). The work factor system. In H. B. Maynard (Ed.), Maynard's Industrial Engineering Handbook (3rd ed., pp. 5.65-5.101). New York: McGraw-Hill Book Company.

Rae, A. (1966). Work study; A practical primer. London: Odhams Books Ltd.

Ramcharan, D. J., & Martin, L. A. (1988). A prototype expert system for computerized work measurement. 1988 International Industrial Engineering Conference Proceedings (pp. 578-583). Norcross, GA: Industrial Engineering and Management Press, Institute of Industrial Engineers.

Rotroff, V. H. (1959). Work measurement. New York: Reinhold Publishing Corporation.

Sakamoto, S. (1987). Key to productivity: Work measurement: International survey report. The MTM Journal, 13(1), 68-75.

Salvendy, G. (Ed.). (1982). Handbook of industrial engineering (2nd ed.). New York: John Wiley & Sons, Inc.

Schwab, J. L. (1971). Methods time measurement. In H. B. Maynard (Ed.), Maynard's Industrial Engineering Handbook (3rd ed., pp. 5.20-5.64). New York: McGraw-Hill Book Company.

Shih, T. Y. (1984). Strategic industries and productivity. Proceedings of The Conference of Strategic Industries and Economical Development (pp. 22-25). Taipei, Taiwan: Chinese Association of Engineers.

Shin, S., Riel, P. F., & Sink, D. S. (1988). Productivity measurement: A situational approach. 1988 International Industrial Engineering Conference Proceedings (pp. 555-560). Norcross, GA: Institute of Industrial Engineers.

Sink, D. S., & Rossler, P. (1987). Performance measurement and evaluation: Who for, what for, tools and techniques. 1987 International Industrial Engineering Conference Proceedings. Norcross, GA: Industrial Engineering and Management Press, Institute of Industrial Engineers.

Smith, G. L. (1978). Work measurement: A systems approach. Columbus, OH: Grid Publishing, Inc.

The State of Small Business, Ministry of Economic Affairs. (R. O. C.). (1993). White paper of small business. Taipei, Taiwan: Ministry of Economic Affairs.

Statistics Institute. (1992, April). Major export products. Journal of Chinese Statistics (Taiwan), pp. 16-18.

Sudman, S., & Bradburn, N. M. (1982). Asking questions. San Francisco: Jossey-Bass Publishers.

Taylor, F. W. (1967). The principles of scientific management. New York: W. W. Norton & Company, Inc.

Tsai, C. P. (1993). Active electronics parts and assembly industry. In Industrial Bureau of R.O.C. (Eds.), Republic of China 1992 Industrial Development Annual Report (pp. 310-321). Taipei, Taiwan: Industry Bureau of R.O.C.

Vollmann, T. E., Berry, W. L., & Whybark, D. C. (1984). Manufacturing planning and control systems. Homewood, IL: Richard D. Irwin, Inc.

Wang, C. K. (1992). Sino-American-European electronics trade. Reference Papers on Economic Development and Prospects of the Republic of China (pp. 71.1-71.5). Taipei, Taiwan: Board of Foreign Trade, Ministry of Economic Affairs, R.O.C.

Wang, T. H. (1964). Modern industrial and business management. Taipei, Taiwan: San Ming Book Company.

White, M. R. (1987). Selecting a technical research design. In E. N. Israel & R. T. Wright (Eds.), Conducting technical research 36th yearbook (pp. 68-87). Mission Hill, CA: Glencoe.

Wiersma, W. (1991). Research methods in education: An introduction. Boston: Allyn and Bacon.

Wynne, J. D. (1982). Learning statistics: A common-sense approach. New York: Macmillan Publishing Co., Inc.

Yeh, L. Y. (1992). Analysis of the present condition of consumer's electronics industry. Taiwan Economics Research Monthly, 15(3), 70-74.

