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PRODUCTIVITY MEASUREMENT IN AIRCRAFT MAINTENANCE ORGANIZATIONS

THESIS

Billy J. Gililland, Captain, USAF

AFIT/GLM/LSM/90S-20

The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

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IN AIRCRAFT MAINTENANCE ORGANIZATIONS

THESIS

Presented to the Faculty of the School of Systems and Logistics

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Billy J. Gililland, B.S.

Captain, USAF

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PREFACE

I would like to acknowledge the help of my advisor, Major Jacob Simons, for his patience and guidance in this endeavor. This thesis is dedicated to Jackson L. and Sheila C. Gililland who taught me that with God's help all things are possible and whose example has been and continues to be my inspiration. Above all, I would like to thank Jenny Gililland for her unwavering love and support.

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Abstract

This research was undertaken to explore productivity measuremer. in aircraft maintenance units and to examine the relatior iips of the measures used to evaluate a unit's productivity. Review of current literature and regulatory guidance concerning productivity measurement provided the basis for the development of an interview questionnaire. A questionnaire was administered to DCMs and chiefs of analysis at ten MAC wings. Additionally, managers in the maintenance management, cost and manpower divisions at headquarters MAC were interviewed. From these interviews, information concerning current productivity measurement methodology was gathered and thirteen measures were identified for analysis. Of the thirteen measures evaluated, eight produced the strongest explainable model reflecting maintenance productivity. Manhours per flying hour was the predominant output when viewed as a result of the influence of mission capable rates and maintenance scheduling effectiveness. Cannibalization rates, delayed discrepancies (both awaiting parts and awaiting maintenance) and the average number of aircraft possessed were the inputs which appeared to contribute most significantly to mission capable rates and maintenance scheduling effectiveness.

PRODUCTIVITY MEASUREMENT IN AIRCRAFT MAINTENANCE ORGANIZATIONS

I. Introduction

General Issue

"Our productivity is the wonder of the world." This remark was made by President Dwight Eisenhower during his inaugural address, January 20, 1959. In the late 1950's the United States was indeed the world's industrial leader. We had vanquished the powers of totalitarianism in the second World War and successfully defended the first open challenge of communism to a democratic nation in Korea. Labor productivity growth was material and consistent. From the end of World War II until the mid 60's national labor productivity, in terms of the percentage of the populace employed and the gross national product, progressed at an annual average rate of 3.2%. However, the national growth rate slowed dramatically after 1965 and during the decade of the seventies with the average advance barely exceeding one percent. Productivity appeared to reach the worst point in the years between 1978 and 1982 when labor productivity actually deteriorated by an average of 0.2% per year. Although we experienced a slight comeback in the

80's, compared to other industrialized nations, the U.S. has not fared well (1:4-7).
Our labor productivity rate has been exceeded by virtually every other industrialized country in the world. With the current federal budget deficits of over 200 billion dollars, many economists are forecasting a major economic recession in the 1990's (2:35).

The economic outlook is not good for the U. S. Meanwhile the world is on the threshold of epic change. Eastern Europe is moving rapidly towards increased democratization as the Soviet empire is crumbling in the face of economic reality. The perception of a greatly reduced threat to national security has Congress demanding a smaller piece of the budget for Defense. Consequently, the Department of Defense is scrambling to salvage a viable defense plan in the face of a resounding claim by entitlement minded congressmen for the so-called "peace dividend" (3:43).

Air Force Secretary Donald B. Rice, during an interview conducted in the early part of 1990, suggested that the Air Force of the 1990's would be substantially smaller. The Secretary also pointed out that the U.S. has always maintained a clear advantage in the air war and remarked, "we don't want to contemplate" fighting under any other condition (4:12). Because of the reality of economic constraints, productivity is a major concern to the Air

Force, the DoD and the United States as a whole. In public organizations, productivity improvement has become increasingly important as the demand for quality services has increased faster than the tax revenues that support them. Many methods to enhance productivity have been examined, but little progress has been made. The absence of a widely accepted definition of productivity and specific measurement criteria has greatly frustrated the effort (5:5).

Problem Statement

Productivity in general, and specifically in service organizations is difficult to define. Therefore, measuring productivity is equally difficult. The Air Force has implemented Department of Defense productivity enhancement initiatives; however, it is unclear how performance efforts are affected by these initiatives.

Justification

Executive Order 12552, Productivity Improvement Program For The Federal Government, establishes a government wide program to improve the quality, timeliness, and efficiency of government services. President Reagan set a goal of a 20% productivity increase by 1992 (6:1). Air Force Regulation 25-3 reflects the attempt by the Department of the Air Force to support this goal. One of the objectives of the Productivity Enhancement Program, as outlined by this regulation, is to provide productivity data for use by functional managers at all organizational levels (7:2).

Aircraft maintenance is the most manpower intensive activity in the U. S. Air Force. It is the largest facet of logistics in terms of money, manpower, facilities or any other resource one might consider (8:17.23). Therefore, productivity measurement in aircraft maintenance is of extreme importance. In order to ensure achievement of the Air Force productivity goals the reliability and validity of productivity measures in aircraft maintenance organizations must be evaluated.

Research Objectives

Explore productivity measurement in United States Air Force aircraft maintenance organizations in order to:

1) Identify the measurement methods in use.

2) Understand the relationships among the various productivity measures.

3) Evaluate the effect of maintenance productivity measurement on the accomplishment of Air Force productivity objectives.

Research Questions

1) Are aircraft maintenance managers familiar with the Air Force guidance concerning productivity measurement?

2) What methods of productivity measurement have been specified by regulation for aircraft maintenance organizations?

3) Which of the specified methods of productivity measurement are actually implemented?

4) Are there methods of productivity measurement used by aircraft maintenance organizations other than those specified by regulation?

5) What are the nature and strengths of the relationships among the measures implemented by aircraft maintenance organizations?

6) Of the measures implemented by aircraft maintenance organizations, which contribute most significantly to explaining maintenance productivity?

Scope and Limitations

The scope of this research is limited to the Military Airlift Command's aircraft maintenance organizations. The following limitations apply to this research:

a) Various results may not apply to commands outside the scope of this project.

b) The complexity of the construct of "productivity" may confound the data based on differences in perceptions of those being interviewed, because the research itself is largely concerned with clarifying that very construct.

c) Interview input is limited to three areas: Major Command Division offices, wing level Deputy Commander's for Maintenance and their maintenance data analysis offices.

d) Individual data values from the Consolidated Aircraft Maintenance System for Airlift are subject to errors in accuracy.

Summary

This introductory chapter discussed the importance of productivity measurement in the DOD, the difficulty in determining the reliability and validity of productivity measurement data, the justification and scope of the research, and the research questions to be examined and answered.

Chapter II, Background, describes the development of productivity as a concept and a practical measure of performance. The background chapter provides a basic understanding of productivity in the context of history, common definitions and emerging application in industry.

II. Background

Before proceeding with an evaluation of productivity measurement in any environment, it is necessary to have the clearest possible understanding of productivity as a concept and as a performance measurement in practice. A review of industry related literature will equip the reader with a knowledge base from which to begin to evaluate the productivity measurement in a military environment. This chapter provides background information concerning productivity in the context of history, common definitions and emerging applications in industry.

A historical perspective of productivity measurement provides valuable insight into the relationship between changes in the national socio-economic structure and the changes in application of productivity measurement. Of particular interest is the motivation behind the changes that have occurred.

Examination of common definitions of productivity helps to clarify the concept in view of the many different ways the term is used. In this chapter productivity is defined from the perspectives of the accountant, engineer, and manager. A brief explanation of each definition is presented to reinforce understanding and to exhibit practical application.

As with any area of study and application, new concepts emerge over time. This chapter explores the most recent conceptual changes in the area of productivity measurement. The Total Quality Management (TQM) application of W. Edwards Deming and the Theory of Constraints as developed by Eliyahu Goldratt are examined. Deming's applications of TQM in service organizations are of particular interest as are Goldratt's views concerning efficiency and effectiveness. Together, these concepts serve to enhance the knowledge base used to examine productivity measurement as practiced by the Department of Defense and to later use as an analysis tool for qualitative evaluation.

Productivity - Historical Perspective

Current management thinking can best be understood in light of its historical development (9:2). Productivity as a management concept has evolved concurrently with the major trends in management. Although not specifically defined until the early twentieth century, productivity has always been a natural estimate of the success of a perceived effort. Early philosophers such as Plato and Aristotle taught many principles relating to management and the concern for the effective use of resources (10:385). The progression of management thought and its relation to the development of the productivity concept may be divided into four periods: (1) early influences, (2) scientific management, (3) human relations, and (4) refinement and synthesis.

Early Influences. Mosaic law is among the earliest of recorded history. It reflects an attempt to control the behavior of the Jewish society and to instruct the people concerning daily life. It could be said then, that the Ten Commandments of the Bible were the first recorded management principles. From the Ten Commandments, the Levitical law developed specific instructions for success. The principle was that as the people prospered individually they would return a portion to God through his emissaries, the priests. This served two purposes; to keep the effort focused on pleasing God and to build the infrastructure of the society.

> "Bring the whole tithe into the storehouse, that there may be food in my house. Test me in this," says the Lord Almighty, "and see if I will not throw open the floodgates of heaven and pour out so much blessing that you will not have room enough for it." (11:923)

The principle of increased blessing as a follow-on to diligent effort is prevalent throughout the Bible. Early philosophers sought to explain this principle in the absence of a God figure or to relate work and reward to man-centered precepts. Aristotle's "Organon" of logic, translated by Boethius (479-525 A.D.), became the basis for medieval thought. Logic means the art and method of correct thinking (12:156) The logician investigates the evidence of a relation between premises and conclusions in arguments. If the conclusion follows from, or is implied by the premise, the reasoning is correct; otherwise, it is incorrect (13:5). It soon became universally accepted that a productive society was one which worked hard and managed its resources correctly. The methods by which this was achieved varied greatly; but, for the most part, the age prior to scientific management was a period of tremendous extremes. The Roman Empire, the Roman Catholic Church and the early feudal system were examples of centralized management and the dependence upon authority and, even force, to maintain a productive society (14:617). The unifying thought of this age was the logical premise that hard work brought reward on earth and in heaven.

By the Fifteenth Century and with the development of the merchant city states, trade prospered in Europe. In order to defend the growing merchant fleets, naval fleets also grew. In 1436, Venice opened its own shipyard for the purpose of defense. The shipyard was known as the Arsenal; and by the Sixteenth Century, the Arsenal of Venice was probably the largest industrial plant in the world (15:78). It was here that history first records the use of assembly lines, standardization, warehousing, cost control and the close supervision of personnel. Warehouses were arranged along a canal so that the galleys could be brought to the equipment. All rigging and deck equipment was standardized so that few items had to be specially fitted. It was necessary not only to build new ships, but to repair or refit ships already in use. The Arsenal kept many items warehoused for this purpose. Personnel at the Arsenal were closely supervised, particularly concerning working hours and output. This close supervision along with the development of an efficient system to track the cost of inventory contributed to one of the most sophisticated organizations of that era. The modern organization, however, did not emerge until the late Eighteenth Century and the period known as the Industrial Revolution (16:434-442).

In the Sixteenth Century a period of tremendous change began to sweep Europe. Reformation of the, then dominant, Roman Catholic Church created an environment of new thinking and forever changed the acceptance of domination based on religious dogma. The advent of Protestantism and the doctrines of Martin Luther and John Calvin placed an emphasis on the freedom of man to seek God independent of the church. Along with this freedom came a new sense of nationalism in Europe and a new competitive spirit based on the Calvinistic belief that one's election into the kingdom of God was made sure by hard work. This belief is what has become known as the Protestant work ethic (17:400-405).

Because of the Reformation, the cultural climate in Europe favored the growth of commerce and industry. In particular, the English government was especially open and sensitive to the development of commerce. The English social values favored achievement and profit-making. In addition, England had ample supplies of coal and iron, essential ingredients of the industrialized society (18:115,117).

Before the development of the steam engine, England had a number of small but thriving industries in such areas as textiles and iron products. The introduction of the steam engine made it possible for the expansion of these industries by lowering production costs. As the markets expanded due to lower costs, there was a need for more production, machines, workers, and more capital to finance expansion. All these changes demanded new management practices and larger organizations. This industrial growth changed the culture in favor of expansion because of the implied promise of prosperity. These cultural changes came about as a result of the shift from home manufacturing to large scale factory production - the Industrial Revolution (19:41-45).

The Industrial Revolution continued and was transported to the United States in the late Eighteenth Century. The bountiful supply of raw materials and encouragement by the new representative government fed the development of industry and the need for more sophisticated forms of management. The idea continued to be the transformation of effort into reward. The development of interchangeable parts by Eli Whitney for the manufacture of firearms and the potential use of standardization to increase productive capacity grew at an ever increasing rate and perhaps culminated in the assembly line techniques developed by Henry Ford in the early Twentieth Century (20:216-235).

Scientific Management. In the early Twentieth Century, the United States was an industrial powerhouse. The national attributes which so ably transferred the Industrial Revolution from Europe continued to fuel the American industrial machinery. The national prosperity brought with it a re-examination of the concept of the nature of work and the relationships between labor and management. A new philosophy of management became widely accepted. This philosophy was based on the assumption that very few workers could handle or even wanted a high degree of autonomy on their jobs. Therefore, the simpler the task, the greater the output--this was the philosophy that started the Scientific Management Movement (21:93). Frederick Taylor is considered by many to be the man responsible for scientific management; although, in recent years his role has been somewhat disputed (20:37). Nevertheless, Taylor's book, "The Principles of Scientific Management," had a tremendous effect on management thought of that day and it continues to hold a very important place in management education.

It was Taylor and his contemporaries who first introduced the term "productivity" as a word describing industrial efficiency (22:312).

Taylor proposed that managers increase productivity by using four basic scientific principles:

1. Developing a true science of management to determine the most efficient method for performing each task.
2. Selecting the workers carefully and scientifically so that workers were given responsibility for performing the tasks for which they were best suited.
3. Educating and training workers scientifically to perform tasks in the best prescribed manner.
4. Arranging close cooperation between those who plan the work and those who do it to assure that all the work would be performed in strict accordance with the principles derived from scientific analysis.

Taylor believed that these principles would benefit the organization and the workers.

Taylor's work was shop-oriented and included many studies of methods to increase the output of individual workers. He was criticized as being just another "time study analyst" and this criticism led to his appearance before a special United States House Comm e charged with investigating the principles of the scientific management school. Taylor defended his ideas as the beginning of a mental revolution on the part of both workers and managers:

> "The great revolution that takes place in the mental attitude of the two parties under scientific management is that both sides take their eyes off the division of the surplus as the all-important matter, and together turn their attention toward increasing the size of the surplus until this surplus becomes so large that it is unnecessary to quarrel over how it shall be divided. They come to see when they stop pulling against one another, and instead both turn and push shoulder to shoulder in the same direction, the size of the surplus created by their joint efforts is truly outstanding." (23:63)

Taylor sought to eliminate the raw exercise of authority by making managers subject to rules and discipline as much as the workers. Management's job was to place the right worker in the right job according to scientific selection. Management "from the hip" gave way to the science of each task.

Frank and Lillian Gilbreth made significant contributions to scientific management in the fields of motion and time study (22:44). Henry Gantt studied habits in industry and developed improvements in Taylor's piece rate system. Gantt also made a substantial contribution to management planning and control processes through the development of scheduling charts which related facts to significant units of time (22:48). Harrington Emerson wrote two important books on the subject of efficiency. His work emphasized the importance of correct organization in the effort to achieve high productivity. He set forth a number of principles of efficiency which still apply (22:44-56).

With the growth of scientific management came the development of administrative management. As a result of greater efficiency in industry, organizations grew and became more complex. Because of this great growth, the need for an overall understanding of the management process became apparent. Henry Fayol, a French industrialist became one of the first and most prominent contributors to administrative management thinking. Fayol analyzed the manager's job in terms of universal commonalities. He identified five management functions: planning, organizing, commanding, coordinating and controlling. These functions are still widely used as one means of understanding the manager's tasks (24:4). The combination of scientific and administrative management served to place more emphasis on the skill of the manager and one's ability to get the best effort from the wor Unfortunately, scientific and administrative management tended to become one-sided. With the emphasis given to changes in methods and organization design for the sole purpose of improving productivity, little thought was given to the worker and his or her well-being (25:53).

It was during this period that productivity became synonymous with efficiency. The ratio of input to output of workers and processes became the prominent measure of performance. Continuous improvement in the efficiency of each step of the process of a plant became the organizational goal, and the desires of the worker were given ever-decreasing emphasis. The early 1900's was a period of plenty in the United States and the hunger for more drove the industrial machine to greater technology and less consideration for the human interests involved.

The excesses of the age in the market place and in the human arena lashed back at the American economy and the people. The vision of Taylor and others for a "new idea of cooperation and peace being substituted for the old idea of discord and war" in management/worker relations was never realized (26:211).

Human Relations. While scientific management was becoming the watchword for American industry, new studies were being developed that would drastically change the perception of the worker's role in industry and the methods by which organizations could become more productive (26:212). It became increasingly apparent that factors other than money motivated people and some employees were "self-starters" who did not need to be closely supervised.

The human relations school of thought had its beginnings in the late 1930's and the early 1940's. The basic idea was that worker performance is related to psychological and social factors rather than the physical environment. It revolutionized management thinking by focusing attention on the components of a job and worker satisfaction on the part of the employee (27:3). Attention shifted away from the scientific measurement of piece work toward a better understanding of the nature of interpersonal and group relationships on the job.

The human relations movement soon attracted wide attention in both academic and industrial circles. Many organizations revised their management approach to increase emphasis on the human factor (28:6). However, many proponents of human relations drew inferences from their research that were difficult to support. For example, some equated morale in an organization with productivity. Morale describes a person's satisfaction with membership in an organization. Productivity is related to many factors such as discipline, control and motivation, but in the total mix of these factors, morale may be relatively insignificant. No clear relationship appears to exist between morale and productivity (29:24).

One reason academia and industry gave such credence to the theory of human relations was that its effects were studied in a more "scientific" manner than were those of scientific management. Comparative studies such as those conducted at the Hawthorne Plant utilized experimental designs and drew conclusions based on the outcome of manipulation within these designs. Where the scientific managers were concerned with efficiencies, the human relationists studied behavior associated with efficiencies. They went a step further in their research by asking why things happened.

The human relations movement sought to respond to the excesses of the previous decades. The national economy was beginning a slow comeback from the Great Depression. Many people had experienced joblessness, while a very few remained economically solvent. Labor unions were a fact of life in the late Thirties and people were demanding fair treatment by industry and the protection of their rights by the government. However, human relations could not solve all the problems of management and by the late 1950's serious signs of disillusionment were widespread in industry. Some authorities even recommended returning to a philosophy of benevolent authoritarianism (30:82-90).

Refinement and Synthesis. In the late 1950's, managers began to understand that no single set of laws can be applied to all management problems. The methods of scientific management and human relations continued to advance into such areas as motion and time study, operations research and industrial relations. In addition, new concepts began to evolve by combining these approaches.

The last forty years have seen an advance in technology unlike any in history. These technological advances have allowed scientists and managers to create increasingly complex organizations and perform detailed analyses based on volumes of information. The contingency and systems approaches to management are two major concepts to emerge from this era (31:55).

Contingency theory recognizes that every organization exists in a unique environment. It attempts to analyze and understand the relationships between the organization and its environment with the purpose of taking specific management actions necessary to deal with problems. The contingency approach is analytical and situational and seeks to develop the most practical answer to the question (31:371).

The systems approach gives managers a way of looking at the organization as a whole that is greater than the sum of its parts. The term "system" refers to a series of interrelated and interdependent parts: in a system, any interaction of the parts affects the whole. A system has inputs, processes and outputs. There is constant feedback between the environment and the system. This allows for very accurate analysis tools. Managers can observe the effect of changes within the system based on the effects on its various parts. For example, in a manufacturing organization where the goal is to ship as many products as possible, a manager can observe the effect of robot installation on overall productivity and its effect on transportation and material handling. The manager may find it is best to not install robots or to install a small number of robots because the increased cost of material handling and transportation overcomes the benefits of the increased sales. Ideally, the systems approach would view the effect on all parts of the organization and make the decision by optimizing the effect on the whole organization (32:16).

During this refinement and synthesis period, productivity measurement has also become more complex. It is still thought of as a ratio of output to input in most cases, yet the number and importance of variables which make up the measurement differ within and among organizations.

Despite the advances in technology and the increased emphasis on productivity measurement, the late Sixties and the decade of the Seventies were periods of economic decline in the United States. A world recession, meager recovery and return to recession were major contributors to this decline. Additionally, the petroleum crisis and world competition spurred by technology also had a detrimental effect on the American economy. The net result has been a renewed search for productivity enhancement initiatives (34:135).

<u>Summary.</u> This section of background provided a historical perspective of productivity. We have learned that there has always been a concern for productivity in industry. From biblical times until the present, we have

sought to define, measure and enhance our ability to produce goods and services. The methodology and concern for productivity measures have continued to change based on the changes in the national economy and advances in technology. It seems that during periods of relative affluence American industry was content to stay with whatever seemed to be working. However, the major advances in management thought and productivity measurement have come as a result of hard times. Desperation seems to be the best stimulus for creative thought.

With each advance in technology and change in management concepts, we have become increasingly diverse. Today, there are still many different ways to view productivity and to apply measurement methods to assess performance. Hopefully, we have learned from history the importance of embracing new concepts without falling prey to faddish enthusiasm. The next section will examine three of the most common definitions of productivity in industry today.

Productivity - Three Common Definitions

What is productivity? This basic question has been pondered by government and industry since the term was first used in the early part of the Twentieth Century. Not only has the definition changed based on management trends, but also productivity may be defined according to the occupational background of the observer. In this section of the literature review, three common definitions of productivity are examined. First, the accountant's view of productivity is examined to provide an understanding of the cost accounting tools used to measure financial performance in organizations. Second, the engineer's perspective of productivity provides a scientific view in terms of machine efficiency and the attempt to apply this definition to complex organizations. Lastly, the manager's definition of productivity seeks to integrate all performance indicators into one basic measurement of multi or total factor productivity.

The Accountant's View. Accounting furnishes information which management needs in order to operate a business efficiently and meet its responsibilities to the owners of the enterprise, creditors, employees, government and the general public (35:32). Therefore, the accountant concerns himself with the financial welfare of the organization. Financial performance is measured and reported in three basic formats:

1. Historical reports
2. Current performance reports
3. Future performance reports

Historical reports summarize all transactions carried on by an organization in the past. They are used to make general, overall appraisals of the success of past operations. Current performance reports pertain to activities that are taking place at the time of the report. They measure the current efficiencies of certain key activities or operations at various levels of the organization. These reports aid in the control of the daily functions of the enterprise. Future reports are financial forecasts used to plan future operations. Together these reports say to the accountant, "This is what we have done in the past, this is how it is affecting our current performance and based on these trends, this is what we should do in the future." This is the basis for the cost accounting system which is prevalent in American industry (36:10.11-10.22).

Cost accounting is one aspect of general accounting procedures concerned with reporting and analyzing detailed cost information for internal management decisions. It provides answers to the following questions:

1. What kinds of costs are the company incurring?
2. What is the cost per unit and in total, for each of the different types of products manufactured or sold?
3. What portion of total cost is assignable to ending inventories and what portion to operating expenses?
4. What amount of cost is each department head or other manager responsible for?

5. How do the changes in output, product mix, climate, or other operating conditions affect the amount of costs?

The answers to these questions give managers insight into the cost-benefit ratio of their decisions (37:387-388). This type of financial data provides a primary source of input for decision making. In fact, cost accounting has been so fully integrated into productivity concepts that it is, many times, the only system for measuring performance. The idea is that if an organization minimizes the costs associated with all of its activities, the effect is maximum benefit in the form of higher profits (38:17). Most other definitions of productivity have become subordinate to this basic ratio expressed as:

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}} \qquad \frac{\text{Total Profit}}{\text{Total Cost}}$$

The accountant holds to the definition of productivity as a measure of efficiency and translates the ratio into dollars and cents (38:32).

The Engineer's View. Engineers are usually the technical problem solvers in an organization. They provide the human link between the scientist and the manager (39:1). Engineers most often work at the firm level where they design and implement work processes. Consequently, the engineer's perspective is typically limited to a micro view of productivity. The mechanical or industrial engineer is usually concerned with efficiencies in working groups or processes rather than the performance of the organization as a whole. Like the accountant, the engineer believes that efficient processes will yield an efficient organization (40:65-87).

The engineering approach to productivity is derived from the basic definition of mechanical efficiency:

$$\text{Mechanical Efficiency} = \frac{E}{E + L}$$

In this formula, E is the energy output of the machine and L is the energy lost in performing the output (41:422). For example, the efficiency of an electric motor is the ratio between the power delivered by the motor to the machinery which it drives, and the power it receives from the generator. If a motor receives 50 kilowatts from a generator and the output is only 47 kilowatts, then the machine is 94% efficient.

$$\frac{E}{E + L} = \frac{47 \text{ kw}}{50 \text{ kw}} = 94\%$$

A subtlety in this concept is the notion that perfect efficiency can never be better than 100%. While this may be true in the physical sense, financial efficiencies can and should exceed 100% so that an organization may show a profit (41:423). This subtlety indicates a potential barrier in the conceptual understanding of productivity in an organization. While the accountants are looking for a department with higher financial productivity in the form of reduced cost and accelerated throughput, the engineers may be convinced that the processes are at their peak efficiency.

Another way an engineer may view productivity is derived from the absolute efficiency formula:

$$\text{Absolute Efficiency} = \frac{E}{E1}$$

In this formula, E is the energy output of the machine and E1 is the total potential output. This formula is useful to the engineer when calculating efficiency in classes of machinery where the total potential output is much larger than that represented by the amount actually used to operate the machine (41:425). This concept has been extensively developed in the field of industrial engineering which is concerned with methods for calculating potential output standards. The practice of work measurement applies this principle to answer two basic questions:

1. What is the best way to do a particular job?
2. When this best method is used, what is the standard level of output to be expected, given the production environment, materials, labor force, etc.?

Work measurement and methods time measurement are the engineer's answer to the application of absolute efficiency to output efficiency or the productivity of an organization (41:36-39).

$$\text{Output Efficiency} = \frac{\text{Actual Output}}{\text{Potential Output}}$$

Considerable advances have been made in applying work measurement techniques to many different working environments. When engineered standards are not available or feasible, there are many other methods to define potential output. Some of these methods are the use of performance history, technical estimates made by knowledgeable individuals, or statistical samples (42:188-190).

While accepting the basic understanding of productivity as a ratio of output to input, the engineer's definition differs from the accountant's in terms of this perspective of the organization. Although both agree that efficient pieces contribute to an efficient whole, they differ somewhat on how this is to be achieved. The accountant looks for efficient costs where the engineer is inclined toward mechanical processes. The manager's task is to integrate these concepts into a broader and more useful definition of productivity.

The Manager's View. Productivity, in the view of American managers, is the relationship between the output of an organization and it's required inputs. While this definition is similar to those of the accountant and engineer, there is an important conceptual difference. Managers are concerned with the total health of an organization, including the welfare of the employees, the quality of products and the impact on the community and environment. This broad view of the organization has given rise to a definition of productivity which is much larger in focus than those already seen (44:23). Unlike the straightforward view of the productivity of a mechanical device, the complexity of an organization suggests a need for a macro-approach to measurement.

Three basic levels of productivity measurement are: (1) partial measure, (2) multi-factor, and (3) total factor (33:304). The three measures are differentiated based on the range of inputs included. If there is only one input, this is referred to as partial productivity. If there is more than one input, but not all available inputs are used, the result is multi-factor productivity. If all inputs are considered, the measure is called total factor productivity. The accepted belief in industry is that the more inputs one can consider when measuring productivity, the more useful the information will be. With the proliferation of computer systems in the United States, managers have a great deal of information with which to work (33:305).

A useful indicator of an organization's effectiveness in addressing productivity is the total productivity measure. Total productivity is defined as total output divided by the sum of all the inputs: (45:106)

$$\text{Total Productivity} = \frac{\text{Output}}{\text{Labor + Materials + Capital + Energy}}$$

Management's task is to bridge the gap from physical measures of operational control to the "big picture" needs of the entire organization. Productivity measures are needed for effective strategic planning: a strategic business plan is incomplete if productivity improvement is not an integral element of the plan.

One approach to measurement is illustrated by a report from a total performance measurement system developed by the American productivity center.

Table 1 Multi-factor Productivity (46:312)

	Performance Indexes (%)			Effects on Profit		
Input	Profitability	Productivity	Price Recovery	Profitability	Productivity	Price Recovery
Labor	91.5	112.0	81.7	$(3,307)	$3,511	$(6,818)
Material	88.3	97.9	90.3	(3,099)	(478)	(2,621)
Energy	87.8	113.6	77.3	(460)	367	(827)
Capital	106.4	100.7	107.7	2,196	261	1,935
Total	95.5	104.2	91.7	$(4,670)	$3,661	$(8,331)

The first three columns provide indexes of profitability (productivity x price recovery), productivity (outputs / inputs) and price recovery (the degree to which increases in unit costs of inputs are recovered by increases in selling prices), and for each of the major inputs and in total. By examining the "total" line, one can conclude that a 4.5% decline in profits (100-95.5) resulted from a large drop in price recovery (the company was not able to get through increases in input costs to the customer) which was partially offset by a 4.2% increase in total productivity. The last three columns of the report provide the dollar impact of the changes in the indexes. This information shows that a large percentage drop in the productivity of a minor input may be of less consequence than a smaller decline in a major input. A measurement system like this enables management to grasp the productivity performance of a company and its major components. It strengthens the planning process by making the long range impact of productivity and price recovery easy to understand (46:314).

While measurement is integral to the productivity management process, it is not a cure-all. There is no perfect system of measurement. Many activities within an organization are difficult to quantify and, in fact, may elude measurement altogether. For example, service organizations and government agencies produce outputs that are difficult to measure and where profit is not the objective. How does one measure customer service or national security? The manager must strive to balance the effect of these intangibles on organizational effectiveness. The total productivity measure is an attempt to control the broad concept of productivity by examining as many of the components of an organization as possible.

Summary. Productivity is defined in many different ways. The background of the observer and the level of responsibility one has in an organization are key determinants as to how one may view productivity and the measurement application one may attempt to implement. This section has examined three of the most common definitions of productivity. These different, yet associated views, help point out the complexity of productivity management.

Trends

Corporate America is constantly looking for "better margins," meaning larger profit. Increasing productivity in industry is one way of increasing profits; therefore, concern for industrial productivity enhancement has been on the rise. The major reason for the increase in concern of late is a result of the drastic economic slowdown of the 1970's. The conditions which contributed to this slowdown included a world recession, a meager recovery, another recession, extensive drought and the petroleum crisis. While the United States was increasing its national debt to survive, foreign competition, spurred by technological advances, was taking over traditionally American markets (47:61). In the 1980's, the American economy became increasingly service-oriented as the United States left more and more of the manufacturing to other countries (48:64).

Once again desperate times have created an environment ready for new ideas.

Two men have emerged with ideas which are changing the way Americans view business and productivity. In this section, the Total Quality Management concepts of W. Edwards Deming will be discussed in general and as they relate to service organizations. Also, the Theory of Constraints developed by Eliyahu Goldratt is examined. Together, these concepts represent prominent influences in current management thought and productivity concepts.

Total Quality Control. William Edwards Deming was born in the United States in 1900. At the age of fifty, he was invited to Japan to help revive its war-torn economy, but not until the 1980's was his expertise recognized in the United States. Today, "The Deming Management Method" is taught in most universities and industry is applying the Total Quality Control (TQC) concept proposed by Deming in an effort to regain the competitive position once held by the U.S. (49:3).