APPENDIX A

LETTER FOR REQUEST RECOMMENDATION FOR EXPERT FOR JURY

The University of Northern Iowa

敬啟者：

本人在美國北愛荷華大學進修所提的博士論文，初步定名為〞臺灣電子業應用動作與工時研究的特質及其與企業大小的相關性〞，本研究中所設計之問卷需經測試之程序，此問卷之目的乃是探討〞動作與工時研究〞在臺灣電子業方面的應用狀況。煩請貴單位推薦六位資深工業工程師，本人將專函邀請每位工程師參加此問卷的測試工作，並協助審核問卷之效度。

隨函附上推薦表一份請查收，並至誠感謝貴單位的鼎力協助。　順頌

公　　綏

美國北愛荷華大學博士班

張裕帑　敬上

The University of Northern Iowa

Dear :

This letter is requesting your recommendation of some experts in motion and time study to validate the survey instrument which will be used in my doctoral dissertation at the University of Northern Iowa, tentatively titled "The Characteristics in the Use of Motion and Time Study in Taiwan's Electronics Industry and Their Relationship to Business Size". The experts you are going to recommend are hoped to be experienced industrial engineers with more than THREE years experience working in the area of motion and time study.

I will contact each of the experts you are going to recommend and ask them for joining in the jury to validate the survey instrument. Enclosed is a recommendation form. Thank you very much for your assistance.

Sincerely,

Betty Chang
Doctoral Candidate,
Department of Industrial Technology,
University of Northern Iowa

APPENDIX B

RECOMMENDATION FORM FOR EXPERT FOR JURY

推薦表

茲推薦資深工業工程師數位如下表:

	姓名	工作單位
1.	______________	________________________________
2.	______________	________________________________
3.	______________	________________________________
4.	______________	________________________________
5.	______________	________________________________
6.	______________	________________________________

RECOMMENDATION FORM

The following experienced industrial engineers would be recommended for the purpose of validating the survey instrument of motion and time study:

NAME	WORKING ORGANIZATION
________________	______________________________
________________	______________________________
________________	______________________________
________________	______________________________
________________	______________________________
________________	______________________________

APPENDIX C

THE COVER LETTER FOR PILOT TEST

～先生：

感謝您答應參與本問卷的測試。隨信附上的這份問卷將用於本人在美國北愛荷華大學進修所提的博士論文，初步定名為"臺灣電子業應用動作與工時研究的特質及其與企業大小的相關性"，問卷內容是有關臺灣電子業動作與工時研究的實施及相關訓練事宜。首先請您就問卷上的問題逐題回答，並同時審核各題題目是否表達合宜，清晰易懂，以便能獲得本研究所需的適當答案。如果您有任何寶貴意見，請儘量提出，多多批評指教，千萬不要客氣。

問卷及建議寫好之後，請利用回郵信封，儘可能在一星期內寄回。再一次感謝您的鼎力協助。敬祝

大　　安

張　楮　帑　敬上

82年 9月 30日

*此項研究由北愛荷華大學工業技術系教授Dr. John T. Fecik 指導進行。

The University of Northern Iowa

Dear Mr. :

Thank you for agreeing to take part in this study as a member of panel of experts. The questionnaire enclosed concerns the implementation and training practices of motion and time study in electronics industry in Taiwan.

The purpose of the pilot test is to determine if the questions are appropriate and easily understood to obtain responses needed for the study. Therefore, your help is particularly desirable to validate the survey instrument. Would you please respond to each question on the questionnaire and indicate if the questions are clear and suitable. Your offering of comments will be mostly welcome. Thank you for your assistance.

Sincerely,

Betty Chang
Doctoral Candidate

This study is under the direction of Dr. John T. Fecik, Professor, Department of Industrial Technology, University of Northern Iowa.

APPENDIX D

LETTER FOR REQUEST RECOMMENDATION FOR HIGHLY PRODUCTIVE FIRMS

敬啟者：

本人在美國北愛荷華大學進修所提的博士論文，初步定名為〞臺灣電子業應用動作與工時研究的特質及其與企業大小的相關性〞，此研究中需探討實施〞動作與工時研究〞功效卓著的電子製造業大型，中型，小型廠商各數家（備註）。敬請貴單位推薦大型，中型，小型電子製造廠商各一家，將所推薦的廠商名稱填在推薦表上，並利用回郵信封寄出。

隨函附上八十一年度製造業業績前五百名公司名單，以供參考，並至誠感謝貴單位的鼎力協助。　順頌

公　綏

美國北愛荷華大學博士班

張祐帝　敬上

備註：大型，中型，小型廠商分類如下：
大型 --員工人數在1000人以上者
中型 --員工人數在200-999人之間者
小型 --員工人數在200人以下者

The University of Northern Iowa

Dear Mr.   :