The basic premise of the Deming philosophy is that productivity increases with quality improvement and that low quality means high cost and loss of competitive position. Regardless of the particular view of productivity held, this philosophy is applicable.

For years, there has been a perceived conflict between quality and productivity in American industry. If quality was increased, productivity dropped off or vice versa. The consensus of management was to strike the balance by making quality standards only as good as they had to be, while pushing for as much production as possible (50:1). The fallacy of this tradeoff has been demonstrated by a loss of competitive position to foreign sources, especially in manufactured goods. The clear message from Japan and Germany is that quality products translate into increased market share. The predominant messenger for quality has been and remains W. Edwards Deming.

As a statistician, Dr. Deming has continuously sought to develop sources of improvement. Understanding that statistical evaluation is not a cure-all for quality problems, he concluded that what was needed was a change in basic management philosophy, but a philosophy which made effective use of statistical methods for quality control. Dr. Deming developed this philosophy as described in "The Fourteen Points" and " The Seven Deadly Diseases"(50:23). These items explain how to create an environment conducive to increased productivity and how to avoid the obstacles that thwart productivity.

"The Fourteen Points of Management"

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.

2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to

the challenge, must learn their responsibilities, and take on leadership for change.

3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.

5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.

6. Institute training on the job.

7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.

8. Drive out fear, so that everyone may work effectively for the company.

9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.

11a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.

b. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.

12a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.

b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, inter alia, abolishment of the annual or merit rating and of management by objective.

13. Institute a vigorous program of education and self-improvement.

14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.

"The Seven Deadly Diseases"

1. Lack of constancy of purpose to plan product and service that will have a market and keep the company in business, and provide jobs.

2. Emphasis on short-term profits: short-term thinking (just the opposite from constancy of purpose to stay in business), fed by fear of unfriendly takeover, and by push from bankers and owners for dividends.

3. Evaluation of performance, merit rating, or annual review.

4. Mobility of management; job hopping.

5. Management by use only of visible figures, with little or no consideration of figures that are unknown or unknowable. (Peculiar to industry in the U.S., and beyond the scope of this book.)

6. Excessive medical costs.

7. Excessive costs of liability, swelled by lawyers that work on contingency fees. (50:23-35)

Simply reviewing the framework behind the philosophy is not enough. To understand its application, it must be viewed at work in an organization. Because of the expansion of service industries in the American economy, application of the Deming Method will be viewed in the service sector.

A service organization is one which earns a profit by providing a convenience to a customer. Service organizations include restaurants, hotels, bars, banks, hospitals, maintenance and government agencies. Six out of seven people in the American labor force are engaged in service industries; therefore, it is obvious that for the quality of life to be improved in the United States, we must be concerned with the quality and productivity in services (51:185).

In his book, "Out of Crisis," Dr. Deming cites an example of TQC application in the municipal services of Madison, Wisconsin. In 1984, there were so many complaints about the quality of service in the Motor Equipment Division that morale had seriously declined. As a result, the mayor decided to transform the management of the division to emphasize improvement in the quality of customer service.

The mechanics employed in the division, through surveys and informal discussions, collected data concerning the major customer complaints. They found the overriding complaint to be excessive downtime of vehicles. The mechanics drew a flow diagram of the process for the repair of vehicles and collected data to determine how much time was needed to complete each step of the process.

By comparing the costs associated with major repair and the costs of simple maintenance procedures implemented to prevent major repairs, they justified the institution of a comprehensive maintenance program.

The application of the Deming method as these mechanics learned it, greatly improved the quality and productivity of their workcenter. Dr. Deming goes on to suggest that the same method can be applied in any fleet of vehicles. The emphasis was to create an environment which promoted the idea of doing things right the first time (50:245-247).

The U.S. quality movement has been slow to take hold. Total Quality Management is present at only a handful of leading U.S. companies and, for the most part, companies are implementing the concept on an independent basis. However, this philosophy is catching on and as the success of its implementation has grown, so has the call for more information. The nation's manufacturers, as well as service organizations in both the public and private sectors, are investing in TQM as a means to make "Made in America" a guarantee of quality once again (49:8-16). As Deming states in his book, "Quality, Productivity and Competitive Position":

> "The benefits of better quality through improvement of the process are not just better quality and the long-range improvement of market position that goes along with it, but greater productivity and much better profit as well." (51:3)

TQM brings together both the contingency and systems concepts of organizational management. It recognizes that every organization exists in a unique environment, and it attempts to view the organization as a whole greater than the sum of its parts. Productivity may, in this sense, be thought of as the effectiveness with which the resource inputs such as personnel, materials, machinery and information are translated into customer oriented outputs. Today, these outputs involve all the relevant marketing, engineering and service activities of the organization rather than just the activities of the laborers (52:389).

The output of service organizations is a level of perceived customer satisfaction. TQM is particularly well suited to explain and enhance this output because quality is a determination made by the customer. It is based upon the customers experience with the service measured against his or her requirements (52:6). Whether the service provided is a fast meal, electricity or national defense, the customer is the one who measures the quality of output and who thereby effects the organization's productivity.

The Theory of Constraints. Another emerging management philosophy in America industry is known as The Theory of Constraints (TOC). Initially implemented in the form of a production scheduling software, it has now developed into a comprehensive school of thought. Dr. Eliyahu Goldratt began by examining jobs scheduled through the manufacturing process while considering the limitations of facilities, machines, personnel or anything that caused a system to fall short of its performance objectives. TOC tells us that if we can identify the system constraint, learn how to exploit it, and then subordinate all other activities to maximize the efficiency of the constraint, the system's profit earning performance will increase dramatically (51:120-132).

TOC was developed in answer to the major problems facing manufacturing in the United States. Goldratt boiled these problems down to the general failure of the traditional cost accounting system predominant in American industry and the resulting emphasis on efficiencies. He believes that cost accounting as a performance measure is no longer valid because it forces managers to concentrate on local measures such as machine efficiency or direct labor hours. Therefore, cost accounting deals with only the local expense of actions and not the impact of these actions on the overall organization (53:37). The belief has always been that if each part of the process is efficient, the entire process will be effective.

Goldratt describes the problem faced by industry with an illustration known as "the hockey stick phenomenon." This phenomenon is a result of organizations rushing to meet quotas at the end of a time period. It is referred to as a hockey stick because the production process, when viewed graphically, looks like a hockey stick with a flat bottom and rapidly rising handle. The cause of the problem is that organizations use two sets of measures. As seen in figure 1, at the start of the period, efficiencies driven by cost accounting policies are used to determine how well standards are being maintained. These local measurements encourage releasing large amounts of material to minimize process set-ups and forcing each machine to reach its maximum efficiency. As the period continues, the organization becomes driven by another system of performance measurement: the pressure to sell products becomes the overriding concern. To ensure the quotas are met or a profit is shown, overtime is authorized, employees work weekends and general panic takes over the organization. As the end of the period passes, the cost accounting measures come back into use and efficiencies are once again the watchword (54:34).

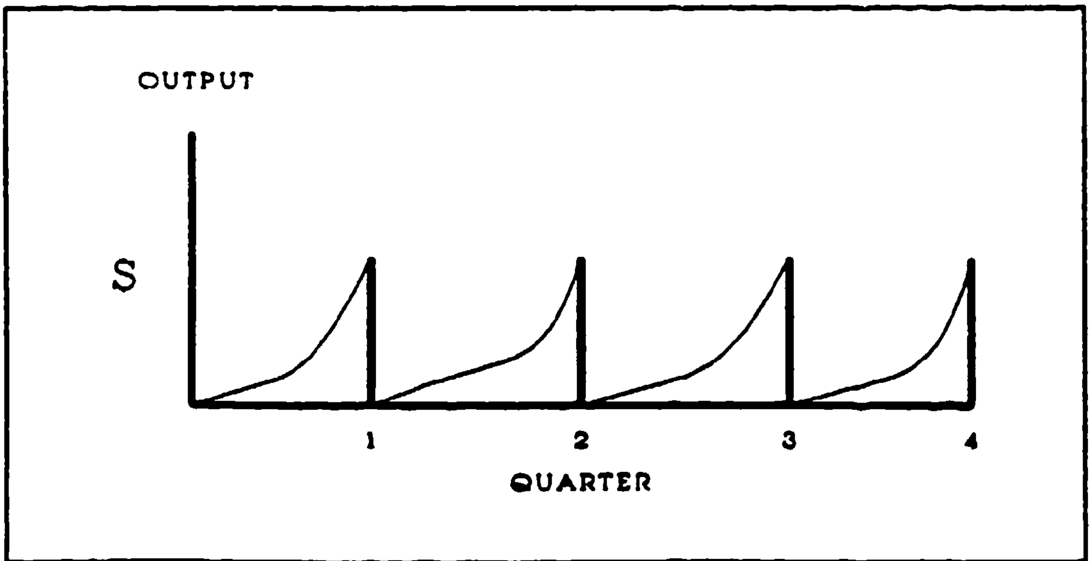

Figure 1 The Hockey Stick Phenomenon

The General Theory of Constraints suggests that each organization must define its goal and then realize that everything contributing to the goal is productivity and everything not contributing to the goal is counterproductive. According to Goldratt, productivity is all the actions that bring a company closer to its goals. He goes on to say that the goal of any firm is to make money (54:71-75).

Productivity is frequently viewed as a measure of output per labor hour, but this measurement does not ensure the organization will make money. For example, extra output can be produced and not sold, making this output excess inventory. If the product has not been sold, it has not made any money for the organization and, may in fact accrue additional expenses. Likewise, if each machine in a process is producing pieces at maximum efficiency, but these pieces do not come together as a product, then these efficiencies do not translate into profit (55:44-51).

TOC is based on the idea that to adequately measure an organization's performance, the evaluation should be made from a financial perspective and from an operational perspective.

In financial terms, organizations keep track of net profit, return on investment and cash flow. Goldratt defines each of these measurements, respectively, as an absolute measurement in dollars, a relative measure based on investment and a survival measurement. To evaluate an organization's performance, all three of these measures should be used. Viewing only one or two without the others will present a misleading picture of the organization's financial health. For instance, a company may show a high net profit but have a very low return on investment. Net profit and ROI may be high and the company could still go bankrupt because of a lack of cash flow to pay its bills (55:54).

Operational measures translate financial measurements into ideas that can be easily grasped at the productive level. It is not an easy task to motivate people on the shop floor by selling corporate financial goals. Recognizing this, the TOC has defined three operational measures which serve as guidance to those responsible for a firm's performance. Throughput is the rate at which money is generated by the system through sales. Inventory is all the money that the system has invested in purchasing things it intends to sell. Operating expenses include all the money that a system spends to turn inventory into throughput. With these three measurements, a company can determine how well it is meeting its goal. The operational goal then becomes to increase throughput while simultaneously reducing inventory and operating expense (56:55,56).

The critical factor in the Theory of Constraints is the absolute importance of measuring the right things. Organizational effectiveness is the dominant measure while efficiency is only a part of the overall picture. The success of the Japanese can be attributed to their measurement of organizational effectiveness based on long-term performance and not short-term financial reports or local performance measures.

In the Toyota Kanban system, the performance of a worker is based on meeting the schedule for the product each day and maintaining the flow of material as opposed to maximizing the number of parts produced. Worker idle time is an important part of the Kanban system. The idle time of workers provides time to clean work areas, conduct training and accomplish preventive maintenance. The Japanese recognize that the importance of a resource should be evaluated based on the system's performance and not local efficiencies (57:56).

The success of Dr. Goldratt's theory in practice offers strong evidence as to its validity. The important fact to note is that, like the Total Quality Management theory of W. Edwards Deming, TOC is based on the idea of continuing improvement. It is not simply a mechanical formula for success in manufacturing. The General Theory of Constraints is intuitive and applies in practice to any business venture. An organization must know its goal and subordinate all activities to that goal. The greatest challenge may be the development of a solid performance measurement system. Efficiency and effectiveness measures for an organization should exhibit a direct cause and effect relationship, not a correlation relationship. Efficiencies should be used very cautiously and great . . . should be taken when identifying how these efficiencie . . ect the productivity of the firm (59:57).

Chapter Summary

In this chapter, we have examined productivity both conceptually and practically. We have developed a background concerning productivity in the context of history, common definitions and current management trends.

We have seen the development of productivity in direct relation to changes in economies and political structures. Each step through history has added to the complexity of management as an impetus to motivate production. History describes a five thousand year series of swings in the productivity pendulum---always seeking a balance between the inherent right of the individual to a quality life and the overpowering momentum of progressive economies.

The advances of science and technology have given rise to increasingly complex definitions of productivity. We have defined productivity in the view of the accountant, the engineer and the manager. Each view seeks to answer the question, "What is productivity?" We believe that once we answer this question, we can manipulate it to our advantage. Instead, we see that the definitions offered by different viewpoints may conflict and can serve to confound the issue rather than clarify it.

Finally, we discussed the management trends in American industry and how they are changing the concept of productivity once again. Total Quality Management and the Theory of Constraints are philosophies of management which go back to the basics and at the same time utilize science and technology. Perhaps together, they have found the balance we have long sought. By combining statistical quality control and capacity planning with fundamental policies concerning goal planning and quality of life, we can almost begin to see an advantage for both the worker and the manager without extreme sacrifice for either.

III. Literature Review

Introduction

Having established a national, if not world concern for productivity growth in the preceding chapter, this literature review examines the federal government's approach to defining, measuring and managing productivity. Additionally, productivity research conducted within the Air Force and specifically dealing with aircraft maintenance is examined. The background study, accomplished in Chapter II, revealed that productivity as a management concept has continually changed throughout history and that it can be viewed differently depending on the perspective or technical orientation of the observer. The purpose of this chapter is to understand how the Department of Defense views productivity and how it translates this view into objectives to be accomplished by military organizations. The review of current research literature in this area establishes research trends and describes the attempts to apply the research conclusions to productivity in aircraft maintenance units.

The Executive Order for productivity improvement and resulting Department of Defense directives are first reviewed to establish basic definitions and guidelines for productivity improvement. Next, the Air Force Productivity Enhancement Program, governed by AFR 25-3, is presented.

This shows how the Air Force attempts to operationalize the concepts defined by the higher headquarter agencies. The Military Airlift Command regulations concerning maintenance management and performance standards are then introduced in order to exhibit published guidelines for managing productivity in an aircraft maintenance environment. Finally, a summary of the productivity research conducted in the Air Force is reviewed. Defense Technical Information Center (DTIC) annotated bibliographies and individual studies are evaluated to determine the current state of research in this area and to emphasize the need for a specific look at the methods used to manage productivity in Air Force aircraft maintenance units.

This review focuses on the relationship between productivity management and the Department of Defense. Except where necessary, specific detail has been omitted. The larger publications, such as AFR 25-3 and MACR 66-1 are generalized. The purpose is to point out how the concern for productivity is evident in a military environment and how that concern is or is not passed on to the aircraft maintenance units of the Military Airlift Command.

Productivity in the Federal Government

In February 1986, President Reagan released Executive Order 12552, entitled, Productivity Improvement Program for the Federal Government. The purpose of this order is to establish a government-wide program to address what many see as a productivity crisis in the United States. Labor costs per unit of output and the annual inflation rate since 1960 have risen rapidly. As the rate of increase in money income exceeds the rate of gain in worker productivity, the resulting rise in labor costs essentially reduces the number of items that can be produced. (59:655) Because of the unique role of the federal government in the national economy, it is critical that federal agencies be mindful of this crisis and lead American industry in the pursuit of productivity and economic growth (60:165).

Since the administration of President Franklin Roosevelt, the federal government has become a major factor in the national economy. Use of federal tax revenues to fund government services is common practice. Some economists argue that government injection of capital into the economy is the only way the nation has been able to maintain economic growth (59:268-270). These same economists feel that the only sure method for overcoming the current federal budget deficit is to increase the nation's productivity. The methods proposed for doing this differ greatly, but the important fact to note is that the federal government is seemingly seeking to take the lead in this endeavor.

> "The goal of the program shall be to improve the quality and timeliness of service to the public, and to achieve a 20 percent productivity increase in appropriate functions by 1992." (6:1)

Productivity is defined, in this order, as the efficiency with which resources are used to produce a government service or products at specified levels of quality and timeliness. (6:1) The order proceeds in very general terms to define services, measurement systems and performance standards. The complete executive order can be viewed as a source document in Appendix A. The important fact to be gained for this review is that this order gives no specific guidance for measuring and reporting an organization's productivity. Each federal agency must define its function as related to the entire federal system and establish its own measurement and reporting criteria. One must then wonder how, if each agency is allowed to measure productivity differently, the resulting improvement can be monitored at the federal level. Will the combined improvement contribute a similar increase in national productivity? If so, how is this to be measured?

In terms of the national economy, productivity is synonymous with "labor productivity." Labor productivity is measured in terms of worker output and is reported by the Bureau of Labor Statistics. It measures, on the average, what a worker produces per hour of work and is considered to be a good indicator of the trend in the growth rate for the nation's standard of living. (60:23) Next, we will review the Department of Defense directives which establish the policy for DOD productivity measurement and we will see how subordinate functions are to report productivity data to the Secretary of Defense and then to the Bureau of Labor Statistics.

Productivity in the DoD

The Department of Defense is responsible for providing the military forces needed to deter war and protect the security of our country. Each military department is organized separately under a civilian secretary and functions under the direction, authority and control of the Secretary of Defense. The secretary of a military department is responsible for efficient operation of the functions performed within the department and as they relate to the entire DoD (61:174).

DoD directive 5010.31, DoD Productivity Program, establishes policy, applicability and scope for fulfilling the requirement of the President's productivity program. It applies to all DoD components, but is specifically addressed to the support functions of these organizations. In essence, the policy is meant to focus management attention on increasing defense outputs in keeping with the defense preparedness mission (62:1). The program is established as a labor oriented program and is, therefore, focused on labor cost savings as well as reduction in unit cost of operations. It directs the establishment of productivity goals and a planned approach to productivity enhancement.

As part of the planned approach, the program emphasizes work measurement and statistical methods to measure workforce efficiency. It also suggests an aggressive and cohesive program to improve workforce motivation and the quality of working life (62:2).

Overall responsibility for the program is assigned to the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics). Additionally, the Assistant Secretary of Defense (Comptroller) is assigned the responsibility to ensure that productivity efforts are integrated into DoD resource management systems. These responsibilities, at both levels, are carried out by the issuance of further policy guidelines and more detailed definitions of terms (62:34). At this point, the number of DoD directives affecting the productivity program grows rapidly. Rather than attempt to review each one, we will remain fixed on the basic purpose which, at this point, is to show how the productivity program translates into measurement criteria and how the program continued down through the Department of the Air Force.

DoD Directive 5010.32 is the Productivity Enhancement, Measurement, and Evaluation Operating Guideline and Reporting Instruction. It is a general guideline and like 5010.31 applies to all DoD components. This instruction, however, specifies the goals, general guidelines and reporting requirements for the head of each component (63:1-4).

The establishment of annual productivity improvement goals consistent with DoD planning and programming guidelines, and the subdivision of these goals by major Command prior to the beginning of each fiscal year are the basic goals for each department head. Additionally, each component must implement a program which addresses specific minimum provisions (63:2). The following is a summary of these provisions:

A. Priority emphasis on productivity enhancement at all echelons.

B. Maximum use of existing resource system in productivity measurement and evaluation.

C. Systematic reviews of major functions to effect methods improvement and appropriate use of labor performance standards where used.

D. Effective capital investment planning.

E. Development and appropriate use of productivity evaluation indicators.

F. Accumulation of productivity data by major commands and operating agencies.

G. Utilization of productivity and performance data in the development of requirements and allocations of manpower and fund resources.

H. Optimum effective use of standard time data in the development and updating of labor performance standards.

I. Adequate staffing and training of personnel to sustain a viable Productivity Program.

J. Periodic field reviews to assess program effectiveness.

K. Productivity measurement and evaluation. (63:3)

Although the directive provides more specific guidance than seen before, it is clear that each component maintains a basic autonomy when establishing measurement criteria. Enclosures and additions to the directive provide explanations for the provisions listed above. They address productivity measurement and evaluation, fast pay-back capital investment opportunities, definitions of terms, and reporting procedures. Of these, the information important to this review is that addressing measurement, evaluation and reporting.

Enclosure #3 of 5010.34 structures the measurement and evaluation of productivity by major program or functional area to disclose trends on a year-to-year basis. This requires the establishment and use of summary level indicators intended to represent true measures of the primary mission of each functional area. The data needed to accomplish measurement and evaluation is to be gathered from existing data systems or the modification of existing systems (63:3,4).

Section VI of enclosure three lists functions and suggested indicators for measurement and evaluation. The following is an excerpt from this section pertaining to maintenance:

No.	Title/Scope	Suggested Indicators
E.11	Intermediate Maintenance Activities This area covers personnel engaged in maintenance and repair of equipment at installation level.	Number of end items processed
E.12	Depot Maintenance Activities This area covers personnel engaged in depot level maintenance and repair of equipment. (63:48)	Number of end items processed

This by no means limits maintenance organizations to this indicator nor does it list all types of maintenance activities. However, the list continues the objective of the program to measure labor productivity at a minimum. The reporting guidelines in Enclosure #4 continue on this basic objective. The forms used to report productivity data to the Bureau of Labor Statistics is sectioned into input/output figures and man-year summaries for each component. Samples of report forms and definitions of terms used in this directive are exhibited in Appendix B.

The DoD Directives addressing productivity are very general and deal mainly with labor efficiency. The purpose is to manage labor resources within DoD components to meet the national productivity objectives. However, in establishing the guidelines for the component agencies the productivity picture rapidly expands to include resources other than labor. Each component must build upon the rudimentary guidelines of the directives to establish more specific productivity programs while seeking to remain consistent with the national goal. The Air Force's Productivity Improvement Program is one attempt to do this.

Productivity in the Air Force

Air Force Regulation 25-3, Air Force Productivity Improvement Program (PIP), provides the framework for focusing and coordinating all productivity related programs in the Department of the Air Force. It applies to all Air Force units and activities including Air Force Reserve and Air National Guard and is intended to implement DoD Directive 5010.31 and DoD Instruction 5010.32 (7:1).

The regulation defines productivity as a measure of an organization's performance and includes both efficiency and effectiveness.

> "Productivity is doing things right (efficiency) and doing the right things (effectiveness)." (7:4)

The program objectives are to establish productivity awareness and promote the use of productivity planning, improvement, research, recognition and workforce motivation programs. Additionally, the program seeks to improve organizational effectiveness and efficiency and maintain a measurement system to evaluate performance (7:4).

Policy goals focus on total factor productivity improvement. The regulation reflects the recognition by the Air Force of the importance of monitoring labor productivity, but includes other factors such as equipment, process, energy, materials and facilities. The policy is to direct consideration of these factors toward supplementation of the existing planning, programming and budgeting system. Employing approved cost factors and data gathered by accepted work measurement methods makes it easier to defend requirements during Program Objective Memorandum (POM) and budget reviews. The use of existing management structures and the involvement of personnel are emphasized for productivity improvement. The regulation establishes as policy, avoidance of arbitrary reduction in resources, claiming that any reduction in resources should be accompanied by either a corresponding decrease in workload or a more efficient means of workload accomplishment (7:4,5).

Responsibility for implementation of AFR 25-3 is assigned to various offices at Air Staff and Major Command level. The Director of Maintenance and Supply is simply tasked to provide functional assistance for Productivity Enhancing Capital Investment Programs (PECI). Major commands are to appoint a productivity principle to serve as a focal point for productivity, take part in PECI programs, implement a Productivity Improvement Program and identify the productivity impact for submitted initiatives. Procedures for accomplishing these tasks are described in other chapters of the regulation. Rather than examine these in detail, we will look first at guidelines for productivity measurement and then at how the Air Force provides input to the Federal Productivity Measurement Project.

Chapter 2 of AFR 25-3 outlines PIP guidelines. The purpose of this chapter is to assist organizations in establishing and implementing PIP programs. This is the only direct reference to productivity measurement in the regulation. Here, organizations are encouraged to develop procedures for collecting and analyzing productivity data, but only in very general terms. It encourages micro and macro measurement systems which make effective use of available data and are simple in structure. (7:10)

> "The particular measurement system selected depends on the scope and depth of the productivity effort being measured and the specific needs of management." (7:10)

At this point we see that the major commands are still left much to their own devices for effecting measurement and evaluation programs.

The Air Force does have a role in the annual measurement of federal productivity as outlined in DoD Instruction 5010.34. Chapter 5 of AFR 25-3 describes this role and provides instruction for the Air Force Functional Offices of Primary Responsibility (OPR). The Air Staff productivity office provides data to the Bureau of Labor Statistics concerning trends in labor productivity for the public. Functional OPR's must report input/output data and man-year summaries to Air Staff which verifies the information, compiles it and submits it to the Bureau of Labor Statistics (7:31). The only OPR related to aircraft maintenance required to report as part of this program is the Depot Maintenance function at Headquarters, Air Force Logistics Command (7:60).

MAC Regulation 173-1 provides guidelines for the establishment of management performance standards. The objective of the MAC Management System as outlined by this regulation is to improve the Command's performance and effectiveness by identifying and resolving potential problems and encouraging corrective action. The responsibility for this program is given to the DCS/Comptroller and to the cost function at each level of management (65:1).

The performance standards are developed and monitored by the MAC Performance Standards Committee. This committee consists of representatives from each directorate at the Headquarters level. They review all standards annually and request data necessary to develop new standards. The published standards which apply to the aircraft maintenance field are:

1) Home Station Launch Reliability
2) Enroute Launch Reliability
3) Aircraft Mission Capable Goals (65:5-13)

For a detailed look at these standards and how they are derived, see Appendix C. As stated earlier in this section, a cohesive program for managing productivity information is not maintained at the Major Command level in the Air Force. MAC looks at productivity in various ways and includes productivity in the general "performance indicator" grouping (66:1).

There are three separate directorates at the headquarters MAC level which yield productivity information, and each one views productivity in a different way. The Programs and Resources Directorate is concerned with manpower and quality of life issues. It is in this directorate that the MAC Productivity Division is located. The MAC Comptroller views productivity issues in strict terms of cost accounting and measures it in terms of the efficient use of funds. The Logistics Directorate, of which aircraft maintenance is a large part, views productivity in terms of providing weapon systems in support of the airlift mission. Effective use of logistics resources is their major concern (66:1).

It is at this point that the Productivity Program for the DOD has the potential to loose cohesion. As the program is tracked to the major command level, the MAC supplement to AFR 25-3 is less than one half page in length and refers only to item additions to the basic regulation. There is no consolidated program for productivity in MAC and the MAC productivity office in the Management Engineering Division is concerned only with Fast Payback Capital Investment (FASCAP) and the suggestion program. (66:2)

General H. T. Johnson, the Commander in Chief of MAC has recognized the need for a single channel of information concerning productivity and has tasked LTC Hayden of the Policy and Doctrine division to establish a Total Quality Management (TQM) office for this purpose. LTC Hayden envisions the TQM program, Action Eagle, as an umbrella for all productivity programs. Its purpose is to establish an audit trail for productivity initiatives and bring them all together under the general measure of customer satisfaction (67:1).

Productivity in MAC Maintenance

MAC Regulation 66-1, Volumes I - VI set up the maintenance management system for all MAC activities which perform on- equipmentand off-equipment maintenance of aircraft and aircraft support equipment. Together, they provide the Wing level guidance to maintenance managers and their staffs for directing and controlling subordinate maintenance activities in compliance with command maintenance policies and operating instructions (68:1) Duties and responsibilities for all managers and guidelines for all workcenters are contained in these volumes. Volume II deals specifically with maintenance management and the Deputy Commander for Maintenance (DCM) (68:2).

DCM The MAC DCM has the overall responsibility for planning, scheduling, directing and controlling the maintenance function for a given Wing. Authority for achieving this responsibility is delegated to squadron commanders and various staff functions. Productivity planning and measurement take place at each of these levels for the purpose of meeting mission objectives. However, the DCM staff functions of Plans and Scheduling (P & S), Quality Assurance (QA) and Management Information Systems and Analysis (MIS & A) have the responsibility to report to the DCM concerning the ability of the maintenance organizations to meet mission requirements within specified limits of quality and timeliness (68:1-106).

P & S Plans and Scheduling is the DCM staff function tasked with representing the DCM in negotiations with the operations scheduling function to produce a flying and maintenance schedule which makes the most efficient use of resources (68:20). The operational planning cycle is accomplished through a series of scheduling meetings where the requirements of the operational mission are reconciled with scheduled and unscheduled maintenance to be accomplished.

Planning begins with a comparison of the unit's quarterly flying hour allocation against the projected airframe availability. The quarterly projection is then broken down into monthly planning schedules which reconcile the maintenance capabilities to known operational requirements. Weekly meetings are held by maintenance and operations to review the past week's accomplishments and refine the coming week's schedule.

Additionally, maintenance must plan long-range to ensure the proper and effective use of maintenance resources (68:20). The Maintenance Planning Cycle considers the planning and support of mission requirements, particularly the availability and serviceability of facilities, tools and equipment, and material. Long-range planning is needed to support future requirements such as Programmed Depot Maintenance (PDM) schedules, Time Compliance Technical Orders (TCTO), Quality Assurance activities and scheduled exercises (68:20).

Plans and Scheduling maps out the function of the maintenance complex for a given period of time. Production planning starts here, but it must be tracked and evaluated and compared to some standard before it translates into a performance indicator such as productivity (68:21).

MIS & A This function provides information to the DCM to evaluate how well the unit is meeting its requirements for flying and maintenance. The information gathered from data systems within the maintenance complex is analyzed to yield answers to questions posed by maintenance managers such as:

A. Were operations requirements realistic?

B. What were the causes of deviations from the operational and/or maintenance schedule?

C. Are particular systems or equipment items negatively impacting performance goals?

D. Are enough qualified maintenance personnel available to meet mission requirements? (68:106)

"The analysis process is defined as the methodical conversion of raw data into a form useful for managerial control. It begins when the data are first assembled and ends when they are applied for decision making or control." (68:106)

The overall objective is to provide information which will be used by maintenance managers to improve the maintenance operation. This is accomplished by viewing maintenance management reports, looking for trends and managing the information systems (68:80).

The information analyzed by MIS & A can be reported individually to concerned supervisors or directly to the DCM. MAC Reg 66-1 requires the MIS & A section to publish a maintenance digest which summarizes the performance of the maintenance complex for the preceding month. Again, the overall objective is to improve the maintenance operation by analyzing maintenance data (68:83).

Each unit must publish a maintenance digest each month and send a copy to the MIS & A office of the Logistics Maintenance Management Division at Headquarters MAC. At a minimum the digest must have the following information:

1. Home Station Air Abort Rate
2. Labor Hour/Flying Hour

3. Base Self-Sufficiency Capability
4. Top Ten Man-Hour Consumers
5. Top Ten Failures by Work Unit Code
6. Delayed Discrepancies/Average Possessed Aircraft
7. Cannibalization/Departure Rate (68:83)

Attachment #1 of MAC Reg 66-1 Volume II contains the formulas required to compute these measurements and others which may assist maintenance management in evaluating performance. Of these, only one refers directly to productivity. Productivity as defined by this formula measures the man hours documented in the Maintenance Data Collection System against the total available time to perform maintenance. For this formula and the others suggested for use by Attachment #1, see Appendix C.

QA The quality of maintenance is the concern of every individual working in the maintenance complex. The DCM tasks the Quality Assurance staff function with the responsibility of assessing equipment condition and personnel proficiency. This is accomplished through the Wing Quality Assurance Program (QAP) (68:62,64).

The QAP provides information to the DCM based on samples of unit equipment and personnel performance gathered by the inspection process. QA performs Quality Verification Inspections (QVI), Support Equipment Technical Inspections (SETI), Special Inspections (SI), document file inspections for aircraft, acceptance inspections for depot returns and personnel observations. Together these inspections and their evaluation provide a general view of the quality of maintenance performed by a unit.

QA is the primary technical advisor in a maintenance unit and it assists unit workcenters in the resolution of quality problems. It also assists the MIS & A section in developing a monthly condition summary. The summary includes trend analysis of inspections and personnel evaluations, a synopsis of inspection performance and Detected Safety Violations (DSV) by workcenter, and recommended corrective action (68:83).

QA is an important function in the management of a maintenance unit. The level of quality maintained in an organization reflects directly in its ability to produce (51:21). MAC's concern for quality is obvious in the emphasis which is placed on evaluating performance at the unit level, but for the most part, the quality information is not passed on to the Major Command. The information is routed to the Wing commander at the discretion of the DCM (68:62-71).

Previous Research

The Defense community has been studying productivity concepts and seeking to improve productivity performance for some time. Since the subject is included in many different fields of study, productivity related literature is found in many disciplines including engineering, accounting, economics, psychology, operations research and management.

Additionally, research has been conducted in many different types of organizations and at different organizational levels. There are studies of productivity at the DOD level as well as at the Major Command level. Large groups have been studied as have individuals and small working groups (69:68-80). Productivity improvement methods are usually tailored to meet the needs of specific functional areas or individual organizations. Those interested in productivity improvement must find the information for their particular problem from among hundreds of studies. For this reason, this review will be limited to the literature pertaining directly to productivity management in aircraft maintenance units.

Measurement Methods Productivity measurement has been approached in a number of ways. Some attempts to measure productivity in aircraft maintenance units have been constructed around multivariate effectiveness models. This approach to the study of organizational effectiveness attempts to build models which focus on relationships between important variables as they jointly influence organizational success. Such integrative models are generally comprehensive and attempt to account for a larger proportion of the variance in effectiveness. Additionally, they typically hypothesize how the variables under study relate to one another (69:73).

Macro Measurement In a study contracted by the Office of Naval Research in 1975, 17 multivariate models of organizational effectiveness were reviewed (70:10-13). The models were evaluated in terms of their basic evaluation criteria, their normative or descriptive nature, generalizability and derivation. Aircraft maintenance units were among the organizations to which the models were applied. Of the problems noted with this approach, the most significant were related to the overall relevance of the findings and the level of analysis performed.

The questions asked by the researchers were, "Do the models enhance the understanding of the daily activities of organizations" and "do they enable managers to make predictions which may affect productivity?" The study concluded that if such models do not contribute to the understanding of organizational structures, processes or behavior, they are of little value. Those considered to be most useful examined relationships between important variables within a systems framework capable of enhancing the understanding of organizational dynamics (70:13,14).

The study also noted that among models little integration was made between macro and micro models of performance and effectiveness. For example, a study may concentrate on organizational models or human factors within an organization, but seldom are the two levels examined as they contribute to another. Most models dealt exclusively on the macro level, ignoring the relationships among individual measures and productivity. The authors considered it of paramount importance to be able to tell managers in specific terms how they can improve their organization's effectiveness, thereby improving productivity. They felt the ability to make meaningful recommendations was not improved by looking at only the overview (70:14).

Suggestions for future work focused on the examination of operative goals. This involves identifying the intended goals of the organization as opposed to its "official goals" and then measuring the degree to which the intended goals are being achieved. The contention is that such an approach reduces reliance on value premises about what an organization should be doing and relies instead on what it is actually trying to do (70:15). The challenge, of course, is to identify the measures of goal achievement in quantitative terms.

Selection of the most significant variables from among the countless inputs into a productivity model is a problem addressed by a large body of research. Between 1972 and 1980, the Air Force Human Resources Laboratory either contracted or participated in approximately 120 studies dealing with productivity measurement. From those reviewed for this research, the majority were concerned with identifying valid measures to be evaluated. One such study conducted by Arizona State University dealt specifically with Air Force maintenance organizations (69:65-109). Of the studies reviewed, none dealt with analyzing current productivity measurement methodology in the aircraft maintenance environment. Instead, the studies concentrated on establishing new measurement methods.

Micro-Measurement The Arizona State University Department of Industrial Management Systems Engineering was contracted by the Air Force in 1980 to develop a planning model for Air Force Maintenance Organizations. Performance prediction equations for maintenance squadrons were generated using stepwise, multiple regression analysis. Three independent survey instruments were administered to samples of up to 180 maintenance technicians for the purpose of identifying dependent and independent variables to be used in the model development. Two basic variables were identified as model outputs; technician performance rate (speed of work) and performance quality. The models integrated 48 predictor variables related to performance, organizational structure, job tasks and personal characteristics. The resulting models provided predictions of squadron performance while emphasizing the significant factors which contributed to maintenance effectiveness (71:15-35). The study concentrated on the micro view of productivity as seen by the technicians involved in the daily maintenance activities. The view of the wing and command level managers were not considered in this research (71:45).

Integration In October 1980, the Air Force Human Resources Laboratory released a study by the Maryland Center for Productivity and Quality of Working Life which identified productivity measures at both the organizational and individual level. The object[illegible] of the study were to: clarify the meaning of productivity as it applies to Air Force Organizations, describe and critique different productivity measurement methods, and to describe a procedure for generating productivity measures in Air Force Organizations.

The study resulted in several conclusions significant to productivity measurement in aircraft maintenance units. Among these was the assertion that an organizational productivity measurement plan should include multiple measures of both efficiency and effectiveness. Additionally, efficiency and effectiveness measures should be developed for the key facets of mission performance. Recognizing the unlimited number of possible productivity measures, the study suggested care should be given to the selection of those measures which are judged to be most useful to a particular organization (5:76-82). In keeping with the research objectives, the study developed a methodology for generating productivity indicators. The results were incorporated into future studies and have been applied in various forms at Air Force organizations. However, the study did not address the usefulness of existing measures of productivity as they relate to desired productivity improvement.

Application In 1987 the University of Houston's Department of Psychology and Institute for Organizational Behavior Research conducted a field study using many of the precepts defined by earlier work (5:19-43). Robert Pritchard led a research team in developing a productivity measurement system to be tested at five operational units in the aircraft maintenance and supply functions of an Air Force base. The productivity measures derived from the system were used as a basis for feedback to the units. The feedback was presented to each unit and used for the purpose of setting goals and defining incentives (72:35-41). Results proved to be an effective way to measure and improve productivity. The study concluded that feedback increased productivity substantially and that goal setting enhanced productivity even more. However, incentives did not seem to improve productivity over what had already been gained. The conclusions most important to this research were those pertaining to the development and application of measures in the aircraft maintenance unit.

The Communication/Navigation (Com/Nav) branch of an Avionics Maintenance squadron was the test unit for the aircraft maintenance function. Meetings were held with the Com/Nav supervisors to identify outputs and methods of measurements. The outputs were called products and could be measured both qualitatively and quantitatively. For example, the supervisors considered one product to be the quality of repair. They chose to measure the success of providing this product by examining the number of items that were returned immediately after repair, and by examining the percentage of quality control inspections passed by the workcenter.

After developing a list of products and indicators, they established contingencies. The term contingency refers to the relationship between the amount of the indicator and the effectiveness of that amount of the indicator. This concept was derived from an earlier work by Tuttle dealing with productivity (5:76-103). Referring again to the product, quality of repair, and its indicator, percentage of passed quality inspections, contingencies establish the best and worst level of performance expected in that area. Once these performance limits are established for an indicator, they are viewed in relation to the affect on the overall effectiveness of the workcenter. In this way, each indicator is ranked according to its impact on organizational performance.

The system worked quite well when tested. Productivity, as defined by the contingencies, improved dramatically. However, a follow-up study on the same military organization concluded that supervisory interest had declined and the system had been discontinued (73:69-115).

The same approach to measurement and enhancement has been applied to other organizations, but only ones characterized by a highly controlled environment, such as a back shop or pure production function (74:1-18). These types of organizations are easier to study because of their controlled routine. However, the need still exists for an application in a more dynamic work environment. The study concluded that the primary reason for dropping the program was the assignment of new managers who did not see the program's merit. They said that it was too complicated and demanded too much additional time from supervisors who were already stressed for time. This follow up study, highlighted the need for an overall measure of productivity which would integrate the numerous measures in use, yet not serve to complicate an already exceedingly complex task.

Conclusion

Productivity management in the Federal Government and particularly in the DoD is a difficult task. The process begins by defining productivity in terms of labor output; however, at the operational level the definition becomes more complicated as the units seek to measure both efficiency and effectiveness. The resulting measures are numerous and are considered under the umbrella of performance indicators in general. MAC does not appear to provide information to the Federal Productivity Measurement Project and the multi-factor approach to productivity measurement suggested by AFR 25-3 is implemented only at the Wing level.

The Maintenance Management System in MAC utilizes the measurement and analysis of maintenance data to monitor unit performance based on Command standards. However, Command performance standards address only a few areas which could be viewed as productivity concerns. The majority of the responsibility for the evaluation of performance and the development of standards is left to the operational units.

Many studies have been done on productivity measurement. Those studies conducted in the military environment have, for the most part, been concerned with the micro view--understanding what makes individual workers more productive. The underlying idea is that if individual productivity is enhanced, organizational productivity improvement is sure to follow (5:61-73). Having the technician's view is indeed important; however, they have a very limited view of the overall mission of a unit. A more useful approach for evaluating productivity would be to identify pertinent measures based on the desired outputs of maintenance managers in relation to higher headquarters objectives. Once this assessment is made, one could then test the relationships between the individual measures of productivity and the overall productivity objectives of the unit.

IV. Methodology

Introduction

This chapter describes the method of research used to answer the research questions presented in chapter one. The purpose of this research was to explore the manner by which aircraft maintenance units measure productivity, identify the measurement methods in use and to understand their application. In order to accomplish a complete study of the problem as stated in the introductory chapter, the research was conducted in three stages. The first stage consisted of a background study and review of literature dealing with productivity management, both in general and more specifically within the DoD. The second stage of research consisted of telephone interviews with maintenance managers in MAC. The interviews were conducted to gain an understanding of management attitudes toward productivity measurement and to identify the specific measures implemented by the MAC wings. Finally, specific measurement data, identified by the interviews, were statistically analyzed. These exploratory efforts provided the information necessary to understand the theoretical relationships of the identified measures and suggest alternative methods for productivity measurement in aircraft maintenance units.

Stage 1: Background Study

The background study was conducted to identify the development of productivity management through historical review of management concepts, various definitions of productivity and current applications within the private sector. Implicit in the background study was the identification of measurement methods and their application as a part of productivity management. The sources for the background study were management texts, and journal articles.

After establishing an understanding of productivity management in the private sector, the researcher reviewed government documents establishing guidelines for productivity management within the public sector and specifically within the DoD. Directives and regulations were reviewed through each level of management from the Office of the President of the United States to the MAC aircraft maintenance units at the wing level. Additionally, DTIC documents were reviewed in order to determine what other research had been done in the area of productivity management within the DoD and specifically what research pertained to Air Force aircraft maintenance. The purpose of the literature review was to offer a comparison of productivity management methods in the DoD and to identify the measurement criteria at each level of command.

Stage 2: Interviews

Having developed a baseline of productivity management measures and applications in both the private sector and the DoD, the next logical step in the research was to determine how these measures were actually being applied within the MAC maintenance units. An interview instrument was developed and tested for this purpose. The researcher chose to use a structured interview but used open ended questions so that each answer could be explained fully and to ensure the respondent understood each question. The interview instrument was reviewed by AFIT faculty and revised to improve its content validity. A pretest of the instrument was then conducted at the 2750th Test Wing at Wright-Patterson AFB, Ohio. The Wing DCM and the chief of the maintenance analysis section were interviewed and further revisions made to the instrument. These revisions were intended to ensure the respondents understood productivity terms as defined by the Air Force. This strengthened the construct validity of the instrument. The resulting set of questions is included as Appendix E.

After initial interviews at the MAC headquarters to determine the flow of productivity information within the command, the comptroller, programs and resources and logistics directorates were contacted. Telephone interviews were scheduled with these directorates to establish how each interacted with the wings to monitor the command's productivity and to determine how the information from each directorate came together at the headquarters level.

Telephone interviews were then conducted with maintenance managers at ten MAC wings. The individuals contacted were Deputy Commanders for Maintenance or their designees and the Chiefs of the Wing Maintenance Analysis sections. The purpose of the interviews was to identify the measures in use at the wing level and to understand how the broadly defined concepts presented in the background study and literature review were actually being implemented. The DCM interviews gave an indication of the direction productivity management in each Wing was taking while the interviews with the Chiefs of Maintenance Analysis indicated specifically how these directions were being pursued.

Stage 3: Detailed Data Collection and Analysis

Evaluation of the measures specified in stage two as being used at the Wing level to manage productivity was conducted in three parts; data collection, quantitative analysis and qualitative analysis. The purpose of this analysis was to identify those measures most significant for the assessment of an aircraft maintenance units productivity.

It was necessary as part of this analysis to categorize each identified measure as either an input or an output. As stated in chapter III, the DOD definition of productivity is a ratio of inputs to outputs. Outputs are defined as the final products produced or services rendered in a measurable functional area. Inputs are defined as the amount of resources utilized to produce an output (63:34). Because it was unclear which of the identified measures was intended to be the best indicator of a unit's productivity, each measure categorized as an output was used as the dependant variable in a series of regression equations. The remaining measures functioned as independent variables.

From the information gathered by the telephone interviews, the thirteen most commonly used measures were identified. Of the ten wings interviewed, six were chosen to contribute data because they were networked into a central database management system monitored at HQ MAC. This made the data collection easier to accomplish because it could be gathered at one location. The remaining wings utilized local data systems which would have to be accessed individually. The time constraints of this research precluded gathering data from these wings.

Using the information gathered in the interviews and the researcher's personal experience of ten years in MAC aircraft maintenance, a logical model was developed. The purpose of the model was to categorize the thirteen measures as either inputs or outputs according to the DOD productivity definition and to establish the relationships among them. The model was then verified and validated through review by a total of five students and instructors at AFIT with experience in the aircraft maintenance career field. Suggested changes were made to the model based on their input and logical explanations were developed for each association of measures within the model. The basic intent was to establish preliminary theory as to how each measure contributed to the overall assessment of productivity within the maintenance units.

A correlation matrix of all the variables was programmed in the System for Elementary Statistical Analysis (SAS). The resulting associations served to either confirm or question the relationships among the measures first purposed by the logical model. Additionally, conclusions were drawn to identify redundant measures by logical interpretation of the matrix. The basic rationale for identifying redundancy was that if two measures were highly correlated with a third, and the two measures were highly correlated with each other, then the measures might be redundant (or collinear). Those measures seeming to indicate redundancy were then logically evaluated to determine if both assessed the same aspect of productivity. If so, the redundant measures were considered as candidates for elimination from the productivity models.

The next step was to revise the model to include only those measures which contributed best to the assessment of productivity. This step was performed by confirming the findings of the correlation analysis with an additional test using stepwise regression. To confirm the validity of the basic ascumption concerning redundant measures, all measures were regressed to each output measure. Stepwise regression using the backward elimination procedure was performed for the purpose of retaining only those measures which most significantly explained the variation of each output measure. The backward elimination process was used because it began with all the measures and eliminated each one as it was tested by itself and in interaction with the others. If more than one independent measure contributed in the same manner to the output measure, only that which contributed most significantly would be retained in the model. The measures which remained in the model were assumed to contribute the most to the explanation of the output (dependent) measure.

A stepwise regression was performed for each of the six measures identified as outputs. The model which was indicated to be most useful to explain the relationships of the various measures was compared to the original logical model. As the relationships of the variables were either confirmed or questioned, logical explanations were sought for practical validation. The output measure and contributing measures which tested most useful were determined to represent "The Productivity Model." The most significant output measure was substituted for productivity and the contributing measures were determined to be the best inputs to productivity in the context of this study. Finally, the revised model was tested for interaction among the measures and residual analysis was performed. The analysis of the residual plots for each measure confirmed or questioned the validity of the final logical model and further established the model's

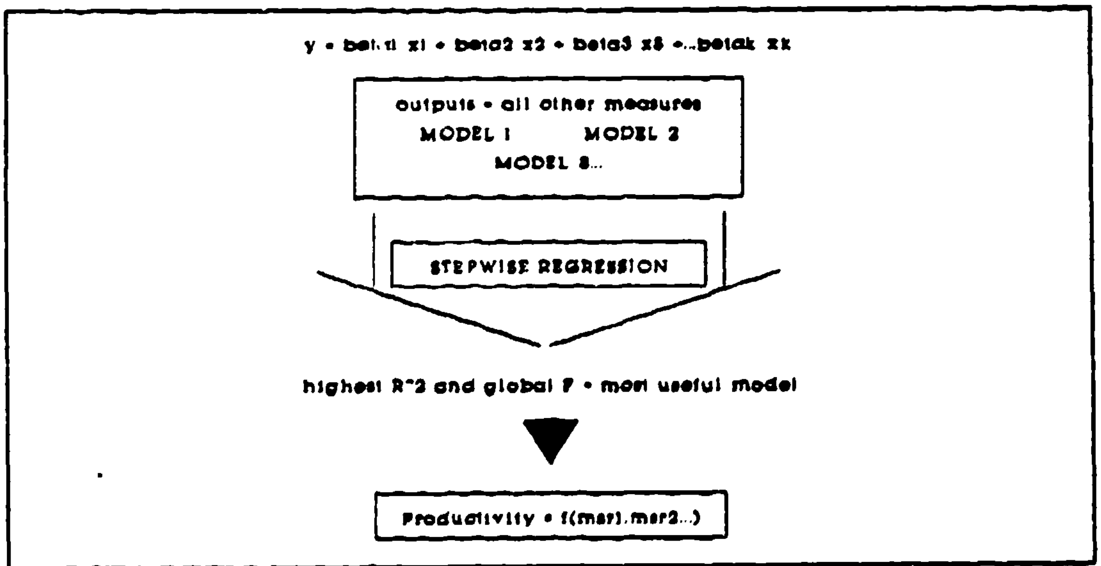

Figure 2 Stepwise Regression Analysis for Productivity Measures.

usefulness. Figure 2 demonstrates the logical flow of the preceding analysis.

The critical interpretation of the information gathered from the qualitative and quantitative analysis of the research data was accomplished by comparing the research findings to the information in the background study and literature review. A final comparison of the analysis results to what was learned about productivity in the public sector established the basis for conclusions and recommendations concerning the stated problem in keeping with the research objectives.

Summary

This study was conducted to explore the method of productivity management in aircraft maintenance units in the Military Airlift Command. The background study and literature review established the level of concern for productivity management in both the private and public sectors of the economy. Additionally, the methods of productivity management employed in the DOD and the U.S. Air Force were explored with emphasis on the identification of the required measurement methods as they are implemented at each level of command. Having established a baseline of information, maintenance managers from ten MAC wings were interviewed to identify how productivity is measured at the wing level and to establish how these measures are utilized for productivity management. As a result of these interviews, thirteen measures were identified and statistically analyzed. Simple correlation and stepwise regression were used to establish the relationships among the variables and to eliminate redundancy. The remaining measures were evaluated as to their logical usefulness for the explanation of productivity in aircraft maintenance units.

V. FINDINGS AND ANALYSIS

Introduction

This chapter presents the answers to the research questions posed in chapter I. The sources used to gather data consisted of a background study, literature review and telephone interviews. The review of regulatory guidance provided a view of current methodology for productivity measurement in the Military Airlift Command. Telephone interviews conducted with MAC maintenance managers confirmed the measurement methods actually used at the Wing level and established the flow of productivity information to the Major Command headquarters. Once the measurements were identified, six months of data for each measurement was gathered from the various wings and analyzed to determine the relationships among the measures as they effect productivity in aircraft maintenance units.

Current Productivity Measurement

Productivity management in the Federal Government is concerned with labor output. The presidential order which serves as the primary guidance for productivity improvement defines productivity as the efficient use of government resources to produce a desired output in the form of goods and services. Each DOD component gathers labor hour data and reports it to the Bureau of Labor Statistics to be used in conjunction with data from the private sector. Together these data inputs yield a national productivity figure for a given year.

Productivity data from the DOD components are gathered by functional area from existing data systems. Those gathered to measure Air Force aircraft maintenance productivity are primarily in the areas of intermediate and depot maintenance actions. These data are gathered from the Air Force Logistics Command and indicated by the number of items processed. The data is routed through the Air Staff where it is verified, compiled and submitted to the Bureau of labor Statistics.

In addition to the macro measurement of labor productivity, each Major command is responsible for establishing productivity goals and developing programs for managing productivity in compliance with AFR 25-3. The maintenance management system in MAC utilizes the measurement and analysis of maintenance data to improve unit performance based on Command standards. The Command standards deal specifically with departure reliability and mission capable rates. The responsibility for development and evaluation of performance standards which contribute to the effective and efficient performance of the operational mission is left to the operational units.

Each operational wing in MAC must comply with MACR 66-1 which establishes the maintenance management system. Included in this regulation are a number of suggested measures to assist in performance evaluation and enhancement.

Because of the broad definition of productivity as a measure of both efficiency and effectiveness, several measures are used by each wing maintenance activity. It is up to the unit to define the measures which help to evaluate the accomplishment of unit objectives.

Interview Conduct

Telephone interviews were conducted with wing level maintenance managers and directorate level managers at HQ MAC. Wing Deputy Commanders for Maintenance or those whom they designate and Chiefs of the maintenance data analysis sections were asked a series of questions to establish the level of familiarity with productivity initiatives in the Air Force, identify specific productivity measures used by aircraft maintenance units and to explain their opinions concerning productivity management at the wing level. Managers within the comptroller, programs and resources and logistics directorates were asked the same series of questions to establish the flow of information from the wings to the HQ and how the information is used once received.

Twenty three interviews were conducted. Three were conducted within the Directorates at HQ MAC while the remaining twenty were split evenly among DCM's and Chief's of analysis at ten MAC Wings. The following narratives are summaries of the responses dealing specifically with the research questions as presented in chapter I.

Interview Findings

Research Question 1: Are aircraft maintenance managers familiar with Air Force guidance concerning productivity measurement?

Finding 1: Fifty percent of those interviewed were not familiar with AFR 25-3, the Air Force Productivity Enhancement Program. Of those familiar with the regulation, the majority thought of it as a continuation of the Model Installation and Suggestion programs. There was no detailed knowledge of regulatory guidance for the measurement of productivity at either the Major Command or Wing level.

When asked which aspect of productivity concerned them most, efficiency or effectiveness, the responses varied by functional grouping. The DCM's responded overwhelmingly that effectiveness was the primary issue in productivity measurement. The maintenance data analysts and HQ level managers felt both issues were of equal importance. In general, all groups agreed that efficiency would become increasingly important with the current defense reduction.

Thirteen of the twenty three respondents considered productivity measurement to be an important issue. They believe quantitative measurement of maintenance data to be the only valid method of tracking the overall performance of a unit. Those who did not consider productivity measurement to be an important issue cited problems with the Maintenance Data Collection System. Many felt the MDC system was too subject to error for the resulting measures to be truly valid. The respondent from the Comptroller Directorate explained that aircraft maintenance had little input to the command level productivity picture. He claimed productivity is a function of cost and is measured by the ratio of cost per unit of support. Although the aircraft maintenance function does factor into the cost of support, productivity management emphasis is placed on cost management as opposed to the individual support processes.

Research Question 2: What methods of productivity measurement have been specified by regulation for aircraft maintenance units?

Finding 2: The respondent from the Comptroller Directorate was the only one from the HQ level aware of a specified measure for aircraft maintenance productivity. Supply cost per flying hour is the input associated with aircraft maintenance. It is reported by the Resource manager at each wing to HQ MAC. The DCM's did not have specific knowledge of required measures, but felt that departure reliability and mission capable rates were the measures of greatest concern to MAC. The maintenance data analysts referred to MACR 66-1, Volume II as listing the requirements for productivity measurement. Paragraph 4-14 of this regulation lists seven reports which must be generated for inclusion in the monthly maintenance digest. These reports are viewed by maintenance managers as meas ~es of productivity. For the remainder of this study the reports will be referred to as productivity measures. The required measures of productivity are:

1. manhour per flying hour
2. cannibalization actions per aircraft
3. awaiting maintenance discrepancies
4. awaiting parts discrepancies
5. maintenance air aborts
6. base self sufficiency
7. high component failures/work hour consumers

Research Question 3: Which of the specified methods of productivity measurement are actually implemented?

Finding 3: The purpose of this question was to discover if the measures actually in use at the wing level were consistent with regulatory guidance; therefore, only wing level responses were recorded. The majority of respondents in both functional groups at the wing level stated that all required measures were reported and used by maintenance managers. The remaining respondents agreed that all required measures are reported, but they asserted that their actual use is situational. For example, if awaiting maintenance discrepancies exhibit an upward trend over time, only then do they become an item of interest. They also cautioned that no measure should be used in isolation for productivity measurement. All respondents agreed that the measures in use must be viewed together as in the multi-factored approach.

Research Question 4: Are there methods of productivity measurement used by aircraft maintenance organizations other than those specified by regulation?

Finding 4: There are measures in use in addition to those required by regulation. Mission capable rates and departure reliability rates, although not included in the list of required measures, are reported by every MAC wing. Departure reliability has been the traditional measure of effectiveness in MAC. However, in an effort to standardize the measure of effectiveness across commands in the Air Force, mission capable rates have been increasingly emphasized. Appendix F exhibits the correspondence between the Department of the Air Force and HQ MAC which established the requirement for this emphasis. Appendix G lists the measures gathered and reported by each wing interviewed.

Statistical Analysis and Findings

Research Question 5: What are the nature and strength of the relationships among the measures implemented by aircraft maintenance organizations?

Finding 5: To answer this question the thirteen most common measures used by MAC aircraft maintenance units were chosen and categorized as either input or output measures contributing to an overall measure of productivity as explained in chapter IV. A logical model was developed from these measures and validated by the statistical analysis of data gathered in each measurement area.

A Priori Logical Analysis. The logical model presented in Figure 3 is a representation of the thirteen productivity measures most used by MAC. In parenthesis, between each measure, is a negative or positive symbol which represents the logical relationships among the measures.

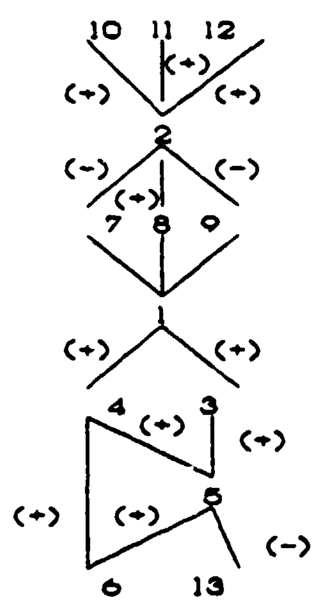

Figure 3 A Priori Logical Model for MAC Productivity Measures

The absence of a symbol between measures (e.g. 1 and 7) indicates that the relationship was not apparent to the researcher.

Table 2 MAC Productivity Measures

OUTPUT

Nomenclature	Variable name
labor hour/flying hour	msr1
mission capable rate	msr2
repeat/reoccurring discrepancies	msr7
maintenance scheduling effectiveness	msr8
maintenance air aborts	msr9
homestation reliability	msr10
enroute reliability	msr11
training reliability	msr12

INPUT

Nomenclature	Variable name
cannibalization	msr3
awaiting maintenance discrepancies	msr4
awaiting parts discrepancies	msr5
average possessed aircraft	msr6
base self sufficiency	msr13

Measurement categories. The preceeding table exhibits the thirteen measures chosen for analysis. The nomenclature and corresponding variable name is identified for each measure. Additionally, the table exhibits how each measure was categorized as input or output in terms of its contribution to the basic productivity definition.

Recognizing the complexity of the relationships among the measures shown, the model in Figure 3 is simplified to show those relationships that are most obvious. The model assumes that the measures positioned at the lower levels of the figure contribute to those positioned above them. The measures at the bottom of the figure are considered to be the basic inputs which contribute to each measure above as indicated by the connecting lines. The measures at the top of the figure are the final outputs of the model.

Base self sufficiency (msr13) is the measure of a units ability to repair assets and return them to use. Msr13 and the average number of possessed aircraft (msr6) represent the basic model inputs. These measures will affect all other measures in the model, either directly, as in msr5 or through other measures, as in msr1.

Awaiting parts discrepancies (msr5) are aircraft discrepancies which have been troubleshot by maintenance personnel, but cannot be repaired until a specific part is received from supply. This measure represents the responsiveness of the supply system to maintenance requirements. It is directly affected by msr13 and msr6. The number of possessed aircraft at any given time (msr6) will affect the number of awaiting parts discrepancies by increasing or decreasing the demand for parts from supply. F rthermore, as the base intermediate repair facilities eturn more items to use (msr13) the demand on supply is reduced which in turn reduces the number of awaiting parts discrepancies.

The average number of aircraft possessed by a wing (msr6) and the awaiting parts discrepancies (msr5) contribute to the number of discrepancies awaiting maintenance (msr4). Discrepancies awaiting parts become awaiting maintenance once the parts are received and until the repair task is completed. Also, because an aircraft system may be awaiting parts for one component while other components in the system also require maintenance, the repair of the entire system (all bad components) may not be accomplished until the part in question is received. Each aircraft possessed by a wing represents some potential number of maintenance tasks. The number of tasks increase or decrease with the number of aircraft possessed (msr6) as do the number of discrepancies awaiting parts (msr5) and maintenance (msr4).

Manhour per flying hour (msr1) represents the maintenance effort expended to sustain an aircraft for one hour of flight. The model indicates that awaiting maintenance discrepancies (msr4) and the number of cannibalization per aircraft (msr3) have a direct affect on msr1. These measures represent the total maintenance effort. All awaiting maintenance discrepancies represent potential manhour consuming tasks. Likewise, every completed task was at one time recorded as an item awaiting maintenance. Therefore, an increase in msr4 will cause in increase in msr1.

Cannibalizations are a result of the inability of supply to provide the needed parts. An increase in msr5 may result in an increase in msr3 as parts are taken from other aircraft to make up for the lack of parts in the supply system. These cannibalization actions add to the manhour per flying hour rate for a given wing.

The next level of relationships in the model is somewhat unclear. The model shows that msr1 contributes to mission capable rates (msr2) via repeat/reoccurring discrepancies (msr7), maintenance scheduling effectiveness (msr8), and maintenance air aborts (msr9). However, it is unclear whether the net relationships are positive or negative. For example, does more maintenance effort (msr1) decrease the number of repeat/reoccurring discrepancies (msr7), or does the increased requirement for maintenance suggested by a higher manhour per flying hour rate increase repeat/ reoccurring discrepancies? Maintenance scheduling effectiveness (msr8) measures a unit's ability to meet the periodic maintenance schedule. Maintenance air aborts (msr9) are those aircraft which must return to base because of maintenance problems encountered after takeoff.

Measures seven, eight and nine directly affect the mission capable rate (msr2). As repeat/reoccurring discrepancies and maintenance air aborts increase, a unit's ability to provide mission capable aircraft is decreased. However, maintenance scheduling effectiveness positively affects mission capable rates. Aircraft are required to be inspected and maintained at certain intervals. The aircraft cannot be declared mission capable if these periodic inspections and the resulting maintenance is not completed.