This letter is requesting your recommendation of some electronics manufacturers with successful implementation of motion and time study, whose successful experience will be studied in my doctoral dissertation at the University of Northern Iowa, tentatively titled "The Characteristics in the Use of Motion and Time Study in Taiwan's Electronics Industry and Their Relationship to Business Size". Since the effective application of motion and time study in different size electronics industries will be needed to be studied, I would like to ask for your recommendation of ONE industry in each of the categories of SMALL, MEDIUM, and LARGE electronics manufacturers*, which have successful implementation of motion and time study.

Enclosed is a recommendation form. Please put the names of the manufacturers recommended on the form and return it in the provided envelope as soon as possible. The list of the "Top 1000 Manufacturers of Taiwan" enclosed is for your references. Thank you very much for your assistance.

Sincerely,

Betty Chang
Doctoral Candidate,
Department of Industrial Technology,
University of Northern Iowa

* Categories for electronics industry size:
Small industries -- with employees less than 200
Medium industries -- with employees between 200 to 999
Large industries -- with employees more than 1000

APPENDIX E

RECOMMENDATION FOR HIGHLY PRODUCTIVE FIRMS

推薦表

兹推薦實施"動作與工時研究"功效卓著的電子業廠商代表如下:

大型廠商:
\---------------------------------------

中型廠商:
\---------------------------------------

小型廠商:
\---------------------------------------

RECOMMENDATION FORM

We would like to recommend electronics manufacturers with successful implementation of motion and time study as follows:

BUSINESS SIZE	MANUFACTURER RECOMMENDED
Large industries:	______________________
Medium industries:	______________________
Small industries:	______________________

APPENDIX F

SUPPORT LETTER FROM INDUSTRIAL ENGINEERING ASSOCIATION

中國工業工程學會用箋

親愛的工業工程師：

動作研究與工時研究的實施對於工廠的效率及製造程序的改進有極大的影響。因此，在本學會協助下，張蓓蒂女士決定進行一項有關「動作研究與工時研究在台灣電子工業界應用的特質」的研究。各位工業工程師在動作研究與工時研究的實施方面，是台灣工業界站在第一線上的尖兵，因此，我們相信您對這些問題的看法將是最具有代表性的。希望您能挪出十分鐘左右的時間回答這份問卷，並請在三天內將問卷寄於回郵信封中寄出。

這項研究計劃之成敗與其貢獻，全賴您對此問卷之及時回應及精確的回答。所填問卷的內容，僅為研究之用，保證保守機密，絕不單獨對外發表。謝謝您的協助與合作。順頌

公綏

中國工業工程學會副祕書長　杜壯

中華民國八十二年十一月三日

INDUSTRIAL ENGINEERING ASSOCIATION
REPUBLIC OF CHINA

Dear Industrial Engineer Member:

The implementation of motion and time study is influential to a plant's efficiency and manufacturing process improvements. Therefore, we have decided to conduct a study regarding motion and time study.

Your response is very important for this study because of your experience in the implementation of motion and time study in the electronics industry. Would you spend ten to fifteen minutes to answer this questionnaire and return it in the envelope provided in three days. Be assured that your responses will be kept confidential, no questionnaire will be individually reported. Thank you for your assistance.

Sincerely,

C. Tu
Assistant General Secretary
Industrial Engineering Association
Republic of China

APPENDIX G

THE FOLLOW-UP LETTER

The University of Northern Iowa

親愛的工業工程師:

大約在兩周之前,您曾經收到一份有關"動作與工時研究在電子業實施的特質"的調查問卷.目前我們已經陸續收到部份寄回的問卷.如果您的問卷已經塡好並寄回,我在此衷心的感謝您的幫忙.

如果您的問卷還沒有寄回,麻煩您抽出十分鐘左右的時間回答此問卷並儘快寄出,因爲您的回答對此研究的正確性將有決定性的影響.謝謝您的合作.

順　頌

公　綏

北愛荷華大學博士班

張蓓蒂 敬啓

The University of Northern Iowa

Dear Industrial Engineers:

About two weeks ago you received a questionnaire regarding the characteristics of motion and time study implementation in electronics industry. If you have already responded and returned the questionnaire, please accept my sincere appreciation.

If you have not returned the questionnaire yet, we hope you spent about ten minutes to fill out and return the questionnaire because your response is more than important for my reserch. Thank you very much for your cooperation.

Sincerely,

Betty Chang
Doctoral Candidate,
Department of Industrial Technology,
University of Northern Iowa

APPENDIX H

TABLES OF COMPARISON OF CURRENT TRAINING PROGRAMS AND PERCEIVED IDEAL TRAINING PROGRAMS

Table 16

Comparison of Current and Perceived Ideal Training Programs

Training program	Small (N = 61) Cur.	Small (N = 61) Ideal	Medium (N = 85) Cur.	Medium (N = 85) Ideal	Large (N = 55) Cur.	Large (N = 55) Ideal
	Business Size					
On-site training	25	37	8	44	48	43
Extensive courses	0	14	6	28	13	17
Certificate courses	11	20	20	41	32	20
Workshops	0	0	9	13	5	0
Other	16	0	7	8	0	6
Total	66	71	99	134	98	86

Note. Cur.--Current

Table 17

Comparison of Current and Perceived Ideal Lengths of Training Periods

Training period	Business Size: Small (N = 61) Cur.	Ideal	Medium (N = 85) Cur.	Ideal	Large (N = 55) Cur.	Ideal
1-4 days	19	46	13	44	23	42
1-2 weeks	10	15	0	20	14	6
More than 2 weeks	5	0	8	8	0	7
Other	22	0	50	13	11	0
No respondents	5	0	14	0	7	0
Total	61	61	85	85	55	55

Note. Cur.--Current

Table 18

Comparison of Current and Perceived Ideal Training Content

Training content	Business Size Small (N = 61) Cur.	Ideal	Medium (N = 85) Cur.	Ideal	Large (N = 55) Cur.	Ideal
Work-Simplification	36	51	14	63	36	36
MTM	0	16	13	43	13	18
Computerized WM	5	29	7	49	8	38
Rating	21	30	15	64	18	12
Line Balancing	24	47	20	82	42	47
Other	10	4	30	0	0	0
Total	96	177	99	301	117	151

Note. Cur.--Current

Table 19

Comparison of Current and Perceived Ideal Training Funding

Training funding	Business Size Small (N = 61) Cur.	 Ideal	 Medium (N = 85) Cur.	 Ideal	 Large (N = 55) Cur.	 Ideal
Government	0	0	0	0	0	0
Company	56	21	35	49	55	12
Government & company share	0	40	0	51	0	31
Other agent	0	0	0	0	0	12
No respondents	5	0	50	0	0	0
Total	61	61	85	100	55	55

Note. Cur.--Current

APPENDIX I

THE COVER LETTER AND QUESTIONNAIRE

MOTION AND TIME STUDY IMPLEMENTATION SURVEY

Dear Industrial Engineers:

The purpose of this study is to identify the characteristics of the implementation and the training practices of motion and time study in the electronics industry in Taiwan. The characteristics selected for this research included: (1) types of work measurement techniques employed; (2) company departments which apply time standards; (3) use of motion and time study on indirect labor; (4) employment of incentive wage systems; and (5) person-hours conducting motion and time study.

As you have experience about the implementation of motion and time study in the electronics industry in the real world, your opinions will be particularly important for this study. Each questionnaire will be treated as a confidential document.

Enclosed is a stamped and self-addressed envelope, please complete and return the questionnaire in THREE DAYS. If you have any questions, please fell free to call me at 02-3710074 for clarifications. Your cooperation will be highly appreciated.

Sincerely,

Betty Chang
Doctoral Candidate
Department of Industrial Technology
University of Northern Iowa, U.S.A.

Instructions for Responding

1. Please answer the questions according to the current condition in your plant.
2. While answering the questionnaire, please mark in front of the item(s) which describes the condition in your plant.
3. Try to answer each question. In case that you are not aware of the answer, you may leave that question blank.
4. You may mark more than one answer for those questions with "please mark all that are appropriate".
5. For reasons of confidentiality, please do not put your name on the questionnaire.

1a. How many employees are there in your factory?