The upper portion of the model represents the final output of the total maintenance effort. Departure reliability rates are the traditional measure of maintenance productivity in MAC. Homestation, enroute and training departure reliability are represented in the model as msr10, msr11 and msr12 respectively. Mission capable rates (msr2) impact each of the departure reliability rates for any given wing. The more aircraft a unit has ready to perform the required mission, the more likely the aircraft will takeoff on time. On time takeoffs are the bottom line measure of a units productivity in terms of effectiveness.

Correlational Analysis. Figure 4 exhibits a comparison of the a priori logical model and the same model after correlational analysis. The numbers on the right-hand model represent the actual strength and nature of the original relationships. The correlation matrix from which these figures were extracted is presented in Appendix H.

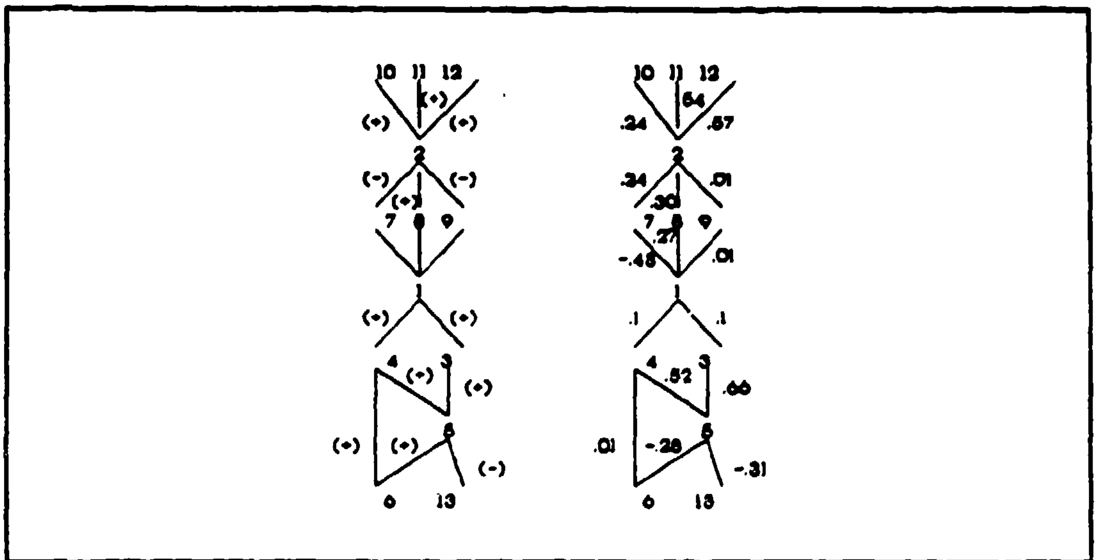

Figure 4 A Comparison of the Logical Model Before and After Correlational Analysis

It is readily apparent that associations assumed to be logical in the priori model are not uniformly upheld by the correlational analysis. Ten of the thirteen posited relationships appeared to be either strongly or marginally supported. However, the a priori model suggests a positive relationship between msr6 and msr5, while the correlation analysis exhibits a negative relationship between these measures. This relationship indicates that awaiting parts discrepancies increase as average possessed aircraft decrease. Likewise, the relationships shown between msr2 and msr7, and msr2 and msr9 after correlational analysis do not agree with the general understanding of these measures.

The correlations suggest that the associations between these measures are positive. In other words, as repeat/ reoccurring discrepancies and maintenance air aborts increase, the unit's mission capable rates seem to increase.

Another observation to be made from the comparison of these models is the relatively weak correlations among some measures. The a priori model is based upon the assumption that these measures have significant associations. Logic suggests that the association between average possessed aircraft and awaiting maintenance discrepancies is reasonably strong. As a unit possesses more aircraft the requirement for maintenance tasks will most likely increase which will in turn increase the number of awaiting maintenance discrepancies. However, the correlational analysis shows the association between these measures to be very weak. Instead, the strongest association with awaiting maintenance discrepancies seems to be cannibalization.

In light of these counter-intuitive findings, the analysis suggests that the associations between the measures are either much more complex than originally thought or that many of the measures may provide redundant information. After viewing the correlation matrix presented in Appendix H, redundancies appeared possible between the following pairs of variables:

1. mission capable rates and cannibalization (-.552)

2. cannibalization and awaiting parts discrepancies (.664)

3. enroute and training reliability (.348)

The above information suggests that mission capable rates, cannibalization and awaiting parts discrepancies may largely overlap in terms of the information they convey to managers. Having understood that awaiting parts discrepancies are an indication of supply's ability to provide the needed parts to maintenance, it follows that cannibalization and mission capable rates may be considered follow-on indicators of supply support.

Reliability rates measure the overall effectiveness of a units maintenance effort. Traditionally, homestation reliability has been the primary performance indicator for a MAC wing. However, homestation reliability can be manipulated by the local maintenance managers. Cannibalization of parts, replacing aircraft with scheduled spares and expediting priority tasks are all ways of ensuring high homestation reliability rates.

Enroute reliability is more of an indication of an aircraft ability to perform the mission because it is not subject to the same level of manipulation. Therefore, enroute reliability rates may be a better indicator of the quality of maintenance performed at homestation as it sustains the aircraft in the system. Training reliability has the lowest priority at homestation. A high training reliability rate also indicates high quality maintenance. If the low priority missions are reliable, then the overall reliability of the unit's aircraft will likely be high as well. Consequently, both training and enroute reliability rates may be good indicators of a unit's maintenance effectiveness and quality level.

Research Question 6: Of the measures implemented by aircraft maintenance organizations, which contribute most significantly to explaining maintenance productivity?

Finding 6: Stepwise regression was used to evaluate the model which best described a maintenance units productivity. Redundant measures do not appear in the resulting models because the stepwise elimination of the measures will retain only those that are most significant. Several models were tested. Table 3 exhibits the dependant variable, the significant measures, R-square and global F values for each model tested. The regression analysis output is presented in Appendix I.

The information in Table 3 exhibits the most significant measures for each of the output measures identified. Of the eight models tested, manhour per flying hour has the highest R square and global F values. The R square value of 95% represents the fraction of the sample variation of the dependent variable that is attributable to

Table 3 Comparison of Stepwise Regression Results for MAC Productivity Measures

DEPENDANT VAR. (productivity)	SIGNIFICANT MEASURES (0.01 level of sig.)	Rsquare	Global F (prob>F)
manhour/flying hr (msr1)	Base 1,3,4,5,6 msr2 msr8	0.959	79.63 (0.0001)
mission capable rates (msr2)	Base 1,2,3,6 msr3 msr4 msr5 msr6	0.734	13.48 (0.0001)
repeat/reoccurring discrepancies (msr7)	Base 1,2,3,4,6,7 msr2 msr4 msr6	0.828	17.90 (0.0001)
maintenance sched effectiveness (msr8)	Base 3,6,7 msr5	0.562	13.84 (0.0001)
maintenance air aborts (msr9)	none	0	0
homestation rel. (msr10)	Base 6 msr5 msr6 msr13	0.429	5.84 (0.0013)
enroute rel. (msr11)	Base 1,3,4,5,6 msr4	0.588	5.73 (0.0003)
training rel. (msr12)	Base 1,3,6 msr3 msr4 msr5 msr13	0.515	6.08 (0.0001)

the dependant variables in the regression model. In general, the larger the R square value is, the better the model fits the data. The global F statistic is the result of the test of global usefulness for each model. According to the information in table 3, 80% of the variability of the data is explained by the manhour per flying hour model with a 99% level of confidence. The form of this model is shown as:

productivity: msr1 = 71.27 + 125.45 b1 - 19.16 b3 - 22.58 b4 - 32.09 b5 - 31.99 b6 - .4718 msr2 + .1317 msr8

Not surprisingly, this equation seems to indicate that the model is highly dependant on differences among the various bases from which the data was gathered. This suggests that factors unique to a given base strongly affect the productivity of a unit. Identifying these factors is an area for future research. The information of interest to this study is the indication that mission capable rates and maintenance scheduling effectiveness are the measures which best explain manhour per flying hour and may therefore be the most useful indicators of a unit's productivity. However, mission capable rates and maintenance scheduling effectiveness are among the measures classified as outputs. Therefore, it is important to address these measures in the context of the inputs which contribute to their development. If managers understand which inputs are most significant to these measures, they may be able to control their effect on the unit's productivity.

Table 3 indicates that mission capable rates are most significantly affected by cannibalization rates (msr3), awaiting maintenance and awaiting parts discrepancies (msr4 and msr5) and average possessed aircraft (msr6). Additionally, maintenance scheduling effectiveness is affected most significantly by the number of discrepancies awaiting parts (msr5). These measures are indicated by the models determined to be the third and fourth most significant models in the table. When these relationships are combined with those identified in the manhour per flying hour model, a more complete model emerges. The R square and global F values are not as strong for these models as for the manhour per flying hour model which substantiates the supposition that other measures contribute to the overall output from a subordinate level.

Figure 5 shows the logical model resulting from this analysis in comparison to the a priori logical model. Further piecewise additions to this model would seem inappropriate due to the rapidly decreasing statistical significance of the regression models produced and an absence of apparent rationale for how these models relate to each other or to the overall model produced thus far. The final logical model exhibits the three output measures most significant from among the seven shown a priori. Four of the original five inputs remain. Understanding which outputs are most significant and identifying the contributing inputs may enable the maintenance manager to more effectively focus on areas which enhance productivity.

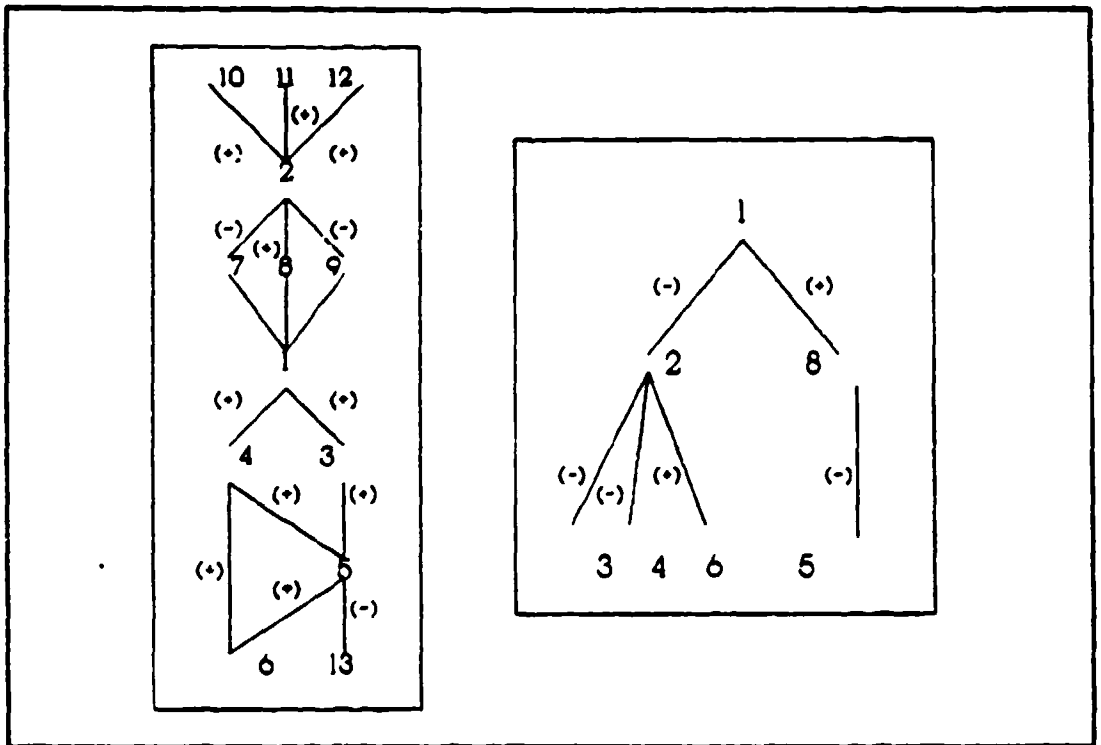

Figure 5 Comparing the A Priori Model With The Final Logical Model for MAC Aircraft Maintenance Units

Summary

The research conducted to support this study provided significant insight into productivity measurement in MAC aircraft maintenance units. MAC requires each unit to publish a monthly maintenance digest containing at least seven management reports. Each unit publishes additional reports according to local concerns and includes them with the ones required by MAC. These reports are collectively viewed as productivity indicators and used for trend analysis.

Thirteen of the most commonly used productivity measures were chosen for statistical analysis. An a priori logical model was developed to explain the currently assumed associations of the measures as they relate to maintenance productivity. The assumed associations of the measures were largely, but not completely supported by the statistical analysis. Regression models were developed to isolate the measures which best explain productivity as defined by the DOD and stepwise elimination reduced the contributing measures to those most significant. A combination of three regression models produced a revised overall productivity model.

Chapter VI, Conclusions and Recommendations, will further explain the outcome of this research. Based on the literature review, responses to interviews, and statistical analysis, conclusions are drawn and recommendations made. Also, suggested topics for further research in the area of aircraft maintenance productivity are addressed.

VI. Conclusions and Recommendations

Introduction

This research effort was undertaken to explore productivity measurement in aircraft maintenance units, specifically focusing on the Military Airlift Command. This chapter details the conclusions drawn from the findings and analysis of the research questions presented in chapter one. The conclusions are based on effective compliance with regulatory guidance as well as integration of current DOD productivity measurement methodology with industrial trends. Further discussion of the conclusions provides additional insight into the problems faced by MAC in the effective measurement and management of aircraft maintenance productivity. Additionally, the current trends in productivity management as discussed in the background chapter are briefly applied to the research findings. Recommendations are made for the improvement of productivity measurement in aircraft maintenance units and for future research to be conducted in this important area.

Conclusions

1. Aircraft maintenance managers in MAC are not familiar with the Air Force guidance concerning productivity measurement. Therefore, measurement methods and application are inconsistent and do not support the intent of the

Productivity Improvement Program for the Federal Government as directed by the President.

2. The seven reports required by MACR 66-1 Volume II for inclusion in the monthly maintenance digests of each MAC wing were used as sources for productivity information in this research. However, there are no specific productivity indices for aircraft maintenance in use in MAC. Instead, the information reported is used together as a kind of multi-factor measure of performance in general. The significance assigned to each measure in performance evaluation is not consistent among the wings and there is no clear guidance in this regard established from within the Major Command.

3. Each wing gathers data and reports information in addition to that which is required by MACR 66-1. These reported measures may indicate the information important to the local maintenance managers. The application of these measures to the productivity management of a wing is not dictated by MAC. However, these measures are included in the digest forwarded to the numbered Air Forces and headquarters.

4. The nature and strength of the relationships among the measures implemented by aircraft maintenance organizations are not readily apparent. There is no regulatory guidance available to managers for critical interpretation of these relationships as they apply to

productivity. Therefore, emphasis placed on management initiatives as a result of the information yielded by these measures may be inconsistent with the intent of the Air Force Productivity Improvement Program. This research attempts to establish the nature and strength of the relationships in the absence of regulatory guidance. The results of this effort were presented in Chapter V, Findings and Analysis.

5. Of the thirteen measures evaluated, eight produced the strongest explainable model reflecting maintenance productivity. Manhours per flying hour was the predominant output when viewed as a result of the influence of mission capable rates and maintenance scheduling effectiveness. Cannibalization rates, delayed discrepancies (both awaiting parts and awaiting maintenance) and the average number of possessed aircraft were the inputs which which appeared to contribute most significantly to mission capable rates and maintenance scheduling effectiveness. By understanding the relationships among these measures and monitoring their interaction, a manager may be better able to positively influence a maintenance unit's productivity.

Further Discussion

Current Productivity Management. As stated in the first conclusion, MAC maintenance managers are not familiar with the Air Force guidance concerning productivity measurement. Although they recognize a need for managing issues of both efficiency and effectiveness, for the most part they are concerned with mission effectiveness only. In the words of one DCM, "The bottom line is providing the airframes necessary to launch the required missions on time."

There is not a clear method for relating the various productivity measures to an evaluation of the overall performance of a MAC wing. Although MACR 173-1 specifies the standards for particular measures, there is no current guidance for viewing the relationships of the numerous measures used in the command and the assumed associations of the measures are not fully supported by the quantitative analysis of this research. Instead, non-intuitive associations emerge for consideration in the evaluation of maintenance productivity.

There is not a standardized method to evaluate maintenance productivity as defined by the Air Force. The effectiveness measure used most often is departure reliability. It not only impacts the operational mission, but this research suggests it also contributes significantly to a unit's ability to meet the maintenance schedule. If aircraft depart homestation on time and continue through the enroute system as scheduled, their timely return to homestation allows the maintenance schedule to proceed as planned. This, in turn, contributes to the preventive maintenance effort necessary to provide reliable aircraft to the user.

Mission capable rates have been identified by the DOD as the measure of a maintenance unit's effectiveness which should be standardized across commands. It is the measure used to justify spare parts acquisition for the weapon systems and is, therefore, of great concern to the Major Commands. This research suggests that a high mission capable rate contributes significantly to a unit's productivity as measured by manhours per flying hour.

Efficiency is a secondary concern to many unit level maintenance managers. Because of the perception of unlimited resources available through ACIF funding, budget concerns are minimal. Instead, efficiency is viewed in the context of quality. Maintenance air aborts seem to be the quality indicator most significant to Major Command level managers, while wing Maintenance managers are also concerned with repeat/reoccurring discrepancies.

Productivity measurement methodology in the DOD remains consistent until it reaches the major command level. Both the DOD and Air Staff measure productivity in terms of labor hours and the cost associated with providing defense services to the American public. However, the major commands do not report this information to Air Staff. Instead, the maintenance productivity indicator is reported as units processed through the depots and subsystems processed through intermediate level shops at the various wings. This information is reported by the Air Force Logistics Command (AFLC) through retrieval of data from the Maintenance Data Collection System. The command level productivity measures are multi-factored and serve primarily as spares level justification rather than indications of performance. The lack of association of the command level maintenance productivity measures with the higher headquarters summary of manyears by functional element creates a lack of continuity in the overall productivity enhancement programs as outlined in AFR 25-3 and DOD directive 5010.34.

Application of Private Sector Trends to Research Findings. The relationships among the measures identified by this research can be viewed from the perspective of Goldratt's Theory of Constraints. Because the periodic maintenance schedule must be met before aircraft are considered mission capable, these scheduled maintenance activities can be identified as the constraint in the process of providing mission capable aircraft to the user. The maintenance manager must decide how to exploit this constraint. In other words, how can the maintenance schedule be most effectively met without changing the existing flow? Once this question has been answered all activities could be subordinated to maximizing the flow of aircraft through scheduled maintenance activities. Goldratt defines productivity as all the actions that bring a company closer to its goal (38:58). If the goal of an aircraft maintenance unit is to provide a service to the user, manhour per flying hour may be the best measure of all the activities undertaken to meet the goal. Having more than the required number of aircraft mission capable is similar to having finished inventory stockpiled in an industrial environment. The additional airframes represent more manhours expended, but do not contribute any more to meeting the mission objectives or "the goal".

Deming's emphasis on quality as it affects productivity is also relevant to this research. The identified quality indicators, repeat/reoccurring discrepancies and maintenance air aborts, are briefed by exception and are subject to influences from areas beyond the control of maintenance. For example, maintenance air aborts are highly dependant on the aircrews. One crew may fly an aircraft with a malfunction when another crew would abort the mission. The decision of whether to abort or not is totally up to the aircraft commander. An increase in maintenance air aborts or repeat reoccurring discrepancies indicates a problem already exists, whereas analysis of manhour per flying hour rates may provide information for preventive action. The emphasis should then become doing things right the first time. Tracking manhour per flying hour rates in relation to quality inspections might yield a useful composite measure of a unit's productivity.

Recommendations

1. MAC aircraft maintenance managers should become familiar with guidance concerning productivity measurement at the command level as it contributes to the total productivity improvement effort.

2. The MAC supplement to AFR 25-3 should be expanded to provide specific guidance for productivity enhancement initiatives for the airlift environment. These initiatives should be consistent with higher headquarters guidance and conform to the intent of the Productivity Improvement Program in the Federal Government.

3. Measurement criteria should be standardized throughout the command and sufficiently detailed to limit the chance for inaccurate data reporting.

4. Each wing should focus on monitoring and reporting manhours per flying hours, mission capable status, maintenance scheduling effectiveness, cannibalization rates, delayed discrepancies and the average number of possessed aircraft when evaluating aircraft maintenance productivity.

Suggested Research Efforts

Three areas appear to provide great potential for identifying and enhancing productivity measures for aircraft maintenance units. First, a continuation of the methodology of this research in the other Air Force Major Commands would serve to further validate the research findings. However, any further research of this nature should work with a larger data set. Because of the exploratory nature of this research, the data was limited to a six month period. Future research efforts in this area should seek to obtain as much data as possible.

A second area for future study is the effect of the different base environments on the measure of productivity. This research indicted that productivity performance was highly dependant on differences among the bases being measured. Empirical studies are warranted to identify the characteristics of the different bases which contribute to productivity.

Another area of study which would be very significant to aircraft maintenance processes in general, is an application of Goldratt's Thoughtware simulation software to the findings of this study. The simulation of a typical maintenance process at the wing level and the manipulation of the subordinate processes utilizing the Theory of Constraints will test the validity of the findings of this study and may suggest more useful methods of productivity management than those which are currently being used.

Summary

This research was undertaken to explore productivity measurement in aircraft maintenance units and to examine the relationships of the measures used to evaluate a unit's productivity. Review of current literature and regulatory guidance concerning productivity measurement provided the basis for the development of an interview questionnaire. A questionnaire was administered to DCMs and chiefs of analysis at ten MAC wings. Additionally, managers in the maintenance management, cost and manpower divisions at headquarters MAC were interviewed. From these interviews, information concerning current productivity measurement methodology was gathered and thirteen measures were identified for analysis. Analysis of the interview responses and measurement data gathered from six MAC wings resulted in conclusions and recommendations for improved abilities to understand and measure productivity in aircraft maintenance units.

Appendix A: Presidential Order for Productivity Improvement

THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release February 25, 1986

EXECUTIVE ORDER
12552

PRODUCTIVITY IMPROVEMENT PROGRAM FOR THE FEDERAL GOVERNMENT

By the authority vested in me as President by the Constitution and laws of the United States of America, including the Budget and Accounting Act of 1921, as amended, and in order to establish a comprehensive program for the improvement of productivity throughout all Executive departments and agencies, it is hereby ordered as follows:

Section 1. There is hereby established a government-wide program to improve the quality, timeliness, and efficiency of services provided by the Federal government. The goal of the program shall be to improve the quality and timeliness of service to the public, and to achieve a 20 percent productivity increase in appropriate functions by 1992. Each Executive department and agency will be responsible for contributing to the achievement of this goal.

Sec 2. As used in this Order, the term:

(a) "Productivity" means the efficiency with which resources are used to produce a government service or product at specified levels of quality and timeliness;

(b) "Services" means those functions and activities performed by the Federal government to achieve program objectives;

(c) "Common agency functions" means those functions which are found in more than one agency, such as awarding grants or loans to individuals or institutions, providing direct benefit payments, processing claims, or furnishing health care;

(d) "Common government functions" means those functions that are common to every agency, such as administrative services;

(e) "Measurement system" means both the specific measures used to determine whether standards of quality, timeliness, and efficiency of services are being met, and the procedures for the collection and reporting of data resulting from application of productivity measures;

(f) "Organizational performance standard" means a statement which quantifies and describes the desired level of quality, timeliness, and efficiency of services to be provided by an organization;

(g) "Management review" means the review by the Director of the Office of Management and Budget as part of the budget process, of agency accomplishments and plans for management and productivity improvements;

Appendix B: Department of Defense Productivity Definitions and Reports

5010.34 (Encl 3)
Aug 4, 75

DEFINITIONS

The following definitions apply to the DoD Productivity Program. Other useful definitions are contained in the Glossary of Terms in Appendix 4, DoD Manual 5010.15.1-M (reference (e)).

A. Organizational Element. A major command or operating agency of a DoD Component, e.g., Army Materiel Command (AMC), Air Force Audit Agency.

B. Organizational Sub-Element. A subordinate command or operating agency of an organizational element, e.g., U.S. Army Missile Command.

C. Field Element. A base, installation or depot of an organizational sub-element, e.g., Letterkenney Depot.

D. Agency Productivity Principal. The primary contact between an agency and the productivity project team (BLS, OMB, GAO, CSC and the JFMIP).

E. DoD Productivity Principal. The individual in the OASD(I&L) who is responsible for (1) providing overall technical assistance and coordinating DoD efforts on productivity enhancement, measurement and evaluation, (2) submitting DoD productivity data input to BLS and the JFMIP and (3) coordinating, within DoD, productivity requirements initiated by other Federal agencies.

F. DoD Component Productivity Principal. The individual in a DoD Component who is responsible for (1) coordinating productivity efforts within his component and (2) the timely preparation of productivity reports and response to other productivity data requirements levied on his component.

G. OSD Functional Area Productivity Representatives. Individuals on the OSD staff who are responsible for productivity matters in their respective areas.

H. Measurable Areas. The functions/operations of an organizational element, organizational sub-element, or field element for which at least one final output and corresponding manyear inputs can be quantified.

I. Non-Measurable Areas. The functions/operations of an organizational element, organizational sub-element, or field element for which no final outputs and/or corresponding manyear inputs can be quantified.

J. Outputs. The final products produced or services rendered in a measurable functional area by an organizational element, organizational sub-element, or field element.

K. Inputs. The amount of resources (all types) utilized or consumed to produce an output.

L. Labor Input. The amount of labor resources utilized or consumed to produce an output.

M. Manyear of Labor Input. A manyear of labor input for this program constitutes 2,080 paid hours. (This includes regularly scheduled time, overtime, and leave time for all types of employees.)

N. Measured Manyears. The total manyears (civilian and military) expended in a measurable area by an organizational element, organizational sub-element, or field element. Measured manyears can be two types:

1. Direct Manyears. The manyears in a measurable area which are charged directly to the final outputs of the area.

2. Indirect Manyears. All other manyears in a measurable area such as those expended on clerical, typing, secretarial, supervision, executive direction, and general services.

O. Unmeasured Manyears. The total manyears (civilian and military) expended by an organizational element, organizational sub-element or field element in nonmeasurable areas (areas in which no final outputs and corresponding manyears of input can be quantified).

P. Compensation. The total wage costs incurred to produce a product or render a service. Such costs include direct payroll costs plus other direct wage costs such as the Government's contribution for retirement, social security, health insurance, and life insurance. Compensation does not include separation costs such as severance pay and terminal leave payments.

Q. Effectiveness Measurement. Comparison of current performance against pre-established mission objectives (goals). If the right mission objective (goals) are established, effectiveness measurement discloses whether an activity does the right thing at the right time -- it compares what an activity or group of individuals actually accomplish in relation to an assigned mission.

R. Efficiency Measurement. Comparison of current performance against either a pre-established standard or actual performance of a prior period. Efficiency measurement discloses how an activity or group of individuals performs during a current period in relation to either: (1) a standard established for a job or task which they have responsibility for accomplishing; or (2) the level of performance achieved for the job or task in a previous period. Efficiency measurement may be based upon manpower, monies or a combination of both.

PRODUCTIVITY REPORTING

General. Productivity reporting to OSD is an integral element of the DoD Productivity Program. It is necessary in order to satisfy a government-wide requirement levied on all executive departments and agencies and to provide data for internal DoD management purposes. Specifically each DoD Component will submit annually to the OASD(I&L) the following exhibits and data:

Exhibit A - Summary of Manyears by Organizational Elements - This exhibit will be used to recap the manyear data for each organizational element of the reporting Component. For the "Year-end Strength" show the number of personnel authorized at end of FY. For the "Paid Civilian Manyears" show the manyear data reported on Exhibit A-1 of the report submitted under the provisions of OMB Circular No. A-93. For the "Measured Manyears" show the total manyears measured (Paid Civilian, Military, and Indirect Hire Foreign Nationals) for each organizational element.

Exhibit B - Summary of Measured Manyears by Function - This exhibit will be used to recap the measured manyears by function of the reporting Component. The manyear data for each function must agree with the data reported on Exhibit C for each function.

Exhibit C - Input/Output Data - This exhibit will be used to report quantitative input/output data. A separate exhibit will be prepared for each function covered by productivity measurement.

Exhibit C-1 - Description of Indicators - This exhibit will be used to describe new indicators established during a reporting period and to revise the description (as necessary) of any indicators reported in a prior period.

Exhibit D - Revision of Input/Output Data Submitted in Prior Years - This exhibit will be used to report changes in input/output data which were submitted in a prior year and the reasons necessitating the change.

Exhibit E - Productivity Data Verification, Analysis and Outlook - This exhibit will be used to report (1) whether the agency productivity listing (provided from BLS data bank) is correct, (2) whether the productivity indices are representative, and (3) the productivity outlook for the future. A separate exhibit will be submitted for each function.

Exhibit E-1 - Changes Required in BLS Listing - This exhibit will be used to report changes which should be made in the BLS data bank.

Exhibit E-2 - Productivity Analysis - This exhibit will be used to explain productivity indices which are not considered representative and to describe factors which caused either an increase or decrease of more than 5% in productivity.

II. Reporting Due Dates. Each DoD Component will adhere to the following due dates for submission of exhibits and data:

Exhibit	Due Date
A & B	120 days after end of FY
C, C-1, & D	90 days after end of FY
E, E-1, & E-2	21 days after receipt of Agency Listings

Attachments - 8
1. Exhibit A - Summary of Manyears by Organizational Element
2. Exhibit B - Summary of Measured Manyears by Function
3. Exhibit C - FY 197_ Input/Output Data
4. Exhibit C-1 - Description of Indicators
5. Exhibit D - Revision to Input/Output Data Submitted in Prior Years
6. Exhibit E - FY 197_ Productivity Data Verification, Analysis, and Outlook
7. Exhibit E-1 - Changes Required in BLS Data Bank
8. Exhibit E-2 - Productivity Analysis

EXHIJ

SUMMARY OF MANYEARS BY NIZATIONAL ELEMENT

____
(DoD Component)

Fiscal Year ____

	Year-end Strength			Paid Civilian Manyears			Measured Manyears			
Organizational Element	Total	Civilian	Military	Total	Basic	Premium	Total	Paid Civilian	Military	Foreign Nationals
1.										
2.										
3.										
4.										
Total										

5010.34, Aug 4, 75
(Att 2 to Encl 4)

EXHIBIT B

SUMMARY OF MEASURED MANYEARS BY FUNCTION

____
(DoD Component)

Fiscal Year 197_

FUNCTION		MANYEARS			
No.	Title	Total	Paid Civilian	Military	Indirect Hire Foreign Nationals
A.	Medical				
	1 - Hospitals				
	2 - Clinics				
B.	Communications				
	1 - Base Communications				
	2 - Defense Communications				
C.	Accounting, Finance, Auditing				
	1 - Base Acctg & Finance				
	2 - Central Acctg & Finance				
	3 - Internal Auditing				
	4 - Contract Auditing				
D.	Education, Training, Personnel Management				
	1 - Professional Education				
	2 - Dependent Education				
	3 - Military Training				
	4 - Civilian Personnel Mgt.				
	5 - Military Personnel Mgt.				
E.	Logistics				
	1 - Local Procurement				
	2 - Central Procurement				
	3 - Contract Administration				
	- Local Transportation				
	- Depot Transportation				
	- Single Manager Trans.				
	7 - Motor Vehicle Operations				
	8 - Local Supply				
	9 - Depot Supply				
	10 - Inventory Control				
	11 - Intermediate Maintenance				
	12 - Depot Maintenance				
	13 - Motor Vehicle Maintenance				
	14 - Real Property Maint.				
	15 - Dining Facilities				
	16 - Commissary Operations				
	17 - Laundry and Dry Cleaning				
	18 - Printing				
F.	Specialized Manufacturing				
	1 - Maps				
	2 - Clothing				
	3 - Weapons				
	4 - Munitions				
G.	Other				
	1 - Personnel Security				
	2 - Personnel Support & Admin.				
	TOTAL				

EXHIBIT C

FY 197_ INPUT/OUTPUT DATA

____
(DoD Component)

____
(Function - Number and Title)

A. Direct Manyears Indicator	Output Quantity (000)	Manyear Inputs (000)	Compensation (000)
1.			
2.			
3.			
4.			
5.			
Total Direct Manyears		______	______
B. Indirect Manyears		______	______
C. Total Manyears		______	______

D. Breakdown of Manyears

1. Paid Civilian Manyears
2. Military Manyears
3. Indirect Hire Foreign National Manyears ______

Total Manyears ______

E. Other Data

	Yes	No
1. Did any significant quality or process changes occur during the year?	____	____
2. Were there any major capital expenditures during the year which impacted on current year performance?	____	____
3. Did ary significant product mix changes occur during the year?	____	____
4. Did any significant change in the ratio of workload performed inhouse to contracted out occur during the year?	____	____

NOTE: Provide a complete explanation for each "yes" answer.

EXHIBIT C-1
DESCRIPTION OF INDICATORS

____
(DoD Component)

____
(Function - Number and Title)

Indicator	Description

EXHIBIT D

REVISION T 'PUT/OUTPUT DATA SUBMITTEL PRIOR YEARS

____
(DoD Component)

____
(Function - Number, Title, and Output Indicator)

	Fiscal Year					
	1972	1973	1974	1975	1976	1977
A. DATA						
1. Output Quantity						
a. Old						
b. Revised						
2. Manyear Input						
a. Old						
b. Revised						
3. Compensation						
a. Old						
b. Revised						

B. Reason for Change (Provide concise explanation)

EXHIBIT E
FY 197_ PRODUCTIVITY DATA VERIFICATION, ANALYSIS AND OUTLOOK

____
(DoD Component)

____
(Function - Number and Title)

	Yes	No
A. Productivity Data Verification		
1. Does the data shown on the Agency Productivity Listing agree with Exhibit C data as submitted? If "no" complete Exhibit E-1.	____	____

B. Productivity Analysis

1. Total manyear Productivity Index

Current Yr.	Prior Yr.	Change
________	________	________

	Yes	No
2. Is the "Current Year" index representative of the productivity trend for this function.	____	____

If "no" or if the change exceeds 5% (either increase or decrease) complete Exhibit E-2.

C. Productivity Outlook

1. Productivity goal for next year ______________________

2. Briefly describe (a) actions underway or planned to increase productivity during the next year and (b) known factors which will influence the productivity of this function during the next year.

EXHIBIT E-1
CHANGES REQUIRED IN BLS DATA BANK

____
(DoD Component)

____
(Function - Number and Title)

A. Agency listing not in agreement with Exhibit C. Revise as follows:

	Output		Input		Compensation	
Indicator	From	To	From	To	From	To

B. Current Year Exhibit C data incorrect. Revise as follows:

	Output		Input		Compensation	
Indicator	From	To	From	To	From	To

Reason for Change: (Provide Concise Explanation)

EXHIBIT E-2
PRODUCTIVITY ANALYSIS

____
(DoD Component)

____
(Function - Number and Title)

A. Productivity Index

Direct Manyear Productivity Index

Total Manyear Productivity Index

B. Productivity Analysis

1. Are the "current year" indexes representative of the productivity trends for the function? ______ (yes) ______ (no)

   If "no" provide concise explanation.

2. Briefly describe the factors or conditions which caused a productivity change of more than 5% during the current year.

MACR 66-1, Vol II Attachment 1 14 March 1980

A1-14. Formulas. For use by all units. These formulas are mandatory when the applicable factor is referenced or used.

a. ATTRITION RATE = MAINT CANX RATE + NONMAINT MATERIEL CANX RATE + OPS CANX RATE + HHQ CANX RATE + OTHER CANX RATE + *WEATHER CANX RATE.

NOTE: Use four years of weather cancellation data for month being forecast if available; otherwise, as much as available. (If four years' data is not available, start accumulation toward that point. For other elements use past six-months' data.)

b. MISSIONS/SORTIES TO SCHEDULE = $\dfrac{\text{MISSIONS/SORTIES REQUIRED}}{\text{1.0-ATTRITION RATE}}$

c. LABOR HRS PER FLYING HR = $\dfrac{\text{TOTAL DIRECT MDC LABOR-HRS BY MDS (AIRFRAME, ENGINE \& APU/GTC SRD)}}{\text{FLYING HOURS BY MDS}}$

d. LABOR-HRS PER MISSION/SORTIE = $\dfrac{\text{TOTAL DIRECT MDC LABOR-HRS BY MDS (AIRFRAME, ENGINE \& APU/GTC SRD)}}{\text{TOTAL MSNS/SORTIES FLOWN BY MDS}}$

e. ENGINE SHUTDOWN RATE = $\dfrac{\text{TOTAL ENGINES SHUTDOWN}}{\text{FLY HRS X NUMBER OF ENGS ON ACFT}}$ x 00

f. UNSCHEDULED ENG CHANGE RATE = $\dfrac{\text{TOTAL UNSCHEDULED CHANGES}}{\text{TOTAL ENGINES CHANGED}}$ x 00

g. TEST CELL REJECT RATE = $\dfrac{\text{TOTAL TEST CELL REJECTS}}{\text{TOTAL ENGINES TESTED}}$ x 100

h. CANNIBALIZATION PER DEPARTURE RATE = $\dfrac{\text{MICAP CODE 4 + MICAP CODE}}{\text{TOTAL UNIT OWNED AIRCRAFT DEPARTURES FROM HOME STATION}}$ x 100

NOTE: Action taken T for the following type canns only:
Aircraft to aircraft.
Aircraft to engine.
Engine to aircraft.

i. OVERTIME RATE = $\dfrac{\text{TOTAL DIRECT OT EXPENDED CAT LAB 3 AND 4 MINUS COMP-TIME}}{\text{TOTAL DIR LABOR-HOURS EXPENDED (INCLUDE OVERTIME)}}$ x 100

j. PRODUCTIVITY = $\dfrac{\text{TOTAL DIRECT LABOR MDC HRS (INCLUDE OVERTIME)}}{\text{ACTUAL AVAILABLE LABOR HOURS (100 LABOR HRS ASGN + OVERTIME - INDIRECT LABOR HOURS)}}$ x 100

k. LABOR HOUR UTILIZATION RATE = $\dfrac{\text{TOTAL DOCUMENTED MDC}}{\text{TOTAL (100) LABOR HOURS ASSIGNED + OVERTIME}}$ x 100

l. BASE REPAIR CAPABILITY RATE = (SEE T.O. 00-20-2)

m. AVG POSS ACFT = $\dfrac{\text{POSS HRS (AFR 65-110)}}{\text{HRS IN MONTH (24 X DAYS/MONTH)}}$

n. ACFT UTILIZATION RATE	=	HOURS FLOWN ÷ fly days/month / AVG POSS ACFT–FLY DAYS/MONTH
o. DROPPED OBJECT RATE	=	# DROPPED OBJ INCIDENTS / UNIT WORLDWIDE DEPARTURES x 1000
p. FOD RATE (ENGINES)	=	# FOD INCIDENTS / FLYING HOURS X # OF ENGINES x 1000
q. AVG SORTIE LENGTH	=	# FLYING HOURS / # SORTIES FLOWN
r. AVG TRAINING MISSION LENGTH	=	# FLY HRS , TRAINING MSN SYMBOLS / # TRAINING MISSIONS FLOWN
s. AVG OPERATIONAL MISSION LENGTH	=	# FLY HRS, OPERATIONAL MSN SYM / # OPERATIONAL MISSIONS FLOWN
t. MAN-HOURS PER LDG (EN ROUTE)	=	MDC LABOR HOURS BY MDS (EN ROUTE) / TOTAL LANDINGS BY MDS (EN ROUTE)
u. AVG CANNIBALIZATION LABOR HOURS	=	TOTAL LABOR-HRS FOR CANNS BY SRD / TOTAL NUMBER OF CANNS BY SRD
v. HOME STATION AIR ABORT RATE	=	TOTAL UNIT AIRCRAFT ABORTING BACK TO BACK TO HOME STATION / TOTAL UNIT AIRCRAFT DEPARTURES FROM HOME STATION x 100
W. DELAYED DISCREPANCIES PER POSSESSED AIRCRAFT	=	DELAYED DISCREPANCIES / AVERAGE POSSESSED AIRCRAFT

A1-15. Standards:

a. Coefficient of correlation should be 95 for all predictions.

b. Confidence intervals will be computed to not greater than 2.0 SDs.

A1-16. Instructions for Preparing the RCS: MAC-LGM(M) 7105 Plans and Scheduling is OPR for this report. The report consists of three parts. A sample format follows this attachment. Part I provides the wing's recommended maintenance commitment for the next three months. Part II is where the unit will identify projected problem areas that may interfere with their ability to commit the goal airframes and what assistance may be needed. Part III is a report of actual airframes provided by day during the previous calendar month.

NOTE: The following airframe commitment rates are goals for generating airframes: C-5 = 60%; C-141 = 72%; C-130 = 60% weekday, 35% weekend/holiday; and 1 SOW, H-53 = 50% weekday, 30% weekend/holiday. These represent the percentages of possessed airframes that should be committable. Five percent should be added to the above goals for "Operations/HHQ (higher headquarters) tasked spares, operations ground trainers, Air Training Command field training detachments for maintenance training, or to other non-maintenance agencies for non-flying requirements.'

NOTE: 443 MAW will not submit this report. 23 AF units (except 1 SOW) will not submit this report.

NOTE: Reports will be sent to arrive at NAF/LGM and HHQ/LGM no later than the seventh day of the month. If compliance is not possible, telephonically advise MAF/LGM of reason for delay. NAF advise HHQ/LGM of any reasons for noncompliance by the eighth day of the month.

NOTE: NAF/LGM is action OPR for all assistance requests. Requests for assistance will be submitted by MAC NAF to the appropriate HHQ LGMM as a separate request.

A. Part I, Section 1. Recommended committable airframes per day for the first month of the reporting period.

NOTE: Include the calendar days and figures for all of the first month. Include weekends and holidays.

Lines A/AA: Calendar days.

Lines B/BB: Adjusted projected possessed aircraft determined IAW AFR 65-110. If applicable, do not include TF coded aircraft here, or in Part III.

1. (CONUS units) Subtract deploying rotation aircraft and one ROTE spare from possessed three workdays prior to scheduled departure.

MACR 173-1 20 July 1989

Chapter 3

COMMAND MANAGEMENT ITEMS AND PERFORMANCE STANDARDS

Purpose: This chapter identifies the command management items which form the basis for the MAC Management System. An integral part of this chapter is the standards which provide the means for determining performance levels and status of key resources. Except for the mission performance management items which have joint operations, logistics, and air transportation OPRs, items are arranged functionally.

Item No 1-1—HOME STATION DEPARTURE RELIABILITY

a. Raw
b. Transportation
c. Operations
d. Logistics

HQ MAC OPRs: DOC/LGMW/TRKM

HQ MAC OCR: DOCB

PURPOSE: To monitor the operational mission departure reliability from home stations. This provides a method to measure and evaluate logistics reliability of aircraft performance, support capability for operational missions, and aircrew, transportation, and operations center functions. It also supplies a basis for decisions on airframe management.

SOURCE OF DATA: Military Air Integrated Reporting System (MAIRS)/Airlift Implementation and Monitoring Systems (AIMS).

BASIC DIRECTIVE: MACR 55-3, volume III.

E[illegible]VALUATION CRITERIA: All C-5, C-141, C-130, or operational support airlift (OSA) departures meeting the following [illegible] are included in this item.

[illegible] The mission type as defined by the second character of the mission identifier prefix must be:
  (1) Channel (B, K, Q, L, N, J, V) or
  (2) SAAM (W, A) or
  (3) Exercise, JA/ATT (M, R) or
  (4) Miscellaneous (D, H, G).

b. The departure station must be the operator's (unit's) home station.
c. The departure station code must be an "O" or "P".
d. Exception. OSA departures with the first character of the mission identifier suffix equal to "Z" or "T" are excluded.
e. The third character of the mission identifier prefix must be alphabetic.

EVALUATION PERIOD: Monthly.

MAC STANDARDS:

C-5 Home Station	Excellent	Satisfactory	Marginal	Unsatisfactory
Raw	100-92.0	91.9-84.0	83.9-75.0	Below 75.0
Transportation	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
Operations	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
Logistics	100-94.0	93.9-87.0	86.9-85.0	Below 85.0
C-141 Home Station				
Raw	100-95.0	94.9-87.0	86.9-84.0	Below 84.0
Transportation	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
Operations	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
Logistics	100-95.0	94.9-90.0	89.9-88.0	Below 88.0
C-130 Home Station				
Raw	100-96.0	95.9-85.0	84.9-77.0	Below 77.0
T[illegible]portation	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
[illegible]ions	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
[illegible]ics	100-96.0	95.9-88.0	87.9-84.0	Below 84.0

b. Either:
(1) The departure station code is "C", "D", "R", "S", "K", or "J", or
(2) The departure station code is "O" or "P" and the departure station is not the operator's (unit's) home station.
c. The third character of the mission identifier prefix must be alphabetic.

EVALUATION PERIOD: Monthly.

DEFINITIONS:
a. C-5, C-141, and C-130: En route reliability performance is measured at each en route station by type aircraft. These reliability evaluations represent en route station performance by type aircraft.

MAC STANDARDS:

C-5 Route Stations	Excellent	Satisfactory	Marginal	Unsatisfactory
Raw	100-89.0	88.9-67.0	66.9-59.0	Below 59.0
Transportation	100-98.0	97.9-96.0	95.9-93.0	Below 93.0
Operations	100-98.0	97.9-94.0	93.9-92.0	Below 92.0
Logistics	100-91.0	90.9-77.0	76.9-73.0	Below 73.0
C-141 En Route Stations				
Raw	100-93.0	92.9-83.0	82.9-77.0	Below 77.0
Transportation	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
Operations	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
Logistics	100-97.0	96.9-90.0	89.9-87.0	Below 87.0
C-130 En Route Stations				
Raw	100-96.0	95.9-81.0	80.9-75.0	Below 75.0
Transportation	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
Operations	100-98.0	97.9-96.0	95.9-93.0	Below 93.0
Logistics	100-98.0	97.9-89.0	88.9-85.0	Below 85.0

COMPUTATION: En route station departure reliability will be computed separately for each functional category (operations, transportation, logistics, and raw) by aircraft type.

Operations, transportation, and logistics reliability will be computed as follows:

$$\frac{\text{Total En Route Station Dep - No. Functional Dev by Type*}}{\text{Total En Route Station Departures}} \times 100 = \text{\% Reliability}$$

*Operations deviations are those coded 2XX with an X prefix.

Transportation deviations are those coded 3XX with an X prefix.

Logistics deviations are those coded 7XX, 8XX, or 9XX with an X prefix.

Raw departure reliability will be computed as follows:

$$\frac{\text{Total En Route Sta Dep - Total En Route Sta Dev**}}{\text{Total En Route Station Departures}} \times 100 = \text{\% Raw Reliability}$$

**Total en route station deviations include operations, transportation, and logistics deviations, plus miscellaneous deviations and mission required delays.

- Miscellaneous deviations are those coded 1XX with an X prefix.

- Mission-required delays are those coded 500 with an X prefix and are directed/validated by MAC NAF or HQ MAC (ALCC for theater-assigned assets), as necessary, to improve overall MAC mission execution. Delays coded 500 will be included in MAC NAF and MAC-wide systems reliability figures, but count as "on-time" departures in individual departure station reliability figures.

UNITS EVALUATED: 60, 62, 63, 436, 437, 438, 443 MAWs; 314, 317, 374, 435, 463, 513 TAWs***; 313, 316 TAGs; 6[illegible] MAG; 310 MAS.

[illegible] 3 TAW provides 313 TAG reporting through consolidated command post.

STATIONS EVALUATED: All en route st[illegible] sited by MAC mission-identified aircraft.

OSA Home Station (Detachment)	Excellent	Satisfactory	Marginal	Unsatisfactory
Raw	100-97.0	96.9-89.0	88.9-84.0	Below 84.0
Transportation	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
Operations	100-98.0	97.9-96.0	95.9-95.0	Below 95.0
Logistics	100-98.0	97.9-94.0	93.9-92.0	Below 92.0

COMPUTATION: Home station departure reliability will be computed separately for each functional category (operations, transportation, logistics, and raw) by aircraft type.

Operations, transportation, and logistics reliability will be computed as follows:

$$\frac{\text{Total Home Station Dep - No. Functional Dev by Type*}}{\text{Total Home Station Departures}} \times 100 = \%\ \text{Reliability}$$

Raw departure reliability will be computed as follows:

$$\frac{\text{Total Home Station Dep - Total Home Station Dev**}}{\text{Total Home Station Departures}} \times 100 = \%\ \text{Raw Reliability}$$

*Operations deviations are those coded 2XX with an X prefix.

Transportation deviations are those coded 3XX with an X prefix.

Logistics deviations are those coded 7XX, 8XX, or 9XX with an X prefix.

**Total home station deviations include operations, transportation, and logistics deviations, plus miscellaneous deviations and mission required delays.

- Miscellaneous deviations are those coded 1XX with an X prefix.

- Mission-required delays are those coded 500 with an X prefix and are directed/validated by MAC NAF or HQ MAC (ALCC for theater-assigned assets), as necessary, to improve overall MAC mission execution. Delays coded 500 will be included in MAC NAF and MAC-wide systems reliability figures, but count as "on-time" departures in individual departure station reliability figures.

UNITS EVALUATED: 60, 62, 63, 436, 437, 438, 443 MAWs; 314, 317, 374, 435, 463, 513 TAWs***; 313, 316 TAGs; 310 MAS; 616 MAG; 375 AAW; OSA units.

***513 TAW provides 313 TAG reporting through consolidated command post.

Item No 1-2—EN ROUTE STATION DEPARTURE RELIABILITY

a. Raw
b. Transportation
c. Operations
d. Logistics

HQ MAC OPRs: DOC/LGMW/TR

PURPOSE: To monitor the operational mission departure reliability from en route stations. This provides a method to measure and evaluate logistics reliability of aircraft performance, support capability for operational missions, and aircrew, transportation, and operations center functions. It also supplies a basis for decisions on airframe management.

SOURCE OF DATA: Military Air Integrated Reporting System (MAIRS)/Airlift Implementation and Monitoring System (AIMS).

BASIS DIRECTIVE: MACR 55-3, volume III.

EVALUATION CRITERIA: All C-5, C-141, or C-130 departures meeting the following criteria are included in this item.

a. The mission type as defined by the second character of the mission identifier prefix must be
   (1) Channel (B, K, Q, L, N, J, V) or
   (2) SAAM (W, A) or
   (3) Exercise, JA/ATT (M, R) or
   (4) Miscellaneous (D, H, G).

Item No 1-3—C-9 ORIGINATING MISSION DEPARTURE RELIABILITY

HQ MAC OPRs: DO/LG

HQ MAC OCR: DOCB

PURPOSE: To monitor the operational mission departure reliability for originating C-9 missions. This provides a method to measure and evaluate logistics reliability of aircraft performance, support capability for originating missions, and aircrew and operations center functions. It also supplies a basis for decisions on airframe management.

SOURCE OF DATA: Military Air Integrated Reporting System (MAIRS)/Aircraft Implementation and Monitoring System (AIMS).

BASIC DIRECTIVE: MACR 55-2, volume III.

EVALUATION CRITERIA: C-9 departures with the second character of the mission identifier prefix not equal to "U", "S", "E", or "C" and the departure station code equal to "O" or "P" are included in this item.

EVALUATION PERIOD: Monthly.

MAC STANDARDS:

	Excellent	Satisfactory	Marginal	Unsatisfactory
Raw	100-99.0	98.9-95.0	94.9-91.0	Below 91.0
Transportation	100-99.0	98.9-97.0	96.9-96.0	Below 96.0
Operations	100-99.0	98.9-97.0	96.9-96.0	Below 96.0
Logistics	100-99.0	98.9-97.0	96.9-96.0	Below 96.0

COMPUTATION: Originating mission departure reliability will be computed seperately for each functional category (operations, transportation, logistics, and raw).

Operations, transportation, and logistics reliability will be computed as follows:

$$\frac{\text{Total Originating Msn Dep - No. Functional Dev by Type*}}{\text{Total Originating Mission Departures}} \times 100 = \%\ \text{Reliability}$$

*Operations deviations are those coded 2XX with an X prefix. Transportation deviations are those coded 3XX with an X prefix.

Logistics deviations are those coded 7XX, 8XX, or 9XX with an X prefix.

Raw departure reliability will be computed as follows:

$$\frac{\text{Total Orig Msn Dep-Total Orig Msn Dev**}}{\text{Total Originating Mission Departures}} \times 100 = \%\ \text{Raw Reliability}$$

**Total origination mission deviations include operations, transportation, and logistics deviations, plus miscellaneous deviations and mission required delays.

- Miscellaneous deviations are those coded 1XX with an X prefix.

- Mission Required Delays are those coded 500 with an X prefix, and are directed/validated by MAC NAF or HQ MAC (ALCC for theater assigned assets), as necessary, to improve overall MAC mission execution. Delays coded 500 will be included in MAC NAF and MAC-wide systems reliability figures, but count as 'on-time' departures in individual departure station reliability figures.

Item No 2-0—AIRCRAFT MISSION CAPABLE (MC) GOALS

HQ MAC OPR: LGMM

PURPOSE: To provide a meaningful measure of merit for reviewing aircraft status rates.

SOURCE OF DATA: RCS: HAF-LEY(M)7503 (MMICS) and/or HAF-LEY(M)8509 (CAMS) Status Report.

BASIC DIRECTIVE: AFR 66-110.

EVALUATION PERIOD: Monthly.

MAC GOALS:

Aircraft	Percent
C-5	60.0
C-141	75.0
C-130	70.0

Appendix E: Research Interview Instrument

Structured Interview Questionnaire
Productivity in Aircraft Maintenance

Demographics:

Name of interviewee:

Rank or paygrade:

Job title:

Job description:

Organizational level:

Questions:

1. Are you familiar with the Productivity Enhancement Program governed by AFR 25-3? If yes, how do you see the aircraft maintenance environment contributing to this program?

READ DEFINITION OF PRODUCTIVITY FROM AFR 25-3: Productivity is the menasure of an organizations performance. It's not only "effieciency" (the ratio of inputs to outputs), but also "effectiveness" (to what extent the output satisfies mission objectives). Put another way productivity is concerned both with "doing things right "(efficiency) and "doing the right things (effectiveness)

2. Of the aspects of productivity defined by AFR 25-3, which are you most concerned with, efficiency, effectiveness or both?

3. Do you feel aircraft maintenance productivity measurement is an important issue? (why or why not?)

4. What is your regulatory guidance for gathering and reporting productivity measures?

5. What methods of productivity measurement have been specified for aircraft maintenance by the regulatory guidance?

6. Of the methods specified, which ones do you actually use?

7. If there are specified measures not used, why are they not used? (what are their weaknesses?)

8. Where is the data for the specified measures gathered?

9. How often is this data gathered?

10. To whom is this information reported?

11. How often is this information reported?

12. What are you required to report to the next level? (be specific!)

NOTE: the distribution of the monthly summary is important and the measures contained.

13. Is there additinal information reported which is not required? (If so, why?)

14. Are there methods of productivity measurement used on aircraft maintenenace organizations other than those specified by the regulations? (if so, why?)

15. If answer to 14 is yes return to questions 9 through 11.

9a.

10a.

11a.

16. At what point do the budgetary and operational aspects of aircraft maintenace meet?

17. How much control does maintenace management have over the allocation of funds for aircraft maintenace?

18. What affect would more direct control of the maintenace budget by maintenace management have on their productivity?

19. How do you use aircraft maintenance productivity information for management decision making?

DEPARTMENT OF THE AIR FORCE
WASHINGTON 20330

OFFICE OF THE ASSISTANT SECRETARY

General Duane H. Cassidy, USAF
Commander-In-Chief, Military Airlift Command
Scott AFB, Illinois 62225-5001

Dear Duane:

Sometime ago I asked to see a comparison of MC rates across the Air Force. I was somewhat surprised to see that MAC is not only quite a bit lower than TAC and SAC, but also that, with the exception of the C-141, there has been no noticeable improvement since FY 81. In fact, the C-5 has remained the same and the C-130 has declined.

What causes one to "raise his eyebrows" is that MAC seemingly has so much more going for it than do either TAC or SAC—that is, you have enjoyed fuller spares funding, including OWRM, for a longer period; you have had AMS for the C-5, whereas TAC and SAC are just now struggling to implement the rudiments of CAMS.

I believe this issue is of more than just academic interest. With the increasing pressure on the spares budget (only 60% funded for FY 88), the question is being asked whether full spares funding really makes a difference. In MAC's case, the apparent answer would necessarily be "No."

I realize that there are ways to rationalize the MAC anomaly. I also am aware, after talking to Don Logeais, that MAC's measure of effectiveness is on-time departures. However, as I explained to Don, when reports get circulated around this building and over to the Hill, the indicators which appear are uniform across commands and generally consist of MC, FMC, TNMCS and TNMCM (i.e., TM+B+M, TS+B+S) and CANN rate.

According to Don, MAC basically keeps an aircraft in maintenance status from the time it lands until it flies again. I strongly recommend that you rethink this policy, at least in terms of how you record the time. My view is that, no matter how conservative and orthodox you might be with regard to the definition of FMC (Fully Mission Capable), such compunctions need not apply to your definition of MC (Mission Capable). For the latter, it is not necessary to have every spot of corrosion repaired, every seat fully upholstered, every routine TCTO incorporated, etc.

My plea to Don, and to you, is that you give some serious thought to this matter. Somehow MAC needs to demonstrate in terms of the commonly accepted indicators that we have gotten more bang for all of the MAC spares bucks that we have spent since FY 81. Otherwise, there are going to be some long, hot summers ahead.

Cheers,

L.K. MOSEMANN, II
Deputy Assistant Secretary

OFFICE OF THE COMMANDER IN CHIEF
MILITARY AIRLIFT COMMAND
SCOTT AIR FORCE BASE, ILLINOIS 62225-5001

16 May 1986

Mr Lloyd K. Mosemann, II
Deputy Assistant Secretary (Logistics &
Communications)
Office of the Secretary of the Air Force
Washington, DC 20330-1000

Dear Lloyd

I understand your concern in comparing airlift performance indicators against MC rates in other commands. Considerable money has been expended to support spares in recent years, and we need to show that the impact is positive.

Our measure of airlift effectiveness has historically been on-time departures. However, following your conversation with Don Logeais, we have begun a review of MC and CANN rates to redefine our criteria for measuring mission capability. Don will present his findings to the MAC Council and then plans to bring a presentation to you and the Air Staff.

We'll work with your office to find a convenient time. I look forward to your thoughts.