_______ a. Less than 100 employees
_______ b. 100 -- 199 employees
_______ c. 200 -- 299 employees
_______ d. 300 -- 499 employees
_______ e. 500 -- 999 employees
_______ f. 1000 or more employees

1b. Which of the following area is your company classified as?

_______ a. Electronics parts manufacturing
_______ b. Electronics assembly
_______ c. Electronics sub-assembly
_______ d. Electrical appliances manufacturing
_______ e. Other ______________________________
(Please identify)

2. Time standard is defined as "the amount of time that would be taken to perform a specific task, using a specified method, under specific working conditions by a worker who is mentally and physically qualified, trained, and experienced in the specified method, if the worker works at a 'normal pace', and reasonable allowances are made for unavoidable delays, fatigue, and personal needs." Does your company use time standards?

_______ a. Yes

_______ b. No

3. Is establishing time standards a routine work in your department?

_______ a. Yes

_______ b. No

4. How many industrial engineers/technicians are working in the time and motion study field in your factory?

Title	Number of people
Engineer	( )
Technician	( )
Other_______________ (Please identify)	( )

5. What is the average percentage of time a time and motion study analyst spends in the exact motion and time study work every week?

About____________________percent

6. How many hours a week do the industrial engineering personnel and other employees normally work in your company? (Overtime not included)

_______ a. 44 hours/week
_______ b. 48 hours/week
_______ c. 40 hours/week
_______ d. Other ________________________________ (Please identify)

7. What are the major uses of time standards in your company? (Please mark all that are appropriate)

_______ a. For incentive wage system

_______ b. For the basis of setting production process

_______ c. For cost estimation

_______ d. For production planning and scheduling

_______ e. Other ________________________________ (Please identify)

* For the following three questions, a scale is used. Please check on the short line under the scale.
(The scale stands for the percentage of the time a time study technique or time standards are used. 0% stands for 0% of the time, 20% stands for 20% of the time and 100% stands for 100% of the time.)

8. What motion and time study techniques are used in your enterprise? (Please mark all that are appropriate)

Percentage of time	0%	20%	40%	60%	80%	100%
Stopwatch	___	___	___	___	___	___
MTM-1	___	___	___	___	___	___
MTM-2	___	___	___	___	___	___
Work Factor	___	___	___	___	___	___
Standard data Method	___	___	___	___	___	___
Computerized System	___	___	___	___	___	___
Other__________ (please identify)	___	___	___	___	___	___

9. In which of the following planning areas are time standards currently applied in your enterprise? (Please mark all that are appropriate)

Percentage of time	0%	20%	40%	60%	80%	100%
Material Planning	___	___	___	___	___	___
Production planning/scheduling	___	___	___	___	___	___
Capacity Planning	___	___	___	___	___	___
Process Planning	___	___	___	___	___	___
Purchase Planning	___	___	___	___	___	___
Other__________ (Please identify)	___	___	___	___	___	___

10. In which of the following financial areas are time standards currently applied in your enterprise? (Please mark all that are appropriate)

Percentage of time -------->	0%	20%	40%	60%	80%	100%
Cost Estimation	__	__	__	__	__	__
Budget Control	__	__	__	__	__	__
Cost Accounting	__	__	__	__	__	__
Other________ (Please identify)	__	__	__	__	__	__

11. Which of the following indirect labor areas in your company are covered with motion and time study? (Please mark all that are appropriate)

________ a. In Process Quality Control personnel

________ b. Quality Control personnel other than In Process Quality Control section

________ c. Material Handling personnel

________ d. Material Control personnel other than Material Handling section.

________ e. Clerical work area

________ f. Management work area

________ g. Others________________________________
(please identify)

________ h. None of above

12. Is an incentive wage system employed in your factory? What percentage of the direct labor work stations are currently covered by incentive systems?

_______ a. No incentive system is used

_______ b. Under 20% of work stations are covered

_______ c. 21% -- 40% of work stations are covered

_______ d. 41% -- 60% of work stations are covered

_______ e. 61% -- 80% of work stations are covered

_______ f. 81% --100% of work stations are covered

13. What are the problems with conducting motion and time study in your company? (Please mark all that are appropriate)

_______ a. Not enough motion and time study personnel

_______ b. Too costly and too time-consuming

_______ c. Personnel lack motion and time study skills

_______ d. Top management does not support motion and time study

_______ e. It causes conflict with workers

_______ f. Other_______________________________________
(Please identify)

14. How many years have you worked in the field of motion and time study for this factory?

_______ a. Less than 2 years

_______ b. 2 -- 4 years

_______ c. More than 4 years

15. How many years have you totally worked in the motion and time study field?

_______ a. Less than 2 years

_______ b. 2 -- 4 years

_______ c. More than 4 years

The following five questions (16 - 20) are about the motion and time study training programs currently been practiced in your company.

16. Do you think training programs in motion and time study for your engineers or technicians are necessary?

_______ a. Yes

_______ b. No

17. What types of motion and time training programs have been practiced in your company? (Please mark all that are appropriate, if no training programs provided, please mark on item "e" and answer question 21-24 directly.)

_______ a. Classes on-site
_______ b. Extensive classes
_______ c. Certificate programs
_______ d. Workshops
_______ e. None of above
_______ f. Other ______________________________
(Please identify)

18. In terms of the length of time, how long are the training programs currently practiced in your company? (Please mark all that are appropriate)

_______ a. About 1 day.

_______ b. About 1 week.

_______ c. About 1 month.

_______ d. Other______________________________
(Please identify)

19. What skills have been practiced in the motion and time study training in your company? (Please mark all that are appropriate)

_______ a. Work simplification skills

_______ b. MTM skill

_______ c. Computerized work measurement systems

_______ d. Rating skills (of stopwatch time study)

_______ e. Line balancing skill

_______ f. Other ______________________________________
(Please identify)

20. How have the motion and time study training programs been supported in your company? (Please mark all that are appropriate)

_______ a. Government funding.

_______ b. Company funding.

_______ c. Government and company share costs.

_______ d. Other agents ______________________________
(Please identify)

The following questions (21 - 24) are about the ideal motion and time study training programs that can fit the demands of your company.

21. What types of motion and time training programs do you think to be <u>suitable</u> for your motion and time study personnel?

_______ a. Classes on-site
_______ b. Extensive classes
_______ c. Certificate programs
_______ d. Workshops
_______ e. None of above
_______ f. Other ______________________________________
(Please identify)

22. In terms of the length of time, which of the following training programs do you think to be suitable for your motion and time study personnel?

_______ a. About 1 day.

_______ b. About 1 week.

_______ c. About 1 month.

_______ d. Other______________________________
(Please identify)

23. What content should be in the motion and time study training program of your company? (Please mark all that are appropriate)

_______ a. Work simplification skills

_______ b. MTM skill

_______ c. Computerized work measurement systems

_______ d. Rating skills (of stopwatch time study)

_______ e. Line balancing skill

_______ f. Other______________________________
(Please identify)

24. How would you like the training program to be supported?

_______ a. Government funding.

_______ b. Company funding.

_______ c. Government and company share costs.

_______ d. Other agents__________________________
(Please identify)

Thank you for your assistance!

動作研究與工時研究應用狀況調查問卷

各位工程師及技術人員：您好

這份問卷的主要目的，在於瞭解"動作研究與工時研究在台灣電子，電機業應用的特質"，這些特質包括：(1)使用何種時間研究方法，(2)標準工時在工廠各部門之應用，(3) 績效獎金的實施，(4)動作與時間研究在間接人工方面的應用，以及(5)實施動作與時間研究所花的時間。由於您在工業界有實際工作的經驗，所以您的意見至為寶貴。

所填各項資料對外絕對保密。懇請您撥冗回答，並請於答完後，儘量在三天內寄出，如有任何疑問，請電(02)371-0074與我聯絡。謝謝您的熱忱協助與支持。敬祝

大　安

美國北愛荷華大學博士班
張存琴　敬啟

回答說明：
1.因各公司的情況不同，您只需依照貴公司目前的實際情況作答即可。
2.請在您所選的答案格上打勾。
3.下列各題請儘量作答，但因各公司的情況不同，若題目中所敘述的事項您實在不確定或不知道時，該題則可不 作答。
4.問卷中註明"可複選"的題目，可選擇一個以上的答案。
5.為保密起見，請不要在問卷中填入您的姓名。