Sincerely

DUANE H. CASSIDY
General, USAF

Appendix G: MAC Productivity Measures

Productivity Measures

Measures	MAC Wings									
Required	**62nd**	**63rd**	**314th**	**317th**	**375th**	**437th**	**438th**	**443rd**	**446th**	**463rd**
Maintenance Air Aborts	X	X	X	X	X	X	X	X	X	X
Cannibalizations/aircraft	X	X	X	X	X	X	X	X	X	X
Delayed discrepancies										
awaiting parts	X	X	X	X	X	X	X	X	X	X
awaiting maintenance	X	X	X	X	X	X	X	X	X	X
Man hours/ Flying hours	X	X	X	X	X	X	X	X	X	X
Base self sufficiency	X	X	X	X	X	X	X	X	X	X
High component failures	X	X	X	X	X	X	X	X	X	X
High work hour consumers	X	X	X	X	X	X	X	X	X	X
Additional										
Departure reliability rates										
Worldwide	X	X		X			X			
Homestation	X	X	X	X	X	X	X		X	X
Enroute	X	X	X	X	X	X	X		X	X
Training	X	X	X	X	X	X	X	X	X	X
Scheduling effectiveness										
operational		X	X		X	X	X		X	
maintenance	X	X	X		X	X		X	X	
Flying hour program					X		X	X	X	X
Mission Capable status	X	X	X	X	X	X		X	X	X
Engine shop data	X	X	X	X		X	X	X		
Total man hour cost maintainability							X			
Maintenance effectiveness			X							
Work center productivity			X			X				X
Cann response time			X						X	
Aircraft utilization		X							X	
Repeat/ recurring discrepancies	X	X	X	X	X	X	X	X	X	X
Dropped objects		X								

Appendix H: Correlation Matrix for MAC Productivity Measures

Correlation Analysis
Productivity Measures

Measures	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.00												
2	-.065	1.00											
3	.100	-.532	1.00										
4	.150	-.214	.319	1.00									
5	.090	-.330	.004	.036	1.00								
6	-.705	.332	.321	-.000	-.204	1.00							
7	-.430	.341	.301	.177	-.240	.027	1.00						
8	.027	.307	-.232	-.202	-.051	.043	-.254	1.00					
9	-.000	.032	.004	-.173	-.101	-.055	.033	-.000	1.00				
10	-.004	.343	-.006	.150	-.032	.119	.136	.309	-.155	1.00			
11	-.549	.547	-.500	-.311	-.406	.005	-.254	.401	.058	-.042	1.00		
12	-.373	.570	-.457	-.290	-.339	.273	.076	.306	.020	.201	.348	1.00	
13	.070	.443	-.400	.100	-.311	-.134	.233	.164	-.074	.437	.103	.304	1.00

Appendix I: Stepwise Regression Analysis Output

OBS	B1	B2	B3	B4	B5	B6	B7	MONTH	MSR1	MSR2	MSR3	MSR4
1	1	0	0	0	0	0	0	1	82.40	70.50	52.60	6.00
2	1	0	0	0	0	0	0	2	97.90	67.11	45.50	13.00
3	1	0	0	0	0	0	0	3	88.00	74.33	56.60	9.00
4	1	0	0	0	0	0	0	4	90.60	67.79	61.80	13.00
5	1	0	0	0	0	0	0	5	56.20	75.26	61.70	8.00
6	1	0	0	0	0	0	0	6	53.20	75.87	44.60	7.00
7	0	1	0	0	0	0	0	1	32.00	60.52	46.60	26.00
8	0	1	0	0	0	0	0	2	35.20	73.11	49.40	19.00
9	0	1	0	0	0	0	0	3	56.80	81.55	43.20	18.00
10	0	1	0	0	0	0	0	4	59.50	84.81	32.00	27.00
11	0	1	0	0	0	0	0	5	54.40	74.16	43.00	25.00
12	0	1	0	0	0	0	0	6	64.70	73.39	40.60	23.00
13	0	0	1	0	0	0	0	1	21.90	84.88	48.10	16.32
14	0	0	1	0	0	0	0	2	26.58	85.07	59.31	12.26
15	0	0	1	0	0	0	0	3	26.08	83.60	70.71	16.64
16	0	0	1	0	0	0	0	4	26.18	85.09	52.52	18.40
17	0	0	1	0	0	0	0	5	26.64	84.23	55.28	18.71
18	0	0	1	0	0	0	0	6	24.02	83.89	35.65	16.25
19	0	0	0	1	0	0	0	1	21.10	80.93	15.40	9.30
20	0	0	0	1	0	0	0	2	19.30	83.36	17.60	9.50
21	0	0	0	1	0	0	0	3	20.80	81.61	23.70	11.14
22	0	0	0	1	0	0	0	4	22.30	80.20	14.80	13.30
23	0	0	0	1	0	0	0	5	25.10	75.63	23.90	13.10
24	0	0	0	1	0	0	0	6	19.30	80.76	20.10	10.10
25	0	0	0	0	1	0	0	1	10.20	77.51	51.70	14.60
26	0	0	0	0	1	0	0	2	21.70	71.94	91.60	14.80

OBS	MSR5	MSR6	MSR7	MSR8	MSR9	MSR10	MSR11	MSR12	MSR13
1	15.00	6.7	10	83.30	9.00	0.0	0.0	93.3	93.70
2	18.00	6.8	5	91.90	0.00	0.0	0.0	88.6	94.30
3	18.00	6.9	9	96.90	0.00	0.0	0.0	96.2	97.70
4	22.00	6.7	3	100.00	1.80	0.0	0.0	96.2	96.70
5	21.00	6.6	5	100.00	1.70	0.0	0.0	91.4	96.93
6	22.00	6.6	8	100.00	0.00	0.0	0.0	92.5	99.40
7	21.00	13.5	21	94.70	0.70	0.0	0.0	93.3	93.70
8	18.00	13.0	15	79.20	3.00	0.0	0.0	88.6	94.30
9	18.00	11.7	9	93.90	0.60	0.0	0.0	96.2	97.70
10	27.00	9.4	8	100.00	0.60	0.0	0.0	96.2	96.70
11	16.00	10.4	29	89.10	2.40	0.0	0.0	91.4	96.93
12	22.00	10.8	18	100.00	2.50	0.0	0.0	92.5	99.40
13	9.95	48.3	52	97.40	2.00	98.5	95.7	96.6	98.89
14	9.50	49.6	100	100.00	0.70	98.1	95.6	93.9	98.80
15	9.97	48.8	87	99.10	3.30	98.6	94.3	96.5	99.90
16	10.72	49.2	131	98.90	2.30	98.0	94.4	94.7	99.82
17	10.56	48.4	90	96.50	2.80	97.1	94.3	96.7	99.83
18	11.35	41.1	103	98.90	3.70	96.8	94.5	98.1	99.92
19	6.09	30.5	75	88.50	3.76	92.0	95.6	95.6	99.60
20	5.90	29.3	82	79.40	1.76	93.9	94.2	94.6	98.89
21	6.70	28.9	86	83.10	1.19	89.9	95.4	91.0	99.59
22	6.30	30.5	89	72.60	1.75	86.9	95.0	97.2	99.33
23	7.56	29.6	78	81.50	1.30	100.0	96.0	92.3	99.68
24	7.00	31.2	64	76.40	0.91	97.7	95.6	97.6	99.72
25	18.00	47.1	18	96.97	1.70	92.9	94.5	93.9	83.30
26	19.70	45.9	28	77.42	1.66	89.0	95.8	88.6	80.40

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OBS	B1	B2	B3	B4	B5	B6	B7	MONTH	MSR1	MSR2	MSR3	MSR4
27	0	0	0	0	1	0	0	3	10.40	72.15	72.80	7.80
28	0	0	0	0	1	0	0	4	17.10	71.76	96.90	6.50
29	0	0	0	0	1	0	0	5	20.50	72.91	76.00	6.90
30	0	0	0	0	1	0	0	6	19.30	75.32	53.00	6.90

31	0	0	0	0	0	1	0	1	14.30	78.39	85.00	18.30
32	0	0	0	0	0	1	0	2	14.80	80.57	72.00	14.20
33	0	0	0	0	0	1	0	3	13.50	79.99	57.90	15.20
34	0	0	0	0	0	1	0	4	13.20	80.59	25.20	17.80
35	0	0	0	0	0	1	0	5	13.00	80.72	25.50	23.80
36	0	0	0	0	0	1	0	6	17.90	80.59	27.90	21.90
37	0	0	0	0	0	0	1	1	51.80	67.48	86.00	24.00
38	0	0	0	0	0	0	1	2	45.60	72.31	115.00	31.00
39	0	0	0	0	0	0	1	3	50.60	66.45	100.00	26.00
40	0	0	0	0	0	0	1	4	47.00	64.51	123.00	26.00
41	0	0	0	0	0	0	1	5	49.60	64.88	127.00	29.00
42	0	0	0	0	0	0	1	6	48.40	77.20	91.00	23.00
43	-1	-1	-1	-1	-1	-1	-1	1	23.90	75.18	48.00	19.00
44	-1	-1	-1	-1	-1	-1	-1	2	31.60	77.16	50.00	21.00
45	-1	-1	-1	-1	-1	-1	-1	3	23.20	79.22	36.00	16.00
46	-1	-1	-1	-1	-1	-1	-1	4	24.90	79.17	38.00	18.00
47	-1	-1	-1	-1	-1	-1	-1	5	25.90	81.80	40.00	19.00
48	-1	-1	-1	-1	-1	-1	-1	6	21.00	86.78	44.00	12.00

OBS	MSR5	MSR6	MSR7	MSR8	MSR9	MSR10	MSR11	MSR12	MSR13
27	17.20	46.9	51	82.81	1.00	96.4	93.4	95.5	89.60
28	17.60	47.0	24	98.04	2.46	91.4	94.1	94.0	85.50
29	18.30	44.9	100	97.22	1.97	94.7	93.4	94.4	88.90
30	14.60	45.6	73	98.00	2.20	94.5	94.9	98.9	91.60
31	17.60	42.9	69	99.24	0.80	95.5	95.0	95.5	99.90
32	16.60	43.8	57	98.45	0.80	97.7	94.6	94.7	100.00
33	16.30	43.8	74	97.80	0.00	96.6	93.9	97.2	100.00
34	16.90	42.4	43	100.00	0.00	99.1	95.3	99.0	99.90
35	17.20	41.9	48	96.59	0.00	95.5	96.4	95.5	99.70
36	16.20	41.7	60	99.30	1.90	95.4	95.8	98.2	99.70
37	22.00	35.5	91	75.60	0.90	94.1	90.1	87.2	95.80
38	26.00	34.5	67	71.60	1.70	96.2	92.9	87.6	97.10
39	24.00	34.2	76	87.50	0.00	95.0	93.4	92.1	94.60
40	26.00	34.3	98	55.70	0.00	96.9	87.2	92.9	94.00
41	29.00	32.3	135	81.00	1.20	94.0	95.1	88.4	95.50
42	30.00	31.0	102	85.20	5.60	94.1	93.0	94.5	95.70
43	17.00	29.6	59	64.40	2.90	95.0	96.2	96.0	95.60
44	17.00	29.9	43	93.90	1.20	96.4	95.6	94.5	97.10
45	13.00	30.4	63	91.00	0.00	95.8	95.5	96.3	94.60
46	15.00	29.8	87	92.30	1.10	95.2	93.4	92.5	94.00
47	15.00	30.0	67	84.60	0.00	93.8	96.0	94.6	95.50
48	14.00	27.2	80	80.00	1.10	97.6	95.2	96.6	95.70

Backward Elimination Procedure for Dependent Variable MSR2

Step 0 All Variables Entered R-square = 0.76415656 C(p) = 19.00000000

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	1436.16717550	79.78706531	5.22	0.0001
Error	29	443.24765575	15.28440192		
Total	47	1879.41483125			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	80.94416366	45.04227782	49.36041927	3.23	0.0827
B1	-25.46732019	13.47054736	54.63166797	3.57	0.0687
B2	-12.35107798	10.64610214	20.57201915	1.35	0.2554
B3	19.08009408	9.14597008	66.51964460	4.35	0.0459
B4	3.24481016	3.97766001	10.17118884	0.67	0.4213
B5	2.48876359	9.77892996	0.98999515	0.06	0.8009
B6	8.89419035	6.63463589	27.46800400	1.80	0.1905
B7	0.05769106	4.92142378	0.00210031	0.00	0.9907
MONTH	0.24799270	0.46807928	4.29029751	0.28	0.6003
MSR1	0.04255920	0.07852921	4.48924028	0.29	0.5920
MSR3	-0.08432768	0.05495764	35.98591531	2.35	0.1358
MSR4	-0.60731827	0.26029670	83.20392220	5.44	0.0268

MSR5	0.52014015	0.37849223	28.86524646	1.89	0.1799
MSR6	-0.39799769	0.55762456	7.78620355	0.51	0.4811
MSR7	-0.05908912	0.03883001	35.39391043	2.32	0.1389
MSR8	0.01041938	0.09219182	0.19523023	0.01	0.9108
MSR9	0.09279231	0.43658106	0.69046649	0.05	0.8332
MSR12	-0.11634671	0.29797424	2.33023212	0.15	0.6991
MSR13	0.26136317	0.41449510	6.07712885	0.40	0.5333

Bounds on condition number: 200.437, 12692.27

Step 1 Variable B7 Removed R-square = 0.76415544 C(p) = 17.00013742

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	1436.16507519	84.48029854	5.72	0.0001
Error	30	443.24975606	14.77499187		
Total	47	1879.41483125			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	80.80241942	42.65973238	53.00779351	3.59	0.0679
B1	-25.39800014	11.89976943	67.30529000	4.56	0.0411
B2	-12.30104416	9.58913817	24.31375592	1.65	0.2094
B3	19.04453454	8.48325785	74.46336204	5.04	0.0323
B4	3.27240557	3.15238286	15.92148532	1.08	0.3075
B5	2.45335409	9.14439910	1.06349970	0.07	0.7903
B6	8.86694452	6.10976561	31.11903586	2.11	0.1571
MONTH	0.24837509	0.45909399	4.32454210	0.29	0.5925
MSR1	0.04277063	0.07514548	4.78644193	0.32	0.5735
MSR3	-0.08426208	0.05375321	36.30636286	2.46	0.1275

MSR4	-0.60681999	0.25248694	85.34325133	5.78	0.0226
MSR5	0.52249842	0.31521266	40.59662307	2.75	0.1078
MSR6	-0.39507393	0.49035398	9.59101540	0.65	0.4268
MSR7	-0.05893481	0.03591666	39.78132472	2.69	0.1113
MSR8	0.01010843	0.08680949	0.20033649	0.01	0.9081
MSR9	0.09407068	0.41563702	0.75684574	0.05	0.8225
MSR12	-0.11658267	0.29229739	2.35041928	0.16	0.6928
MSR13	0.26168351	0.40664266	6.11862847	0.41	0.5248

Bounds on condition number: 160.3374, 9772.265

Step 2 Variable MSR8 Removed R-square = 0.76404885 C(p) = 15.01324467

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	16	1435.96473870	89.74779617	6.27	0.0001
Error	31	443.45009255	14.30484170		
Total	47	1879.41483125			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	81.27739173	41.78319235	54.12767042	3.78	0.0609
B1	-25.57257211	11.61561432	69.33420061	4.85	0.0353
B2	-12.38274156	9.41004921	24.77039231	1.73	0.1979
B3	19.22953847	8.19949752	78.67672973	5.50	0.0256
B4	3.12053547	2.82389764	17.46800870	1.22	0.2776
B5	2.60849125	8.90172280	1.22832613	0.09	0.7715
B6	8.98601750	5.92697231	32.88151194	2.30	0.1396
MONTH	0.24794630	0.45171607	4.30990039	0.30	0.5870
MSR1	0.04402969	0.07317078	5.17963332	0.36	0.5517
MSR3	-0.08629373	0.05002736	42.56242580	2.98	0.0945
MSR4	-0.61428054	0.24030555	93.47359705	6.53	0.0157
MSR5	0.52901163	0.30523476	42.96803592	3.00	0.0930
MSR6	-0.39845470	0.48164273	9.79018588	0.68	0.4144

MSR7	-0.05936187	0.03515586	40.78520645	2.85	0.1013
MSR9	0.08797112	0.40570977	0.67256203	0.05	0.8298
MSR12	-0.11873894	0.28703150	2.44799349	0.17	0.6820
MSR13	0.27062673	0.39291914	6.78606587	0.47	0.4961

Bounds on condition number: 159.7753, 8979.96

Step 3 Variable MSR9 Removed R-square = 0.76369099 C(p) = 13.05724783

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	15	1435.29217667	95.68614511	6.89	0.0001
Error	32	444.12265458	13.87883296		
Total	47	1879.41483125			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	82.40445453	40.83662445	56.51381872	4.07	0.0521
B1	-26.01797019	11.26102538	74.08732210	5.34	0.0275

B2	-12.85546474	9.01668197	28.21207362	2.03	0.1636
B3	19.74835271	7.72496316	90.70304455	6.54	0.0155
B4	3.09367353	2.77885308	17.20167512	1.24	0.2739
B5	2.96805512	8.61469116	1.64746974	0.12	0.7327
B6	9.20156231	5.75535441	35.47577948	2.56	0.1197
MONTH	0.23051740	0.43783818	3.84709687	0.28	0.6022
MSR1	0.03963467	0.06925252	4.54602837	0.33	0.5711
MSR3	-0.08468371	0.04873102	41.91232468	3.02	0.0919
MSR4	-0.61076576	0.23616115	92.82936730	6.69	0.0145
MSR5	0.52628994	0.30040103	42.59908276	3.07	0.0894
MSR6	-0.43062121	0.45135318	12.63312454	0.91	0.3472
MSR7	-0.05795572	0.03403419	40.24527704	2.90	0.0983
MSR12	-0.10930863	0.27946088	2.12334142	0.15	0.6983
MSR13	0.26181696	0.38494955	6.42008645	0.46	0.5013

Bounds on condition number: 144.6181, 7919.491

Step 4 Variable B5 Removed R-square = 0.76281441 C(p) = 11.16503548

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	1433.64470693	102.40319335	7.58	0.0001
Error	33	445.77012432	13.50818559		
Total	47	1879.41483125			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	84.45614624	39.85698920	60.65275912	4.49	0.0417
B1	-23.12042951	7.38812852	132.28784159	9.79	0.0037
B2	-10.17150328	4.47929514	69.65430249	5.16	0.0298
B3	17.92693343	5.55692947	140.58508935	10.41	0.0028
B4	3.38902822	2.60778353	22.81415098	1.69	0.2027
B6	7.95330439	4.41176722	43.90025555	3.25	0.0806
MONTH	0.29828435	0.38591230	8.07013342	0.60	0.4451
MSR1	0.04160924	0.06808718	5.04482163	0.37	0.5453
MSR3	-0.08955384	0.04600891	51.17779871	3.79	0.0602
MSR4	-0.64435021	0.21221326	124.53628811	9.22	0.0047
MSR5	0.55177311	0.28723896	49.84612417	3.69	0.0634
MSR6	-0.29697831	0.22767351	22.98377940	1.70	0.2011
MSR7	-0.05778141	0.03357294	40.01239562	2.96	0.0946
MSR12	-0.09853932	0.27397399	1.74742059	0.13	0.7214
MSR13	0.18775281	0.31504154	4.79771329	0.36	0.5553

Bounds on condition number: 48.4901, 2814.645

Step 5 Variable MSR12 Removed R-square = 0.76188464 C(p) = 9.27936253

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	13	1431.89728634	110.14594510	8.37	0.0001
Error	34	447.51754491	13.16228073		
Total	47	1879.41483125			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	77.61170116	34.41871712	66.75385156	5.07	0.0309
B1	-22.73171369	7.21446809	130.67330353	9.93	0.0034
B2	-10.12164680	4.41945469	69.03926109	5.25	0.0283
B3	17.72787437	5.45804590	138.85774645	10.55	0.0026
B4	3.42920209	2.57181578	23.40117125	1.78	0.1913
B6	7.82956468	4.34165287	42.80516615	3.25	0.0802
MONTH	0.27293357	0.37453157	6.98985547	0.53	0.4712
MSR1	0.03897996	0.06682126	4.47903594	0.34	0.5635
MSR3	-0.08425163	0.04302153	50.47960999	3.84	0.0584
MSR4	-0.61618453	0.19469405	131.84006042	10.02	0.0033
MSR5	0.52753660	0.27562452	48.21704857	3.66	0.0641
MSR6	-0.30594536	0.22338804	24.68874729	1.88	0.1798
MSR7	-0.05564295	0.03261647	38.30696072	2.91	0.0971
MSR13	0.16323387	0.30361376	3.80459804	0.29	0.5943

Bounds on condition number: 47.45246, 2522.888

Step 6 Variable MSR13 Removed R-square = 0.75986028 C(p) = 7.52828284

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	12	1428.09268831	119.00772403	9.23	0.0001
Error	35	451.32214294	12.89491837		
Total	47	1879.41483125			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	95.80223811	5.16875289	4429.94533646	343.54	0.0001
B1	-25.13225945	5.60892686	258.89407609	20.08	0.0001
B2	-11.78060149	3.13162049	182.48000097	14.15	0.0006
B3	19.74183523	3.92912428	325.53831467	25.25	0.0001
B4	3.82338667	2.43992802	31.66365270	2.46	0.1261
B6	9.68844315	2.59914873	179.16960050	13.89	0.0007
MONTH	0.29740964	0.36795936	8.42420604	0.65	0.4244
MSR1	0.04633397	0.06473859	6.60527886	0.51	0.4789
MSR3	-0.08374710	0.04257222	49.90057619	3.87	0.0571
MSR4	-0.62747685	0.19158186	138.32645041	10.73	0.0024
MSR5	0.52261831	0.27266051	47.37435871	3.67	0.0635
MSR6	-0.39803279	0.14194009	101.40191302	7.86	0.0082
MSR7	-0.05293175	0.03189531	35.51381641	2.75	0.1059

Bounds on condition number: 29.27671, 1368.673

Step 7 Variable MSR1 Removed R-square = 0.75634574 C(p) = 5.96044099

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	1421.48740944	129.22612813	10.16	0.0001
Error	36	457.92742181	12.72020616		
Total	47	1879.41483125			

Parameter Standard Type II

Variable	Estimate	Error	Sum of Squares	F	Prob>F
INTERCEP	97.29364269	4.69793371	5455.69526944	428.90	0.0001
B1	-23.61755090	5.15901639	266.58152884	20.96	0.0001
B2	-11.85085673	3.10880473	184.84459589	14.53	0.0005
B3	19.74513219	3.90241313	325.64750361	25.60	0.0001
B4	3.49094375	2.37902428	27.38937383	2.15	0.1510
B6	9.07037373	2.43482708	176.52583462	13.88	0.0007
MONTH	0.31581739	0.36456427	9.54592481	0.75	0.3921
MSR3	-0.07960348	0.04189001	45.93431490	3.61	0.0654
MSR4	-0.57398961	0.17520539	136.52346229	10.73	0.0023
MSR5	0.51243268	0.27043795	45.67015853	3.59	0.0662
MSR6	-0.43053710	0.13356419	132.17072589	10.39	0.0027
MSR7	-0.05117236	0.03158427	33.39053048	2.62	0.1139

Bounds on condition number: 25.10851, 1092.893

Step 8 Variable MONTH Removed R-square = 0.75126654 C(p) = 4.58499436

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	1411.94148464	141.19414846	11.18	0.0001
Error	37	467.47334661	12.63441477		
Total	47	1879.41483125			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	98.02400578	4.60605144	5722.19238574	452.91	0.0001
B1	-23.84860925	5.13471335	272.55166393	21.57	0.0001
B2	-11.83286980	3.09823423	184.29213744	14.59	0.0005
B3	20.05890562	3.87244237	338.99997999	26.83	0.0001
B4	3.43961238	2.37025250	26.60632615	2.11	0.1552
B6	9.13173347	2.42557535	179.07379732	14.17	0.0006
MSR3	-0.09425911	0.03819238	76.95703086	6.09	0.0183
MSR4	-0.61587409	0.16783323	170.13085099	13.47	0.0008
MSR5	0.60423646	0.24796916	75.01940683	5.94	0.0198
MSR6	-0.43802522	0.13283396	137.38387283	10.87	0.0022
MSR7	-0.04106802	0.02925248	24.90216720	1.97	0.1687

Bounds on condition number: 25.0414, 942.8148

Step 9 Variable MSR7 Removed R-square = 0.73801659 C(p) = 4.21424798

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	1387.03931743	154.11547971	11.89	0.0001
Error	38	492.37551382	12.95725036		
Total	47	1879.41483125			

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Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	95.59143483	4.32190193	6338.71163319	489.20	0.0001
B1	-19.97823101	4.38686357	268.73154857	20.74	0.0001
B2	-9.09824678	2.43992764	180.16664085	13.90	0.0006
B3	17.06818874	3.27490226	351.95815872	27.16	0.0001
B4	1.36981049	1.87375037	6.82411223	0.53	0.4725
B6	8.23418812	2.36951069	156.47215852	12.08	0.0013
MSR3	-0.11144472	0.03663679	119.89389604	9.25	0.0042
MSR4	-0.59229750	0.16911097	158.94581693	12.27	0.0012
MSR5	0.52914927	0.24520650	60.34000017	4.66	0.0373
MSR6	-0.37840867	0.12746143	114.20298572	8.81	0.0052

Bounds on condition number: 17.82283, 633.3789

Step10 Variable B4 Removed R-square = 0.73438561 C(p) = 2.66072357

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	1380.21520521	172.52690065	13.48	0.0001
Error	39	499.19962604	12.79999041		
Total	47	1879.41483125			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	95.49207098	4.29343864	6331.89563894	494.68	0.0001
B1	-18.40437289	3.79009746	301.82203067	23.58	0.0001
B2	-8.13073983	2.03106056	205.12756669	16.03	0.0003
B3	16.06233254	2.94908186	379.71103270	29.66	0.0001
B6	7.98233283	2.32969096	150.27013531	11.74	0.0015
MSR3	-0.10935338	0.03630096	116.15498017	9.07	0.0045
MSR4	-0.54993805	0.15775237	155.55550109	12.15	0.0012
MSR5	0.42457004	0.19718593	59.34121898	4.64	0.0376
MSR6	-0.34562555	0.11846247	108.95814908	8.51	0.0058

Bounds on condition number: 13.46705, 434.7935

All variables left in the model are significant at the 0.1000 level.

Summary of Backward Elimination Procedure for Dependent Variable MSR2

Step	Variable Removed	Number In	Partial R**2	Model R**2	C(p)	F	Prob>F
1	B7	17	0.0000	0.7642	17.0001	0.0001	0.9907
2	MSR8	16	0.0001	0.7640	15.0132	0.0136	0.9081
3	MSR9	15	0.0004	0.7637	13.0572	0.0470	0.8298
4	B5	14	0.0009	0.7628	11.1650	0.1187	0.7327
5	MSR12	13	0.0009	0.7619	9.2794	0.1294	0.7214
6	MSR13	12	0.0020	0.7599	7.5283	0.2891	0.5943
7	MSR1	11	0.0035	0.7563	5.9604	0.5122	0.4789
8	MONTH	10	0.0051	0.7513	4.5850	0.7505	0.3921
9	MSR7	9	0.0132	0.7380	4.2142	1.9710	0.1687
10	B4	8	0.0036	0.7344	2.6607	0.5267	0.4725

Backward Elimination Procedure for Dependent Variable MSR7

Step 0 All Variables Entered R-square = 0.84219855 C(p) = 19.00000000

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	50101.75979606	2783.43109978	8.60	0.0001
Error	29	9387.49020394	323.70655876		
Total	47	59489.25000000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	168.50145197	216.27236876	196.49736008	0.61	0.4422
B1	-127.12927329	61.31384767	1391.63546080	4.30	0.0471
B2	-76.80250974	48.04592090	827.15953254	2.56	0.1208
B3	75.72120693	42.89220967	1008.85723685	3.12	0.0880
B4	12.66411862	18.36427268	153.94088292	0.48	0.4959
B5	26.53226291	44.78316622	113.62410938	0.35	0.5581
B6	33.13196238	30.85741098	373.18729378	1.15	0.2918
B7	39.86225123	21.40492068	1122.65908953	3.47	0.0727
MONTH	3.53242610	2.06273906	949.31224868	2.93	0.0975
MSR1	0.11379678	0.36260582	31.88173244	0.10	0.7559
MSR2	-1.25144162	0.82237622	749.60348503	2.32	0.1389

MSR3	0.11884688	0.26205677	66.57884890	0.21	0.6536
MSR4	-1.61919720	1.27040070	525.85927339	1.62	0.2126
MSR5	-0.23009569	1.79715484	5.30636914	0.02	0.8990
MSR6	-2.13191261	2.55820781	224.81156806	0.69	0.4115
MSR8	0.02521937	0.42433916	1.14338848	0.00	0.9530
MSR9	0.83893919	2.00468893	56.69156930	0.18	0.6787
MSR12	-1.35383306	1.35171301	324.72276985	1.00	0.3248
MSR13	1.90523786	1.88769193	329.75217513	1.02	0.3212

Bounds on condition number: 199.1878, 12569.65

Step 1 Variable MSR8 Removed R-square = 0.84217832 C(p) = 17.00353218

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	50100.61640759	2947.09508280	9.42	0.0001
Error	30	9388.63359241	312.95445308		
Total	47	59489.25000000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	168.57085089	212.64712971	196.66498508	0.63	0.4342
B1	-127.05168093	60.27329205	1390.56771047	4.44	0.0435
B2	-76.64975747	47.17360270	826.23695447	2.64	0.1147
B3	75.89463112	42.07613948	1018.19620120	3.25	0.0813
B4	12.50000775	17.85141629	153.44627314	0.49	0.4892
B5	26.65006147	43.98998673	114.86028883	0.37	0.5492
B6	33.21603322	30.30871248	375.87348626	1.20	0.2818
B7	39.47981229	20.07286300	1210.63340387	3.87	0.0585
MONTH	3.53417783	2.02798515	950.44806629	3.04	0.0916
MSR1	0.11806469	0.34947117	35.71893154	0.11	0.7378

MSR2	-1.25052829	0.80846183	748.77120286	2.39	0.1324
MSR3	0.11474389	0.24856582	66.68949809	0.21	0.6477
MSR4	-1.63246953	1.22967303	551.55904396	1.76	0.1943
MSR5	-0.19994923	1.69521052	4.35384845	0.01	0.9069
MSR6	-2.11985725	2.50744326	223.68256756	0.71	0.4046
MSR9	0.83356970	1.96911153	56.08210933	0.18	0.6751
MSR12	-1.36039049	1.32463939	330.07526625	1.05	0.3126
MSR13	1.92780017	1.81815509	351.83845947	1.12	0.2975

Bounds on condition number: 197.9355, 11702.46

Step 2 Variable MSR5 Removed R-square = 0.84210614 C(p) = 15.01698216

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	16	50096.26255914	3131.01640995	10.33	0.0001
Error	31	9392.98744086	302.99959487		
Total	47	59489.25000000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	169.89240601	208.94707053	200.31681585	0.66	0.4224
B1	-126.58624630	59.17968178	1386.34027496	4.58	0.0404
B2	-75.62595329	45.62472856	832.49797308	2.75	0.1075
B3	76.00958732	41.39041712	1021.83127500	3.37	0.0759
B4	13.92041686	12.98638254	349.22784932	1.15	0.2913
B5	24.87291625	40.66658104	113.34963865	0.37	0.5452
B6	32.62037008	29.40586124	372.86533438	1.23	0.2758
B7	38.31162962	17.17941794	1506.90685405	4.97	0.0331
MONTH	3.51501458	1.98905609	946.24206516	3.12	0.0870
MSR1	0.12601839	0.33740576	42.26734091	0.14	0.7113
MSR2	-1.27727271	0.76357181	847.83148571	2.80	0.1044
MSR3	0.10172778	0.21915559	65.28540598	0.22	0.6456

MSR4	-1.70861940	1.02977574	834.15823941	2.75	0.1072
MSR6	-2.03409269	2.36122402	224.85841228	0.74	0.3956
MSR9	0.87415997	1.90772185	63.62001576	0.21	0.6500
MSR12	-1.39458069	1.27181053	364.32125228	1.20	0.2813
MSR13	1.92453550	1.78879697	350.72909713	1.16	0.2903

Bounds on condition number: 181.2905, 10054.6

Step 3 Variable MSR1 Removed R-square = 0.84139563 C(p) = 13.14755517

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	15	50053.99521823	3336.93301455	11.32	0.0001
Error	32	9435.25478177	294.85171193		
Total	47	59489.25000000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	162.44368471	205.17751621	184.82034708	0.63	0.4344
B1	-124.69793936	58.16513694	1355.17910683	4.60	0.0397

B2	-77.41868904	44.75734455	882.19919209	2.99	0.0933
B3	77.27215126	40.69371321	1063.15116628	3.61	0.0666
B4	12.72563326	12.39547892	310.76767438	1.05	0.3123
B5	26.80899931	39.78883260	133.85742506	0.45	0.5053
B6	31.13030714	28.73958381	345.94695744	1.17	0.2868
B7	39.22512854	16.77423148	1612.30477634	5.47	0.0258
MONTH	3.44903867	1.95437723	918.29663206	3.11	0.0871
MSR2	-1.26539987	0.75258231	833.58753074	2.83	0.1024
MSR3	0.11146683	0.21465316	79.50975372	0.27	0.6071
MSR4	-1.59143388	0.96753619	797.71253684	2.71	0.1098
MSR6	-2.19941610	2.28796621	272.47034559	0.92	0.3436
MSR9	0.66961117	1.80268253	40.68277142	0.14	0.7127
MSR12	-1.34691483	1.24826150	343.29918244	1.16	0.2886
MSR13	2.02436178	1.74477310	396.91910044	1.35	0.2545

Bounds on condition number: 174.9195, 9121.395

Step 4 Variable MSR9 Removed R-square = 0.84071177 C(p) = 11.27323311

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	50013.31244681	3572.37946049	12.44	0.0001
Error	33	9475.93755319	287.14962282		
Total	47	59489.25000000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	180.32475011	196.52830721	241.01485620	0.84	0.3662
B1	-131.80386084	54.20707772	1697.66706551	5.91	0.0206
B2	-82.37320053	42.16196784	1096.07023860	3.82	0.0593
B3	82.86516121	37.30852652	1416.56339459	4.93	0.0333
B4	12.44091986	12.20910180	298.15754649	1.04	0.3156
B5	29.76574363	38.47194528	171.89111600	0.60	0.4446
B6	34.21451182	27.15230198	455.94833653	1.59	0.2165
B7	40.75307010	16.04825860	1851.71094592	6.45	0.0160
MONTH	3.31966932	1.89781066	878.60189707	3.06	0.0896
MSR2	-1.27837567	0.74188732	852.60786502	2.97	0.0942
MSR3	0.11073003	0.21182198	78.46879548	0.27	0.6046
MSR4	-1.67059701	0.93136467	923.87268788	3.22	0.0820
MSR6	-2.48217750	2.12925114	390.22954124	1.36	0.2521
MSR12	-1.30461724	1.22671387	324.77898949	1.13	0.2953
MSR13	1.92843196	1.70286762	368.26048007	1.28	0.2656