1a. 貴廠員工總數為：
□ 少於 100 人　□ 100 -- 199 人之間　□ 200 -- 299 人之間
□ 300 -- 499人之間　□ 500 -- 999 人之間　□ 超過 1000 人

1b. 貴廠的主要產品為：
□ 電子元件製造業　□ 電子裝配業　□ 電子加工業
□ 電力機械器材製造修配業　□ 其　他________________
(請列舉說明)

2. 請問貴工廠是否使用"標準工時"？(註："標準工時"的定義是"完成某一特定工作所需要的時間量，此時間量是由身心健全、經過訓練，並對所使用的操作方法有經驗的作業員，在固定的工作環境下，使用固定的操作方法，以正常速度工作所需要的時間，並加入合理的寬放時間".(包括不可避免的延遲，私事寬放及疲勞寬放)
□ 是　□ 不是

3. 建立標準工時是否為貴部門的例行工作之一？
□ 是　□ 不是

4. 貴廠共有幾位工程師及技術員負責"動作與工時研究"的工作？

職　稱	人　數
工程師	______ 人
技術員	______ 人
其　他______________ (請列舉說明)	______ 人

5. 上述諸位工程師及技術員每星期實際花在"動作研究與工時研究"的時間平均約為每星期總工作時數的百分之多少？
約為百分之 _______

6. 正常情況下貴廠動作研究與工時研究人員及其他員工每星期工作總時數是：
□ 每星期工作時數：44小時　□ 每星期工作時數：48小時
□ 每星期工作時數：40小時　□ 其他________________
(請列舉說明)

7. 貴廠標準工時的主要用途是：(可複選)
☐ 用於獎工制度 ☐ 作為排定製造程序的依據 ☐ 用於預估成本
☐ 用於排定生產計劃及生產日程表 ☐ 其他 ____________________________
(請列舉說明)

下列三個問題均使用百分比作為量表，請在適用於貴廠的百分比下面打勾。所列之百分比表示工時研究方法或標準工時的使用頻率百分比。例如：0% 表示不使用，20% 表示有20% 的時間使用，...依此類推，100% 表示100% 的時間使用(即每次都使用)。

8. 貴廠使用下列哪幾種工時研究方法？(可複選)

	使用時間百分比					
	0%	20%	40%	60%	80%	100%
(1)馬錶測時	---	---	---	---	---	---
(2)MTM-1	---	---	---	---	---	---
(3)MTM-2	---	---	---	---	---	---
(4)Work Factor	---	---	---	---	---	---
(5)標準數據法	---	---	---	---	---	---
(6)電腦化工時研究	---	---	---	---	---	---
(7)其他 ____________ (請列舉說明)	---	---	---	---	---	---

9. 在企劃方面，貴廠的標準工時使用於下列哪幾項範圍？(可複選)

	使用時間百分比					
	0%	20%	40%	60%	80%	100%
(1)物料計劃	---	---	---	---	---	---
(2)生產計劃及排程	---	---	---	---	---	---
(3)產能計劃	---	---	---	---	---	---
(4)製造程序計劃	---	---	---	---	---	---
(5)採購計劃	---	---	---	---	---	---
(6)其他 ____________ (請列舉說明)	---	---	---	---	---	---

10. 在財務管理方面，貴廠的標準工時使用於下列哪幾項範圍？(可複選)

	使用時間百分比					
	0%	20%	40%	60%	80%	100%
(1)成本預估	---	---	---	---	---	---
(2)預算控制	---	---	---	---	---	---
(3)成本會計	---	---	---	---	---	---
(4)其他 ____________ (請列舉說明)	---	---	---	---	---	---

11. 貴廠的標準工時使用於下列哪些間接員工？(可複選)
☐ 生產線上的品管檢驗員 ☐ 非生產線上的其他品管檢驗員 ☐ 物料運送人員
☐ 物料運送員以外的其他物料管理員 ☐ 文書工作人員(如秘書、職員、書記等)
☐ 各級主管 ☐ 以上皆無 ☐ 其他 ______________________
(請列舉說明)