Bounds on condition number: 155.5565, 7690.069

Step 5 Variable MSR3 Removed R-square = 0.83939272 C(p) = 9.51564029

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	13	49934.84365133	3841.14181933	13.67	0.0001
Error	34	9554.40634867	281.01195143		
Total	47	59489.25000000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	205.09079233	188.98877296	330.93683267	1.18	0.2855
B1	-130.55569516	53.57257851	1668.90391733	5.94	0.0202
B2	-81.26204581	41.65590023	1069.41739797	3.81	0.0594
B3	81.77446959	36.84988804	1383.84649229	4.92	0.0333
B4	8.41748414	9.37568949	226.50770127	0.81	0.3756
B5	29.15390320	38.04094908	165.04999643	0.59	0.4487
B6	33.06596117	26.77246774	428.65736073	1.53	0.2253
B7	45.97226291	12.42940057	3844.29038548	13.68	0.0008
MONTH	3.27223703	1.87527175	855.62975836	3.04	0.0900
MSR2	-1.36798130	0.71405766	1031.37961945	3.67	0.0638
MSR4	-1.77342999	0.90057166	1089.72355398	3.88	0.0571
MSR6	-2.36921784	2.09549735	359.22003300	1.28	0.2661
MSR12	-1.45169639	1.18118274	424.46530384	1.51	0.2275
MSR13	1.93286912	1.68454944	369.96629483	1.32	0.2592

Bounds on condition number: 153.9544, 6941.146

Step 6 Variable B5 Removed R-square = 0.83661827 C(p) = 8.02551565

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	12	49769.79365490	4147.48280457	14.94	0.0001
Error	35	9719.45634510	277.69875272		
Total	47	59489.25000000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	208.43654423	187.82122613	342.00488926	1.23	0.2747
B1	-97.01704344	30.71844940	2769.94675409	9.97	0.0033
B2	-52.98844637	19.22916047	2108.70415650	7.59	0.0092
B3	60.53924521	24.14954570	1745.13891288	6.28	0.0170
B4	11.28294680	8.54706053	483.93323665	1.74	0.1954
B6	19.16586531	19.57629664	266.17650501	0.96	0.3343
B7	44.21350736	12.14348136	3681.26806759	13.26	0.0009
MONTH	4.08024492	1.54165770	1945.22786804	7.00	0.0121
MSR2	-1.29218803	0.70299457	938.25615390	3.38	0.0745
MSR4	-1.88236202	0.88402606	1259.07064465	4.53	0.0403
MSR6	-0.99172633	1.07088630	238.16113719	0.86	0.3607
MSR12	-1.28999076	1.15531272	346.21670670	1.25	0.2718
MSR13	1.22459409	1.40007538	212.44935347	0.77	0.3877

Bounds on condition number: 40.77612, 2011.962

Step 7 Variable MSR13 Removed R-square = 0.83304705 C(p) = 6.68181793

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	49557.34430143	4505.21311831	16.33	0.0001
Error	36	9931.90569857	275.88626940		
Total	47	59489.25000000			

Parameter Standard Type II

Variable	Estimate	Error	Sum of Squares	F	Prob>F
INTERCEP	331.41217278	124.12842801	1966.63827758	7.13	0.0113
B1	-115.77611627	21.91994679	7696.42514036	27.90	0.0001
B2	-66.84443088	10.86423774	10443.88366846	37.86	0.0001
B3	76.84727769	15.29802391	6961.71740977	25.23	0.0001
B4	13.82486062	8.01154061	821.52263307	2.98	0.0930
B6	32.34067249	12.46285678	1857.74457466	6.73	0.0136
B7	47.09014954	11.65142407	4506.42561830	16.33	0.0003
MONTH	4.21422584	1.52901445	2095.76468618	7.60	0.0091
MSR2	-1.27448101	0.70040606	913.47577697	3.31	0.0771
MSR4	-1.97713125	0.87449322	1410.22429644	5.11	0.0299
MSR6	-1.76164937	0.60788799	2316.97798445	8.40	0.0064
MSR12	-1.09512280	1.12992191	259.15457085	0.94	0.3389

Bounds on condition number: 20.89922, 847.8329

Step 8 Variable MSR12 Removed R-square = 0.82869073 C(p) = 5.48240279

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	49298.18973059	4929.81897306	17.90	0.0001
Error	37	10191.06026941	275.43406134		
Total	47	59489.25000000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	232.59038276	70.73474169	2978.07484913	10.81	0.0022
B1	-112.67527465	21.66742431	7448.35419123	27.04	0.0001
B2	-65.81927370	10.80375996	10222.89650749	37.12	0.0001
B3	74.60371508	15.10947268	6714.90603950	24.38	0.0001
B4	14.41758988	7.98161509	898.71382086	3.26	0.0790
B6	28.97250488	11.95882539	1616.63763814	5.87	0.0204
B7	48.76949894	11.51241897	4942.89130239	17.95	0.0001
MONTH	3.79774847	1.46618682	1847.95510960	6.71	0.0136
MSR2	-1.36467220	0.69362750	1066.15837604	3.87	0.0567
MSR4	-1.82444664	0.85948116	1241.10136411	4.51	0.0405
MSR6	-1.71118066	0.60515702	2202.28350431	8.00	0.0075

Bounds on condition number: 20.454, 732.6559

All variables left in the model are significant at the 0.1000 level.

Summary of Backward Elimination Procedure for Dependent Variable MSR7

Step	Variable Removed	Number In	Partial R**2	Model R**2	C(p)	F	Prob>F
1	MSR8	17	0.0000	0.8422	17.0035	0.0035	0.9530
2	MSR5	16	0.0001	0.8421	15.0170	0.0139	0.9069
3	MSR1	15	0.0007	0.8414	13.1476	0.1395	0.7113
4	MSR9	14	0.0007	0.8407	11.2732	0.1380	0.7127
5	MSR3	13	0.0013	0.8394	9.5156	0.2733	0.6046
6	B5	12	0.0028	0.8366	8.0285	0.5873	0.4487
7	MSR13	11	0.0036	0.8330	6.6818	0.7650	0.3877
8	MSR12	10	0.0044	0.8287	5.4824	0.9394	0.3389

Backward Elimination Procedure for Dependent Variable MSR8

Step 0 All Variables Entered R-square = 0.66913257 C(p) = 19.00000000

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	3635.21874816	201.95659712	3.26	0.0023
Error	29	1797.51444351	61.98325667		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	1.93778139	95.62199058	0.02545472	0.00	0.9840
B1	3.69022942	28.74177839	1.02177166	0.02	0.8987
B2	6.42708359	21.89832571	5.33925257	0.09	0.7712
B3	6.51013097	19.71471687	6.75884916	0.11	0.7436
B4	-6.56769623	8.00920913	41.67937888	0.67	0.4189
B5	4.54226257	19.69658403	3.29637821	0.05	0.8192
B6	3.17318158	13.75587063	3.29828421	0.05	0.8192
B7	-15.35513897	9.49167084	162.21707087	2.62	0.1165
MONTH	0.05239308	0.94711166	0.18987915	0.00	0.9563
MSR1	0.16866111	0.15582335	72.61715324	1.17	0.2880
MSR2	0.04225398	0.37386805	0.79172252	0.01	0.9108
MSR3	-0.16324615	0.11101330	134.03253748	2.16	0.1522
MSR4	-0.51839203	0.56309605	52.53225700	0.85	0.3648
MSR5	1.19633481	0.75460720	155.78942797	2.51	0.1237
MSR6	0.48825690	1.12912122	11.59017619	0.19	0.6686
MSR7	0.00482900	0.08125236	0.21893576	0.00	0.9530
MSR9	-0.21693684	0.87894195	3.77590111	0.06	0.8068
MSR12	-0.25344628	0.59978746	11.06754901	0.18	0.6757
MSR13	0.88533244	0.82416916	71.52443367	1.15	0.2916

Bounds on condition number: 202.6513, 13339.43

Step 1 Variable MONTH Removed R-square = 0.66909766 C(p) = 17.00306017

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	3635.02906900	213.82523935	3.57	0.0011
Error	30	1797.70412266	59.92347076		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	0.95304827	92.37620610	0.00637830	0.00	0.9918
B1	3.25524741	27.18202924	0.85941160	0.01	0.9055
B2	6.01924778	20.27446898	5.28180681	0.09	0.7686
B3	6.79714578	18.70105145	7.91622407	0.13	0.7188
B4	-6.65069615	7.73559025	44.29393452	0.74	0.3967
B5	5.03797186	17.24624047	5.11351530	0.09	0.7722
B6	3.34428377	13.17903435	3.85865564	0.06	0.8014
B7	-15.31884996	9.31031213	162.22612792	2.71	0.1103
MSR1	0.16791482	0.15263708	72.51951961	1.21	0.2800
MSR2	0.04428397	0.36582847	0.87808193	0.01	0.9045

MSR3	-0.16380569	0.10869913	136.08267367	2.27	0.1423
MSR4	-0.51608578	0.55214124	52.35285448	0.87	0.3574
MSR5	1.19979341	0.73941194	157.77456334	2.63	0.1151
MSR6	0.46534652	1.03282410	12.16458146	0.20	0.6555
MSR7	0.00619180	0.07613029	0.39638352	0.01	0.9357
MSR9	-0.22629079	0.84807109	4.26644537	0.07	0.7914
MSR12	-0.24864209	0.58352265	10.88004787	0.18	0.6731
MSR13	0.89747160	0.78110728	79.10738319	1.32	0.2598

Bounds on condition number: 175.3874, 11295.23

Step 2 Variable MSR7 Removed R-square = 0.66902470 C(p) = 15.00945518

	DF	Sum of Squares	Mean Square	F	Prob>F

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	16	3634.63268548	227.16454284	3.92	0.0006
Error	31	1798.10050619	58.00324214		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	1.64953728	90.49270327	0.01927300	0.00	0.9856
B1	2.18886033	23.42607673	0.50639481	0.01	0.9262
B2	5.30901809	18.00190729	5.04479634	0.09	0.7700
B3	7.44665489	16.63703136	11.62045285	0.20	0.6576
B4	-6.60363922	7.58932106	43.91502092	0.76	0.3909
B5	5.44769015	16.22766779	6.53679475	0.11	0.7394
B6	3.64946975	12.42948695	5.00040753	0.09	0.7710
B7	-15.03296104	8.48199350	182.19877917	3.14	0.0862
MSR1	0.16837660	0.15006764	73.01997477	1.26	0.2705
MSR2	0.03669079	0.34800142	0.64476923	0.01	0.9167
MSR3	-0.16328066	0.10675457	135.69029847	2.34	0.1363
MSR4	-0.52615620	0.52938725	57.29737150	0.99	0.3280
MSR5	1.20002082	0.72746317	157.83663534	2.72	0.1091
MSR6	0.44035438	0.97012541	11.95091491	0.21	0.6531
MSR9	-0.22490935	0.83420501	4.21620476	0.07	0.7892
MSR12	-0.25570838	0.56769783	11.76813726	0.20	0.6555
MSR13	0.91619994	0.73433742	90.29037740	1.56	0.2215

Bounds on condition number: 159.8623, 9096.37

Step 3 Variable B1 Removed R-square = 0.66893149 C(p) = 13.01762504

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	15	3634.12629067	242.27503604	4.31	0.0003
Error	32	1798.60690100	56.20646566		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	6.61121580	72.13041360	0.47218490	0.01	0.9275
B2	3.78409283	7.47838786	14.39109596	0.26	0.6163

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
B3	8.91088910	5.49989552	147.54329413	2.63	0.1150
B4	-6.69433773	7.40948861	45.88017282	0.82	0.3730
B5	6.52935192	11.19456945	19.12104576	0.34	0.5638
B6	4.74367607	4.10066436	75.21559191	1.34	0.2559
B7	-14.79616899	7.96819519	193.80497201	3.45	0.0726
MSR1	0.16996054	0.14677948	75.36189546	1.34	0.2555
MSR2	0.02706732	0.32722207	0.38458440	0.01	0.9346
MSR3	-0.16235238	0.10463203	135.32382538	2.41	0.1306
MSR4	-0.53818088	0.50549048	63.71135605	1.13	0.2950
MSR5	1.19247323	0.71167871	157.80312578	2.81	0.1036
MSR6	0.35844899	0.40913459	43.14282673	0.77	0.3875
MSR9	-0.24414498	0.79578417	5.29043384	0.09	0.7610
MSR12	-0.26216749	0.55467723	12.55634623	0.22	0.6397
MSR13	0.90757545	0.71714090	90.02078026	1.60	0.2148

Bounds on condition number: 29.34193, 2390.705

Step 4 Variable MSR2 Removed R-square = 0.66886070 C(p) = 11.02382969

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	3633.74170627	259.55297902	4.76	0.0001
Error	33	1798.99148539	54.51489350		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	7.52751216	70.19402788	0.62692815	0.01	0.9152
B2	3.93336868	7.14734126	16.51031813	0.30	0.5858
B3	8.99617705	5.32046948	155.85876915	2.86	0.1003
B4	-6.59[illegible]5695	7.19761565	45.74716803	0.84	0.3663
B5	6.28244338	10.62588637	19.05716737	0.35	0.5584
B6	4.67734213	3.96051108	76.03454983	1.39	0.2460
B7	-14.93568056	7.66957265	206.73921823	3.79	0.0600
MSR1	0.17071426	0.14427508	76.32593669	1.40	0.2452
MSR3	-0.16558869	0.09557054	163.65468685	3.00	0.0925
MSR4	-0.55148330	0.47196109	74.43333813	1.37	0.2510
MSR5	1.21204804	0.66100578	183.29234575	3.36	0.0757
MSR6	0.37128839	0.37280801	54.07137978	0.99	0.3265
MSR9	-0.23784741	0.78012303	5.06740735	0.09	0.7624
MSR12	-0.26158378	0.54622256	12.50251909	0.23	0.6352
MSR13	0.91532641	0.70021221	93.15534699	1.71	0.2002

Bounds on condition number: 25.11874, 2013.873

Step 5 Variable MSR9 Removed R-square = 0.66792794 C(p) = 9.10558415

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	13	3628.67429892	279.12879222	5.26	0.0001
Error	34	1804.05889275	53.06055567		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	5.21593729	68.84623724	0.30456227	0.01	0.9401
B2	4.25202660	6.97555839	19.71540359	0.37	0.5462
B3	8.47965536	4.97580381	154.09966891	2.90	0.0975
B4	-6.26394820	7.02044981	42.24139291	0.80	0.3785
B5	6.19532325	10.47920196	18.54570367	0.35	0.5583
B6	4.75973487	3.89821639	79.10519157	1.49	0.2305
B7	-15.46581761	7.36955107	233.68750720	4.40	0.0434
MSR1	0.18571104	0.13380971	102.20496012	1.93	0.1742
MSR3	-0.16744931	0.09409469	168.03829635	3.17	0.0841
MSR4	-0.55593858	0.46539985	75.71343185	1.43	0.2405
MSR5	1.24206453	0.64485512	196.85017809	3.71	0.0625
MSR6	0.40753539	0.34859830	72.51902235	1.37	0.2505
MSR12	-0.29055394	0.53067087	15.90650738	0.30	0.5876
MSR13	0.94335148	0.68483075	100.68211969	1.90	0.1774

Bounds on condition number: 24.8351, 1775.372

Step 6 Variable MSR12 Removed R-square = 0.66500004 C(p) = 7.36221002

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	12	3612.76779154	301.06398263	5.79	0.0001
Error	35	1819.96540012	51.99901143		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-10.46943966	61.97332615	1.48399471	0.03	0.8668
B2	3.86593421	6.87005342	16.46583571	0.32	0.5772
B3	8.58693280	4.92195836	158.26881303	3.04	0.0898
B4	-6.03998070	6.93806112	39.40850375	0.76	0.3899
B5	5.99590490	10.36757969	17.39201071	0.33	0.5667
B6	4.94653130	3.84421939	86.09546571	1.66	0.2066

B7	-14.99063837	7.24469478	222.63587951	4.28	0.0460
MSR1	0.18079758	0.13218820	97.30597070	1.87	0.1800
MSR3	-0.14921906	0.08712199	152.54155851	2.93	0.0956
MSR4	-0.49398189	0.44688578	63.53141898	1.22	0.2766
MSR5	1.15561459	0.61894045	181.26893686	3.49	0.0703
MSR6	0.35694617	0.33275102	59.83589105	1.15	0.2907
MSR13	0.83377879	0.64835308	85.99508766	1.65	0.2069

Bounds on condition number: 24.8051, 1554.405

Step 7 Variable B2 Removed R-square = 0.66196918 C(p) = 5.62785975

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	3596.30195583	326.93654144	6.41	0.0001
Error	36	1836.43123583	51.01197877		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-16.46018178	60.46986161	3.77975348	0.07	0.7870
B3	9.83554955	4.35153225	260.60636457	5.11	0.0300
B4	-6.64583492	6.78865266	48.88820505	0.96	0.3341
B5	9.94336171	7.56117211	88.21864831	1.73	0.1968
B6	5.25978065	3.76742794	99.43002039	1.95	0.1712
B7	-15.33704652	7.14965536	234.73909406	4.60	0.0388
MSR1	0.14293720	0.11267459	82.09387153	1.61	0.2127
MSR3	-0.14265920	0.08551520	141.96624989	2.78	0.1039
MSR4	-0.29832955	0.27811464	58.69715007	1.15	0.2906
MSR5	1.06113653	0.59005262	164.98072683	3.23	0.0805
MSR6	0.20716596	0.19778656	55.96486009	1.10	0.3019
MSR13	0.93685361	0.61600934	117.98886897	2.31	0.1370

Bounds on condition number: 13.44892, 924.0826

Step 8 Variable B4 Removed R-square = 0.65297036 C(p) = 4.41659219

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	3547.41375078	354.74137508	6.96	0.0001
Error	37	1885.31944089	50.95457948		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	-10.09806775	60.08579183	1.43918361	0.03	0.8675
B3	11.50967349	3.99917152	422.05511288	8.28	0.0066
B5	6.16224805	6.49660563	45.84463993	0.90	0.3490
B6	5.23993104	3.76525323	98.68382748	1.94	0.1723
B7	-20.76362609	4.51304876	1078.57306282	21.17	0.0001
MSR1	0.17030072	0.10909110	124.17596787	2.44	0.1270
MSR3	-0.12700877	0.08396030	116.60109920	2.29	0.1388
MSR4	-0.32438822	0.27668207	70.04083965	1.37	0.2485
MSR5	1.47128018	0.41528184	639.63164163	12.55	0.0011
MSR6	0.30469033	0.17077030	162.20934704	3.18	0.0826
MSR13	0.75441080	0.58681195	84.21726150	1.65	0.2066

Bounds on condition number: 9.939649, 527.1538

Step 9 Variable B5 Removed R-square = 0.64453176 C(p) = 3.15622161

	DF	Sum of Squares	Mean Square	F	Prob>F

Regression	9	3501.56911085	389.06323454	7.66	0.0001
Error	38	1931.16408082	50.82010739		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	37.15145629	33.55539349	62.29634848	1.23	0.2752
B3	13.58859227	3.34069017	840.83758536	16.55	0.0002

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Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
B6	7.15754473	3.17228441	258.71373609	5.09	0.0299
B7	-18.42933007	3.77803556	1209.26808542	23.80	0.0001
MSR1	0.16078557	0.10848547	111.63145565	2.20	0.1466
MSR3	-0.15370168	0.07899930	192.37397011	3.79	0.0591
MSR4	-0.46884846	0.23068878	209.91701504	4.13	0.0491
MSR5	1.53796764	0.40872661	719.55523933	14.16	0.0006
MSR6	0.31216238	0.17036327	170.62582853	3.36	0.0747
MSR13	0.29255890	0.32708156	40.65838230	0.80	0.3767

Bounds on condition number: 5.672815, 299.0091

Step10 Variable MSR13 Removed R-square = 0.63704780 C(p) = 1.81217911

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	3460.91072855	432.61384107	8.56	0.0001
Error	39	1971.82246312	50.55955034		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	66.30976087	7.93357938	3531.99258622	69.86	0.0001
B3	13.66001221	3.33116330	850.18518419	16.82	0.0002
B6	8.15328334	2.96291202	382.85185985	7.57	0.0089
B7	-18.63104334	3.76161865	1240.30365864	24.53	0.0001
MSR1	0.17678793	0.10672545	138.73065396	2.74	0.1057
MSR3	-0.15761172	0.07867579	202.90743066	4.01	0.0521
MSR4	-0.36588255	0.19940080	170.22870314	3.37	0.0742
MSR5	1.38701417	0.37130161	705.52326415	13.95	0.0006
MSR6	0.29394361	0.16870710	153.48450756	3.04	0.0893

Bounds on condition number: 5.546335, 233.862

Step11 Variable MSR1 Removed R-square = 0.61151173 C(p) = 2.05037474

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	7	3322.18007459	474.59715351	8.99	0.0001
Error	40	2110.55311707	52.76382793		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	75.93696345	5.51682776	9996.86664956	189.46	0.0001
B3	16.07328375	3.06029801	1455.51966724	27.59	0.0001
B6	7.09502355	2.95561241	304.05280489	5.76	0.0211
B7	-18.24005406	3.83517005	1193.49138071	22.62	0.0001
MSR3	-0.12835237	0.07832074	141.70675187	2.69	0.1091
MSR4	-0.36721070	0.20369949	171.46957869	3.25	0.0790
MSR5	1.48725466	0.37423766	833.32036411	15.79	0.0003
MSR6	0.07440169	0.10663692	25.68542487	0.49	0.4894

Bounds on condition number: 4.580649, 139.9405

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Step12 Variable MSR6 Removed R-square = 0.60678383 C(p) = 0.46476769

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	6	3296.49464973	549.41577495	10.54	0.0001
Error	41	2136.23854194	52.10337907		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	78.13800066	4.49745855	15727.37129828	301.85	0.0001
B3	16.17760547	3.03745284	1478.00288127	28.37	0.0001
B6	7.92394628	2.68932673	452.33667209	8.68	0.0053
B7	-19.03429012	3.63934190	1425.25818569	27.35	0.0001
MSR3	-0.09302451	0.05937716	127.88564477	2.45	0.1249
MSR4	-0.32167607	0.19175027	146.63289917	2.81	0.1010
MSR5	1.33033056	0.29723412	1043.72887771	20.03	0.0001

Bounds on condition number: 3.05043, 82.01235

Step13 Variable MSR3 Removed R-square = 0.58324399 C(p) = 0.52799656

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	5	3168.60900496	633.72180099	11.76	0.0001
Error	42	2264.12418671	53.90771873		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	76.27400412	4.41168877	16113.66431709	298.91	0.0001
B3	15.56095983	3.06354899	1390.83002177	25.80	0.0001
B6	9.21330039	2.60426036	674.70295756	12.52	0.0010
B7	-21.23579291	3.41474458	2084.83393775	38.67	0.0001
MSR4	-0.27675933	0.19284969	111.02417891	2.06	0.1587
MSR5	1.08796540	0.25815991	957.42223743	17.76	0.0001

Bounds on condition number: 2.595654, 48.7456

Step14 Variable MSR4 Removed R-square = 0.56280784 C(p) = 0.31919285

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	4	3057.58482605	764.39620651	13.84	0.0001
Error	43	2375.14836561	55.23600850		
Total	47	5432.73319167			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	73.96894506	4.15922242	17470.15854948	316.28	0.0001

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
B3	15.54200413	3.10103352	1387.46937830	25.12	0.0001
B6	9.49250947	2.62878303	720.23609277	13.04	0.0008
B7	-21.88474043	3.42611680	2253.72414890	40.80	0.0001
MSR5	0.95166369	0.24299349	847.22744272	15.34	0.0003

Bounds on condition number: 2.550136, 31.94136

All variables left in the model are significant at the 0.1000 level.

Summary of Backward Elimination Procedure for Dependent Variable MSR8

Step	Variable Removed	Number In	Partial R**2	Model R**2	C(p)	F	Prob>F
1	MONTH	17	0.0000	0.6691	17.0031	0.0031	0.9563
2	MSR7	16	0.0001	0.6690	15.0095	0.0066	0.9357
3	B1	15	0.0001	0.6689	13.0176	0.0087	0.9262
4	MSR2	14	0.0001	0.6689	11.0238	0.0088	0.9346
5	MSR9	13	0.0009	0.6679	9.1056	0.0930	0.7624
6	MSR12	12	0.0029	0.6650	7.3622	0.2998	0.5876
7	B2	11	0.0030	0.6620	5.6279	0.3167	0.5772
8	B4	10	0.0090	0.6530	4.4166	0.9584	0.3341
9	B5	9	0.0084	0.6445	3.1562	0.8997	0.3490
10	MSR13	8	0.0075	0.6370	1.8122	0.8000	0.3767
11	MSR1	7	0.0255	0.6115	2.0504	2.7439	0.1057
12	MSR6	6	0.0047	0.6068	0.4648	0.4868	0.4894
13	MSR3	5	0.0235	0.5832	0.5280	2.4545	0.1249
14	MSR4	4	0.0204	0.5628	0.3192	2.0595	0.1587

Backward Elimination Procedure for Dependent Variable MSR9

Step 0 All Variables Entered R-square = 0.35556169 C(p) = 19.00000000

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	44.17497303	2.45416517	0.89	0.5948
Error	29	80.06499364	2.76086185		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	18.51179685	19.88623139	2.39241684	0.87	0.3596
B1	-8.04124419	5.88106680	5.16153589	1.87	0.1820
B2	-7.38098961	4.42090594	7.69575642	2.79	0.1058
B3	7.29735750	3.94220803	9.46012436	3.43	0.0744
B4	-2.05070027	1.66688264	4.17867898	1.51	0.2285
B5	5.82758246	4.01758180	5.80887558	2.10	0.1576
B6	3.72623120	2.82225171	4.81274423	1.74	0.1971
B7	2.81044913	2.02550026	5.31534584	1.93	0.1758
MONTH	-0.20636109	0.19619101	3.05451394	1.11	0.3016
MSR1	-0.05397441	0.03201184	7.84872835	2.84	0.1025
MSR2	0.01676132	0.07888079	0.12472078	0.05	0.8332
MSR3	0.01012516	0.02421427	0.48273209	0.17	0.6789
MSR4	0.00451931	0.12056250	0.00387939	0.00	0.9704
MSR5	-0.13626758	0.13407810	1.90426992	0.69	0.4130
MSR6	-0.48091540	0.22176187	12.98399370	4.70	0.0385
MSR7	0.00715523	0.01709780	0.48351690	0.18	0.6787
MSR8	-0.00966281	0.03914988	0.16818641	0.06	0.8068
MSR12	0.10695154	0.12541135	2.00791373	0.73	0.4008
MSR13	-0.09045073	0.17657060	0.72448938	0.26	0.6123

Bounds on condition number: 175.4978, 12325.72

Step 1 Variable MSR4 Removed R-square = 0.35553047 C(p) = 17.00140514

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	44.17109364	2.59829963	0.97	0.5087
Error	30	80.06887303	2.66896243		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	18.84835177	17.44623729	3.11519809	1.17	0.2886
B1	-8.10405293	5.54270810	5.70562184	2.14	0.1541

B2	-7.37667981	4.34523481	7.69197434	2.88	0.0999
B3	7.33570683	3.74323313	10.25021273	3.84	0.0594
B4	-2.04066707	1.61763879	4.24740496	1.59	0.2168
B5	5.78941134	3.82116088	6.12661556	2.30	0.1402
B6	3.74940081	2.70751607	5.11828085	1.92	0.1763
B7	2.82240175	1.96667219	5.49687896	2.06	0.1616
MONTH	-0.20581129	0.19235831	3.05533583	1.14	0.2932
MSR1	-0.05349632	0.02889133	9.15140363	3.43	0.0739

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MSR2	0.01558598	0.07114509	0.12809172	0.05	0.8281
MSR3	0.00975797	0.02177279	0.53608495	0.20	0.6572
MSR5	-0.13300588	0.13677086	2.52404450	0.95	0.3386
MSR6	-0.48047205	0.21772947	12.99703479	4.87	0.0351
MSR7	0.00700752	0.01635825	0.48977554	0.18	0.6714
MSR8	-0.00991084	0.03793905	0.18213374	0.07	0.7957
MSR12	0.10558175	0.11795589	2.13836027	0.80	0.3779
MSR13	-0.09126022	0.17230373	0.74871434	0.28	0.6003

Bounds on condition number: 174.9986, 10896.58

Step 2 Variable MSR2 Removed R-square = 0.35449947 C(p) = 15.04780070

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	16	44.04300191	2.75268762	1.06	0.4254
Error	31	80.19696475	2.58699886		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	19.54301805	16.89017345	3.46346884	1.34	0.2561
B1	-8.43369673	5.25200026	6.67087372	2.58	0.1185
B2	-7.62911495	4.12483223	8.84976985	3.42	0.0739
B3	7.60654217	3.47851540	12.37037689	4.78	0.0364
B4	-2.00901409	1.58624081	4.14976941	1.60	0.2148
B5	5.94062551	3.70014328	6.66842861	2.58	0.1185
B6	3.86303130	2.61624646	5.64021141	2.18	0.1499
B7	2.79854574	1.93326816	5.42096823	2.10	0.1578
MONTH	-0.20293718	0.18894064	2.98448030	1.15	0.2911
MSR1	-0.05398750	0.02835916	9.37552957	3.62	0.0663
MSR3	0.00912612	0.02124695	0.47728215	0.18	0.6705
MSR5	-0.13171760	0.13452985	2.47997062	[illegible]	[illegible]
MSR6	-0.48978276	0.21023669	14.04061735	5.43	0.0265
MSR7	0.00629203	0.01578087	0.41126034	0.16	0.6925
MSR8	-0.00911671	0.03718107	0.15553520	0.06	0.807[illegible]
MSR12	0.10701921	0.11595075	2.20380195	0.85	0.3632
MSR13	-0.08455425	0.16693893	0.66366955	0.26	0.6161

Bounds on condition number: 168.3307, 9655.062

Step 3 Variable MSR8 Removed R-square = 0.35324757 C(p) = 13.10413644

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	15	43.88746671	2.92583111	1.17	0.3452
Error	32	80.35249995	2.51101562		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	19.85636431	16.59258443	3.59600931	1.43	0.2402
B1	-8.51892024	5.16295352	6.83631535	2.72	0.1087

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B2	-7.67391165	4.05981709	8.97160346	3.57	0.0678
B3	7.57296448	3.42439393	12.28043688	4.89	0.0343
B4	-1.94330575	1.54030927	3.99683140	1.59	0.2162
B5	5.85188412	3.62791954	6.53319403	2.60	0.1166
B6	3.85384001	2.57727440	5.61455649	2.24	0.1446
B7	2.96563065	1.78242595	6.95121222	2.77	0.1059
MONTH	-0.20356364	0.18612824	3.00348387	1.20	0.2823
MSR1	-0.05512838	0.02756097	10.04641386	4.00	0.0540
MSR3	0.01036268	0.02033440	0.65212460	0.26	0.6138
MSR5	-0.13993131	0.12836484	2.98391937	1.19	0.2838
MSR6	-0.49393869	0.20645201	14.37332561	5.72	0.0228
MSR7	0.00617549	0.01554033	0.39652604	0.16	0.6937
MSR12	0.10799877	0.11416743	2.24699751	0.89	0.3513
MSR13	-0.09473554	0.15930025	0.88806017	0.35	0.5562