12. 貴廠是否採用獎工制度？直接人工有百分之幾實施獎工制度？
☐ 本廠不採用獎工制度 ☐ 少於20%的工作站採用獎工制度
☐ 約21% -- 40%的工作站採用獎工制度 ☐ 約41% -- 60%的工作站採用獎工制度
☐ 約61% -- 80% 的工作站採用獎工制度 ☐ 約81% --100%的工作站採用獎工制度

13. 貴廠實施動作與工時研究有哪些困難？(可複選)
☐ 從事動作與工時研究的工程師和技術員人數不夠 ☐ 動作與工時研究成本太高又費時
☐ 從事動作與工時研究的工程師和技術員,其專業技術(即動作與工時研究方面的技術)不足
☐ 高層管理人員不支持動作與工時研究的工作
☐ 實施動作與工時研究會引起工人的反彈及造成衝突事件
☐ 其他 __________________________________
(請列舉說明)

14. 您在目前服務的工廠從事動作與工時研究多久了？
☐ 2年以下　☐ 2 -- 4年　☐ 4年以上

15. 您從事動作與工時研究總共有多久？(包括服務於其他工廠)
☐ 2年以下　☐ 2 -- 4年　☐ 4年以上

下列五題是有關貴公司目前所採用有關動作與工時研究方面的訓練課程及項目，請您依照實際情況作答。

16. 您認為貴公司的工程師和技術員需要有關動作與工時研究方面的訓練嗎？
☐ 需要　☐ 不需要

17. 貴公司目前採用下列那種方式的動作與工時研究訓練課程？(可複選)
☐ 工程師和技術員在本公司內上課 ☐ 工程師和技術員參加大學舉辦的推廣教育班
☐ 工程師和技術員參加訓練機構所舉辦的課程，課程結束後可獲結業証明書或其他
證件(如MTM-1藍卡) ☐ Workshops ☐ 以上皆無(回答"以上皆無"者,請直接回答21-24題)
☐ 其他______________________
(請列舉說明)

18. 以訓練期間的時間長短而言，貴公司目前採用下列哪幾項？(可複選)
☐ 每次訓練課程約一天　☐ 每次訓練課程約一星期
☐ 每次訓練課程約一個月　☐ 其他______________________
(請列舉說明)

19. 貴公司目前所採用的訓練課程內容包括下列哪些項目？(可複選)
☐ 有關工作簡化的技術　☐ 有關 MTM 的技術　☐ 有關電腦化時間研究的技術
☐ 有關評比的技術(Rating，通常運用於馬錶測時中，即有關工人動作快慢百分比的評定)
☐ 有關生產線平衡的技術　☐ 其他________________________________
(請列舉說明)

20. 貴公司目前所採用的訓練課程，其經費來源為：
☐ 政府經費　☐ 公司本身經費　☐ 政府與公司分擔經費
☐ 其他機構補助______________
(請列舉說明)

下列各題是有關您心目中認為理想，並能適合貴公司需要的動作與時間研究訓練課程。

21. 您認為下列哪種方式的訓練課程最適合貴公司從事動作與時間研究的工程師與技術員？
☐ 工程師和技術員在本公司內上課 ☐ 工程師和技術員參加大學舉辦的推廣教育班
☐ 工程師和技術員參加訓練機構所舉辦的課程，課程結束後可獲結業証明書或其他
證件(如MTM-1藍卡) ☐ Workshops ☐ 其他______________________
(請列舉說明)

22. 以訓練期間的時間長短而言，您認為下列哪一項最適合貴公司的工程師與技術員？
☐ 每次訓練課程約一天　☐ 每次訓練課程約一星期
☐ 每次訓練課程約一個月　☐ 其他______________________
(請列舉說明)

23. 為配合貴公司工程師與技術員的需要，您認為訓練課程應該包含下列哪些內容？
☐ 有關工作簡化的技術　☐ 有關 MTM 的技術　☐ 有關電腦化時間研究的技術
☐ 有關評比的技術(Rating，通常運用於馬錶測時中，即有關工人動作快慢百分比的評定)
☐ 有關生產線平衡的技術　☐ 其他________________________________
(請列舉說明)

24. 您認為訓練課程的經費來源以下列哪一項最理想？
☐ 政府經費　☐ 公司本身經費　☐ 政府與公司分擔經費
☐ 其他機構補助______________
(請列舉說明)