Bounds on condition number: 167.2366, 8904.459

Step 4 Variable MSR7 Removed R-square = 0.35005596 C(p) = 11.24776044

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	43.49094067	3.10649576	1.27	0.2769
Error	33	80.74902599	2.44694018		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	20.02806183	16.37395954	3.66094980	1.50	0.2299
B1	-9.15872679	4.84249883	8.75295131	3.58	0.0674
B2	-8.15943294	3.82189039	11.15287548	4.56	0.0403
B3	7.94347998	3.25270391	14.59338023	5.96	0.0201
B4	-1.90749580	1.51792528	3.86411237	1.58	0.2177
B5	6.11016307	3.52339174	7.35880154	3.01	0.0922
B6	4.00488269	2.51635898	6.19808830	2.53	0.1210
B7	3.22570645	1.63663442	9.50538431	3.88	0.0572
MONTH	-0.18293118	0.17644470	2.63015670	1.07	0.3074
MSR1	-0.05559339	0.02718251	10.23506136	4.18	0.0489
MSR3	0.01229854	0.01948873	0.97445943	0.40	0.5323
MSR5	-0.15032846	0.12405635	3.59308712	1.47	0.2342
MSR6	-0.50882507	0.20041781	15.77203517	6.45	0.0160
MSR12	0.10213870	0.11175726	2.04386638	0.84	0.3674
MSR13	-0.08215906	0.15411999	0.69537060	0.28	0.5975

Bounds on condition number: 161.7305, 7735.707

Step 5 Variable MSR13 Removed R-square = 0.34445896 C(p) = 9.49962766

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	13	42.79557008	3.29196693	1.37	0.2219
Error	34	81.44439659	2.39542343		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	14.29685903	12.21929568	3.27922499	1.37	0.2501
B1	-9.40709552	4.76902435	9.32039506	3.89	0.0567
B2	-8.40528379	3.75381227	12.00997095	5.01	0.0318
B3	7.88997190	3.21674862	14.41116066	6.02	0.0195
B4	-2.15949832	1.42717336	5.48446881	2.29	0.1395
B5	7.02777054	3.04177217	12.78686482	5.34	0.0271
B6	3.83039217	2.46857572	5.76734419	2.41	0.1300
B7	3.23283116	1.61926030	9.54805701	3.99	0.0539
MONTH	-0.21925352	0.16103568	4.44049337	1.85	0.1823

MSR1	-0.05722041	0.02672478	10.98135902	4.58	0.0395
MSR3	0.01195016	0.01927164	0.92107011	0.38	0.5393
MSR5	-0.14483081	0.12231864	3.35829570	1.40	0.2448
MSR6	-0.51909068	0.19737935	16.56781771	6.92	0.0127
MSR12	0.08367550	0.10513054	1.51747349	0.63	0.4316

Bounds on condition number: 160.2374, 6800.511

Step 6 Variable MSR3 Removed R-square = 0.33704533 C(p) = 7.83324454

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	12	41.87449997	3.48954166	1.48	0.1774
Error	35	82.36546670	2.35329905		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	15.24603900	12.01597362	3.78855188	1.61	0.2129
B1	-8.84025770	4.63925820	8.54495699	3.63	0.0650
B2	-8.11446958	3.69150766	11.37076917	4.83	0.0346
B3	7.56657822	3.14615652	13.61179878	5.78	0.0216
B4	-2.34848418	1.38193827	6.79634016	2.89	0.0981
B5	6.81331919	2.99535815	12.17578789	5.17	0.0292
B6	3.47193603	2.37874213	5.01332452	2.13	0.1533
B7	3.52179479	1.53706076	12.35444227	5.25	0.0281
MONTH	-0.22913211	0.15883050	4.89757619	2.08	0.1580
MSR1	-0.05670487	0.02647593	10.79481794	4.59	0.0393
MSR5	-0.12496629	0.11700664	2.68436689	1.14	0.2928
MSR6	-0.49122040	0.19049655	15.64788628	6.65	0.0143
MSR12	0.06811735	0.10119104	1.06637132	0.45	0.5053

Bounds on condition number: 151.9287, 5974.188

Step 7 Variable MSR12 Removed R-square = 0.32846217 C(p) = 6.21949035

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	40.80812865	3.70982988	1.60	0.1404
Error	36	83.43183802	2.31755106		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	21.85382498	6.87732884	23.40155074	10.10	0.0030
B1	-9.18023330	4.57652443	9.32535076	4.02	0.0524
B2	-8.39522141	3.63990656	12.32858260	5.32	0.0270
B3	7.86877054	3.09022219	15.02670151	6.48	0.0153
B4	-2.31186851	1.37033914	6.59628551	2.85	0.1002
B5	6.97843492	2.96253720	12.85931256	5.55	0.0241
B6	3.77157093	2.31890874	6.13065046	2.65	0.1126
B7	3.28600884	1.48520779	11.34468201	4.90	0.0334
MONTH	-0.20221698	0.15254350	4.07265084	1.76	0.1933
MSR1	-0.05617343	0.02626239	10.60285497	4.58	0.0393
MSR5	-0.12479344	0.11611426	2.67695892	1.16	0.2896
MSR6	-0.50119456	0.18847142	16.38894444	7.07	0.0116

Bounds on condition number: 151.0095, 5387.776

Step 8 Variable MSR5 Removed R-square = 0.30691549 C(p) = 5.18910023

	DF	Sum of Squares	Mean Square	F	Prob>F

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	38.13116972	3.81311697	1.64	0.1339
Error	37	86.10879694	2.32726478		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	18.52383522	6.15289131	21.09489477	9.06	0.0047
B1	-8.37600014	4.52438532	7.97627246	3.43	0.0721
B2	-7.96830247	3.62574130	11.24045244	4.83	0.0343
B3	7.88458983	3.09665643	15.08752359	6.48	0.0152
B4	-1.05008107	0.70821698	5.11633281	2.20	0.1466
B5	6.13671192	2.86312190	10.69147422	4.59	0.0387
B6	3.17746636	2.25677281	4.61351605	1.98	0.1675
B7	1.99160045	0.87089962	12.17065717	5.23	0.0280
MONTH	-0.21850014	0.15210701	4.80231638	2.06	0.1593
MSR1	-0.05795385	0.02626496	11.33070596	4.87	0.0336
MSR6	-0.45650958	0.18421306	14.29238678	6.14	0.0179

Bounds on condition number: 143.6606, 4492.466

Step 9 Variable B6 Removed R-square = 0.26978157 C(p) = 4.86014221

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	33.51765367	3.72418374	1.56	0.1628
Error	38	90.72231299	2.38742929		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	10.77810297	2.79051658	35.61606709	14.92	0.0004
B1	-2.24327904	1.23954565	7.81937544	3.28	0.0782

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
B2	-3.10729796	1.12160095	18.32397043	7.68	0.0086
B3	3.83236152	1.15748815	26.17160467	10.96	0.0020
B4	-0.84795351	0.70242135	3.47919837	1.46	0.2348
B5	2.36432840	1.02230641	12.76979574	5.35	0.0262
B7	1.45067406	0.79161668	8.01752528	3.36	0.0747
MONTH	-0.10897946	0.13239162	1.61770304	0.68	0.4156
MSR1	-0.06307915	0.02634555	13.68634485	5.73	0.0217
MSR6	-0.21318340	0.06459577	26.00333707	10.89	0.0021

Bounds on condition number: 17.21949, 505.5925

Step10 Variable MONTH Removed R-square = 0.25676078 C(p) = 3.44608353

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	31.89995063	3.98749383	1.68	0.1333
Error	39	92.34001604	2.36769272		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	10.13194553	2.66674382	34.17814619	14.44	0.0005
B1	-2.09822523	1.22187408	6.98194859	2.95	0.0939
B2	-2.98088737	1.10643619	17.18556164	7.26	0.0104
B3	3.70164838	1.14179501	24.88509960	10.51	0.0024
B4	-0.84081505	0.69945860	3.42138748	1.45	0.2366
B5	2.25069081	1.00874687	11.78671145	4.98	0.0315
B7	1.40828375	0.78668794	7.58792048	3.20	0.0812
MSR1	-0.06229220	0.02621915	13.36458207	5.64	0.0225
MSR6	-0.20551152	0.06365512	24.67919468	10.42	0.0025

Bounds on condition number: 16.86102, 434.1724

Step11 Variable B4 Removed R-square = 0.22922224 C(p) = 2.68532970

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	7	28.47856315	4.06836616	1.70	0.1369
Error	40	95.76140352	2.39403509		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	8.74504314	2.41758559	31.32497306	13.08	0.0008
B1	-2.24638878	1.22238539	8.08507500	3.38	0.0735
B2	-2.85520870	1.10759601	15.90902116	6.65	0.0137
B3	3.34950650	1.10969890	21.81131516	9.11	0.0044
B5	2.08421023	1.00473778	10.30168096	4.30	0.0445
B7	0.99853055	0.71291594	4.69652425	1.96	0.1690
MSR1	-0.04484670	0.02195754	9.98674517	4.17	0.0477
MSR6	-0.18009747	0.06037484	21.30265952	8.90	0.0048

Bounds on condition number: 15.00113, 327.3285

Step12 Variable B7 Removed R-square = 0.19142020 C(p) = 2.38643773

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	6	23.78203890	3.96367315	1.62	0.1668
Error	41	100.45792777	2.45019336		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	6.77820373	1.99140325	28.39483218	11.59	0.0015
B1	-1.59598673	1.14393377	4.76932758	1.95	0.1705
B2	-2.07152908	0.96702625	11.24361322	4.59	0.0382
B3	2.85957182	1.06540622	17.65110576	7.20	0.0104
B5	1.79143804	0.99421339	7.95508319	3.25	0.0789
MSR1	-0.02925889	0.01914889	5.72043220	2.33	0.1342
MSR6	-0.13393606	0.05117559	16.78300415	6.85	0.0124

Bounds on condition number: 10.53096, 210.8752

Step13 Variable B1 Removed R-square = 0.15303217 C(p) = 2.11391554

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	5	19.01271132	3.80254226	1.52	0.2049
Error	42	105.22725535	2.50541084		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	5.37142557	1.73607683	23.98392141	9.57	0.0035
B2	-1.29219134	0.79821881	6.56581408	2.62	0.1130
B3	1.75811609	0.72343156	14.79718671	5.91	0.0194
B5	0.72395996	0.64197509	3.18619017	1.27	0.2658
MSR1	-0.03294380	0.01917839	7.39268550	2.95	0.0932
MSR6	-0.08440881	0.03727445	12.84789611	5.13	0.0288

Bounds on condition number: 5.463691, 80.80275

Step14 Variable B5 Removed R-square = 0.12738671 C(p) = 1.28797190

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	4	15.82652115	3.95663029	1.57	0.1997
Error	43	108.41344552	2.52124292		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	4.67227706	1.62671834	20.79822438	8.25	0.0063

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
B2	-0.79464734	0.66730243	3.57534658	1.42	0.2403
B3	1.70802367	0.72434438	14.01884600	5.56	0.0230
MSR1	-0.02885112	0.01889	5.88054173	2.33	0.1340
MSR6	-0.06638188	0.03377	9.73694428	3.86	0.0559

Bounds on condition number: 4.458811, 48.50641

Step15 Variable B2 Removed R-square = 0.09860897 C(p) = 0.56298294

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	3	12.25117457	4.08372486	1.60	0.2019
Error	44	111.98879210	2.54519982		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	3.81474750	1.46556293	17.24425887	6.78	0.0126
B3	1.11568384	0.52904366	11.31934107	4.45	0.0407
MSR1	-0.02330116	0.01839414	4.08430612	1.60	0.2119
MSR6	-0.04485931	0.02867230	6.23019984	2.45	0.1249

Bounds on condition number: 3.182334, 22.10222

Step16 Variable MSR1 Removed R-square = 0.06573463 C(p) = 0.04234204

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	2	8.16686845	4.08343423	1.58	0.2166
Error	45	116.07309821	2.57940218		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	2.10602731	0.57690143	34.37508928	13.33	0.0007
B3	0.84896108	0.48850972	7.79764195	3.02	0.0891
MSR6	-0.01555330	0.01705154	2.14603512	0.83	0.3666

Bounds on condition number: 1.110583, 4.44233

Step17 Variable MSR6 Removed R-square = 0.04846132 C(p) = -1.18035172

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	1	6.02083333	6.02083333	2.34	0.1327
Error	46	118.21913333	2.56998116		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F

INTERCEP	1.62416667	0.23138987	126.62003333	49.27	0.0001

B3	0.70833333	0.46277975	6.02083333	2.34	0.1327

Bounds on condition number: 1, 1

Step18 Variable B3 Removed R-square = 0.00000000 C(p) = -0.99957135

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	0	0.00000000	.	.	.
Error	47	124.23996667	2.64340355		
Total	47	124.23996667			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	1.62416667	0.23467191	126.62003333	47.90	0.0001

Bounds on condition number: 0, 0

All variables left in the model are significant at the 0.1000 level.

Summary of Backward Elimination Procedure for Dependent Variable MSR9

Step	Variable Removed	Number In	Partial R**2	Model R**2	C(p)	F	Prob>F
1	MSR4	17	0.0000	0.3555	17.0014	0.0014	0.9704
2	MSR2	16	0.0010	0.3545	15.0478	0.0460	0.8281
3	MSR8	15	0.0013	0.3532	13.1041	0.0601	0.8079
4	MSR7	14	0.0032	0.3501	11.2478	0.1579	0.6937
5	MSR13	13	0.0056	0.3445	9.4996	0.2842	0.5975
6	MSR3	12	0.0074	0.3370	7.8332	0.3845	0.5393
7	MSR12	11	0.0086	0.3285	6.2195	0.4531	0.5053
8	MSR5	10	0.0215	0.3069	5.1891	1.1551	0.2896
9	B6	9	0.0371	0.2698	4.8601	1.9824	0.1676
10	MONTH	8	0.0130	0.2568	3.4461	0.6776	0.4159
11	B4	7	0.0275	0.2292	2.6853	1.4450	0.2366
12	B7	6	0.0378	0.1914	2.3864	1.9618	0.1690
13	B1	5	0.0384	0.1530	2.1139	1.9485	0.1705
14	B5	4	0.0256	0.1274	1.2880	1.2717	0.2658
15	B2	3	0.0288	0.0986	0.5630	1.4181	0.2403
16	MSR1	2	0.0329	0.0657	0.0423	1.6047	0.2119
17	MSR6	1	0.0173	0.0485	-1.1804	0.8320	0.3666
18	B3	0	0.0485	0.0000	-0.9996	2.3428	0.1327

Backward Elimination Procedure for Dependent Variable MSR12

Step 0 All Variables Entered R-square = 0.59899214 C(p) = 19.00000000

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	255.78911221	14.21050623	2.41	0.0170
Error	29	171.24338779	5.90494441		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	63.84403508	27.02843667	32.94690432	5.58	0.0251
B1	-6.06063991	8.80210445	2.79949529	0.47	0.4966
B2	-2.09399943	6.75784017	0.56696089	0.10	0.7589
B3	3.32993140	6.06686300	1.67368620	0.28	0.5985

B4	-0.25724130	2.50010727	0.06251438	0.01	0.9188
B5	2.17567729	6.07155743	0.75823627	0.13	0.7227
B6	2.16975414	4.23054308	1.55326165	0.26	0.6119
B7	-1.10728914	3.05205334	0.77723734	0.13	0.7194
MONTH	0.22850675	0.28924856	3.68528823	0.62	0.4359
MSR1	0.04203365	0.04843230	4.44774314	0.75	0.3926
MSR2	-0.04494915	0.11511876	0.90025708	0.15	0.6991
MSR3	-0.05588877	0.03396909	15.95442877	2.71	0.1107
MSR4	-0.27429388	0.16880559	15.59101590	2.64	0.1150
MSR5	0.29280627	0.23662879	9.04151887	1.53	0.2259
MSR6	0.04635389	0.34952261	0.10385743	0.02	0.8954
MSR7	-0.02469616	0.02465749	5.92348178	1.00	0.3248
MSR8	-0.02414501	0.05713981	1.05436960	0.18	0.6757
MSR9	0.22874846	0.26823040	4.29453540	0.73	0.4008
MSR13	0.37522513	0.24986060	13.31692889	2.26	0.1440

Bounds on condition number: 203.8343, 13326.87

Step 1 Variable B4 Removed R-square = 0.59884575 C(p) = 17.01058679

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	255.72659783	15.04274105	2.63	0.0099
Error	30	171.30590217	5.71019674		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	64.00642564	26.53364320	33.22801918	5.82	0.0222
B1	-5.95536577	8.59706364	2.74010793	0.48	0.4938
B2	-1.96341893	6.52723069	0.51667696	0.09	0.7656
B3	3.19159752	5.95472042	1.64038035	0.29	0.5959
B5	1.90645644	5.38772300	0.71498071	0.13	0.7259
B6	2.10496756	4.11385915	1.49500639	0.26	0.6126
B7	-1.29179538	2.42864085	1.61551849	0.28	0.5987
MONTH	0.23411513	0.27934273	4.01083983	0.70	0.4086
MSR1	0.04343371	0.04570865	5.15594196	0.90	0.3496
MSR2	-0.04674458	0.11189643	0.99650883	0.17	0.6791

MSR3	-0.05544493	0.03313381	15.98939537	2.80	0.1047
MSR4	-0.27726259	0.16355586	16.40973018	2.87	0.1004
MSR5	0.30763875	0.18452914	15.87096090	2.78	0.1059
MSR6	0.05699681	0.32831460	0.17209637	0.03	0.8633
MSR7	-0.02503302	0.02403279	6.19539698	1.08	0.3059
MSR8	-0.02326589	0.05555794	1.00137814	0.18	0.6784
MSR9	0.23505639	0.25678822	4.78459296	0.84	0.3673
MSR13	0.36781404	0.23527523	13.95581664	2.44	0.1285

Bounds on condition number: 185.9824, 11466.54

Step 2 Variable MSR6 Removed R-square = 0.59844274 C(p) = 15.03973124

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	16	255.55450147	15.97215634	2.89	0.0055
Error	31	171.47799853	5.53154834		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	66.02258794	23.48080543	43.73228007	7.91	0.0085
B1	-7.33984288	3.16035419	29.83655817	5.39	0.0269
B2	-3.06376222	1.53477227	22.04291056	3.98	0.0548
B3	4.15191340	2.16970746	20.25540457	3.66	0.0649
B5	2.71223024	2.69286106	5.61224287	1.01	0.3216

B6	2.74372843	1.81103945	12.69618187	2.30	0.1399
B7	-1.14430267	2.24058602	1.44431319	0.26	0.6130
MONTH	0.21803422	0.25938239	3.90854449	0.71	0.4070
MSR1	0.04216857	0.04441250	4.98670880	0.90	0.3497
MSR2	-0.05041542	0.10814791	1.20209048	0.22	0.6444
MSR3	-0.05369532	0.03106623	16.52503874	2.99	0.0939
MSR4	-0.27737141	0.16097585	16.42285381	2.97	0.0948
MSR5	0.30249259	0.17926090	15.75088856	2.85	0.1016
MSR7	-0.02591207	0.02312288	6.94651965	1.26	0.2711
MSR8	-0.02201356	0.05421905	0.91184998	0.16	0.6875
MSR9	0.22034988	0.23859013	4.71809397	0.85	0.3629
MSR13	0.36868816	0.23151256	14.02865380	2.54	0.1214

Bounds on condition number: 21.66738, 2063.47

Step 3 Variable MSR8 Removed R-square = 0.59630743 C(p) = 13.19415267

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	15	254.64265149	16.97617677	3.15	0.0031
Error	32	172.38984851	5.38718277		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	65.64849495	23.15462363	43.30477690	8.04	0.0079
B1	-7.10428379	3.06583564	28.92707855	5.37	0.0270

B2	-2.96849098	1.49680516	21.18861812	3.93	0.0560
B3	3.75362303	1.90985752	20.80947298	3.86	0.0581
B5	2.53420639	2.62182369	5.03313646	0.93	0.3410
B6	2.52847711	1.70895563	11.79283411	2.19	0.1488
B7	-0.73432483	1.97313584	0.74614660	0.14	0.7122
MONTH	0.21974174	0.25594181	3.97104086	0.74	0.3970
MSR1	0.03809321	0.04269507	4.28846176	0.80	0.3789
MSR2	-0.04949931	0.10670410	1.15930537	0.22	0.6459
MSR3	-0.05104579	0.02997413	15.62385925	2.90	0.0983
MSR4	-0.26526541	0.15611241	15.55421618	2.89	0.0990
MSR5	0.26954537	0.15774216	15.73004270	2.92	0.0972
MSR7	-0.02570640	0.02281367	6.83996545	1.27	0.2682
MSR9	0.22744337	0.23482396	5.05386322	0.94	0.3400
MSR13	0.35453143	0.22586544	13.27307789	2.46	0.1263

Bounds on condition number: 20.93714, 1749.377

Step 4 Variable B7 Removed R-square = 0.59456014 C(p) = 11.32051230

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	253.89650489	18.13546463	3.46	0.0017
Error	33	173.13599511	5.24654531		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type 11 Sum of Squares	F	Prob>F
INTERCEP	68.94431510	21.11304909	55.94592206	10.66	0.0026
B1	-7.67351596	2.62213268	44.93170404	8.56	0.0062
B2	-3.07798734	1.44831550	23.69646444	4.52	0.0411
B3	4.00422760	1.76372751	27.04256997	5.15	0.0298
B5	2.11234445	2.33305082	4.30085204	0.82	0.3718
B6	2.65454107	1.65303974	13.52962421	2.58	0.1178
MONTH	0.24058800	0.24645556	4.99970187	0.95	0.3361
MSR1	0.03963453	0.04193539	4.68661738	0.89	0.3515
MSR2	-0.05254674	0.10499158	1.31418390	0.25	0.6201
MSR3	-0.05465356	0.02799055	20.00264866	3.81	0.0594

MSR4	-0.29540210	0.13171440	26.38967526	5.03	0.0317
MSR5	0.26973741	0.15566870	15.75263332	3.00	0.0925
MSR7	-0.03052525	0.01853631	14.22804921	2.71	0.1091
MSR9	0.22170567	0.23123854	4.82288135	0.92	0.3446
MSR13	0.33158426	0.21443132	12.54540889	2.39	0.1316

Bounds on condition number: 15.72596, 1296.378

Step 5 Variable MSR2 Removed R-square = 0.59148266 C(p) = 9.54306883

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	13	252.58232099	19.42940931	3.79	0.0009
Error	34	174.45017901	5.13088762		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	66.33448328	20.23219244	55.15505333	10.75	0.0024
B1	-7.00334599	2.22946389	50.62940009	9.87	0.0035
B2	-2.90162268	1.38921691	22.38382286	4.36	0.0443
B3	3.46921888	1.38731136	32.08544128	6.25	0.0174
B5	2.18405404	2.30263701	4.61522484	0.90	0.3496
B6	2.47944357	1.59768652	12.35713573	2.41	0.1299
MONTH	0.22563169	0.24192562	4.46302128	0.87	0.3576
MSR1	0.03809969	0.04135955	4.35395356	0.85	0.3634
MSR3	-0.04944529	0.02569617	18.99790759	3.70	0.0627
MSR4	-0.26850839	0.11892189	26.15680183	5.10	0.0305
MSR5	0.25106742	0.14945786	14.47890486	2.82	0.1022
MSR7	-0.02856163	0.01791554	13.04063928	2.54	0.1201
MSR9	0.21389276	0.22815388	4.50950578	0.88	0.3551
MSR13	0.31245511	0.20865883	11.50520152	2.24	0.1435

Bounds on condition number: 12.40267, 1020.308

Step 6 Variable MSR1 Removed R-square = 0.58128683 C(p) = 8.28040914

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	12	248.22836743	20.68569729	4.05	0.0006
Error	35	178.80413257	5.10868950		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	65.08780364	20.14316319	53.34004758	10.44	0.0027
B1	-5.39573510	1.38441228	77.60324481	15.19	0.0004
B2	-2.58312858	1.34259140	18.91097047	3.70	0.0625
B3	3.21624642	1.35691483	28.70139202	5.62	0.0234
B5	1.80455159	2.26078032	3.25485303	0.64	0.4301
B6	1.53585087	1.22348857	8.05061528	1.58	0.2177
MONTH	0.24183082	0.24076318	5.15408898	1.01	0.3221
MSR3	-0.04682588	0.02545799	17.13822378	3.35	0.0758
MSR4	-0.23686685	0.11360874	22.20802104	4.35	0.0444
MSR5	0.26664723	0.14817828	16.54346220	3.24	0.0808
MSR7	-0.02949740	0.01784798	13.95401057	2.73	0.1073
MSR9	0.16783828	0.22212808	2.91660132	0.57	0.4550
MSR13	0.33007546	0.20733029	12.94823256	2.53	0.1204

Bounds on condition number: 12.00873, 721.0322

Step 7 Variable MSR9 Removed R-square = 0.57445880 C(p) = 6.77433442

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	245.31176611	22.30106965	4.42	0.0003
Error	36	181.72073389	5.04779816		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	67.88621670	19.68139849	60.05556878	11.90	0.0014
B1	-5.29798969	1.37011588	75.47612596	14.95	0.0004
B2	-2.41998341	1.31719457	17.03832486	3.38	0.0744
B3	3.39620301	1.32786447	33.02035729	6.54	0.0149
B5	1.54589139	2.22135404	2.44469326	0.48	0.4909
B6	1.47839624	1.21379428	7.48847734	1.48	0.2311
MONTH	0.23207284	0.23897946	4.76024695	0.94	0.3380
MSR3	-0.04776165	0.02526166	18.04416660	3.57	0.0667
MSR4	-0.25022844	0.11155120	25.39959688	5.03	0.0311
MSR5	0.27210371	0.14711552	17.26847244	3.42	0.0726
MSR7	-0.02716200	0.01747324	12.19772621	2.42	0.1288
MSR13	0.30475024	0.20338011	11.33373682	2.25	0.1427

Bounds on condition number: 11.73045, 636.1954

Step 8 Variable B5 Removed R-square = 0.56873206 C(p) = 5.18834225

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	242.86707285	24.28670729	4.88	0.0002
Error	37	184.16542715	4.97744398		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	79.52724525	10.29807487	296.84256058	59.64	0.0001
B1	-5.20923804	1.35462769	73.60628338	14.79	0.0005
B2	-1.89166911	1.06889385	15.58933417	3.13	0.0850
B3	3.72306145	1.23334011	45.35666135	9.11	0.0046
B6	2.07[illegible]79550	0.84638789	30.05444915	6.04	0.0188
MONTH	0.27[illegible]40378	0.22949255	7.11622016	1.43	0.2394
MSR3	-0.04[illegible]67550	0.02502784	17.23751831	3.46	0.0707
MSR4	-0.28412776	0.09965197	40.46335896	8.13	0.0071
MSR5	0.26952771	0.14604045	16.95379268	3.41	0.0730
MSR7	-0.02318729	0.01639796	9.95238300	2.00	0.1657
MSR13	0.18529841	0.10833063	14.56287916	2.93	0.0955

Bounds on condition number: 7.394491, 355.0896

Step 9 Variable MONTH Removed R-square = 0.55206771 C(p) = 4.39347132

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	235.75085269	26.19453919	5.20	0.0001
Error	38	191.28164731	5.03372750		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	78.17764939	10.29374477	290.34099029	57.68	0.0001
B1	-5.35010632	1.35710327	78.23277514	15.54	0.0003

B2	-1.79318818	1.07172441	14.09208329	2.80	0.1025

B3	3.89650308	1.23168564	50.37789238	10.01	0.0031
B6	1.99609319	0.84824359	27.87469762	5.54	0.0239
MSR3	-0.05872074	0.02300294	32.80263948	6.52	0.0148
MSR4	-0.32354576	0.09457127	58.91727761	11.70	0.0015
MSR5	0.35443295	0.12833432	38.39478464	7.63	0.0088
MSR7	-0.01550607	0.01517229	5.25764044	1.04	0.3132
MSR13	0.20379974	0.10782438	17.98303544	3.57	0.0664

Bounds on condition number: 5.646304, 273.8667

Step10 Variable MSR7 Removed R-square = 0.53975567 C(p) = 3.28385063

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	230.49321225	28.81165153	5.72	0.0001
Error	39	196.53928775	5.03946892		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	80.79599454	9.97551469	330.59311778	65.60	0.0001
B1	-4.77095481	1.23382816	75.35047954	14.95	0.0004
B2	-1.47350017	1.02564309	10.40141999	2.06	0.1588
B3	3.45195232	1.15297665	45.17241684	8.96	0.0048
B6	1.92057900	0.84550108	26.00284019	5.16	0.0287
MSR3	-0.06834191	0.02100031	53.37129704	10.59	0.0024
MSR4	-0.32558371	0.09460415	59.68836711	11.84	0.0014
MSR5	0.37764769	0.12638007	44.99883198	8.93	0.0048
MSR13	0.16906911	0.10238747	13.74104118	2.73	0.1067

Bounds on condition number: 5.469413, 201.7457

Step11 . Variable B2 Removed R-square = 0.51539822 C(p) = 3.04532702

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	7	220.09179226	31.44168461	6.08	0.0001
Error	40	206.94070774	5.17351769		
Total	47	427.03250000			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	76.87638336	9.68073504	324.55814435	62.73	0.0001
B1	-5.25836327	1.20194142	99.01944868	19.14	0.0001
B3	2.81786457	1.07922805	35.26953408	6.82	0.0126
B6	1.64820999	0.83485868	20.16438974	3.90	0.0553
MSR3	-0.05456075	0.01892829	42.98570208	8.31	0.0063
MSR4	-0.36903296	0.09082417	85.41092123	16.51	0.0002
MSR5	0.34322994	0.12572819	38.55590804	7.45	0.0094
MSR13	0.21737395	0.09798707	25.46029141	4.92	0.0323

Bounds on condition number: 5.272878, 143.1572

All variables left in the model are significant at the 0.1000 level.

Summary of Backward Elimination Procedure for Dependent Variable MSR12

Step	Variable Removed	Number In	Partial R**2	Model R**2	C(p)	F	Prob>F
1	B4	17	0.0001	0.5988	17.0106	0.0106	0.9188
2	MSR6	16	0.0004	0.5984	15.0397	0.0301	0.8633
3	MSR8	15	0.0021	0.5963	13.1942	0.1648	0.6875

4	B7	14	0.0017	0.5946	11.3205	0.1385	0.7122
5	MSR2	13	0.0031	0.5915	9.5431	0.2505	0.6201
6	MSR1	12	0.0102	0.5813	8.2804	0.8486	0.3634
7	MSR9	11	0.0068	0.5745	6.7743	0.5709	0.4550
8	B5	10	0.0057	0.5687	5.1883	0.4843	0.4909
9	MONTH	9	0.0167	0.5521	4.3935	1.4297	0.2394
10	MSR7	8	0.0123	0.5398	3.2839	1.0445	0.3132
11	B2	7	0.0244	0.5154	3.0453	2.0640	0.1588

OBS	B1	B2	B3	B4	B5	B6	B7	MONTH	MSR1	MSR2	MSR3	MSR4
1	0	0	1	0	0	0	0	1	21.90	84.88	48.10	16.32
2	0	0	1	0	0	0	0	2	26.58	85.07	59.31	12.26
3	0	0	1	0	0	0	0	3	26.08	83.60	70.71	16.64
4	0	0	1	0	0	0	0	4	26.18	85.09	52.52	18.40
5	0	0	1	0	0	0	0	5	26.64	84.23	55.28	18.71
6	0	0	1	0	0	0	0	6	24.02	83.89	35.65	16.25
7	0	0	0	1	0	0	0	1	21.10	80.93	15.40	9.30
8	0	0	0	1	0	0	0	2	19.30	83.36	17.60	9.50
9	0	0	0	1	0	0	0	3	20.80	81.61	23.70	11.14
10	0	0	0	1	0	0	0	4	22.30	80.20	14.80	13.30
11	0	0	0	1	0	0	0	5	25.10	75.63	23.90	13.10
12	0	0	0	1	0	0	0	6	19.30	80.76	20.10	10.10
13	0	0	0	0	1	0	0	1	10.20	77.51	51.70	14.80
14	0	0	0	0	1	0	0	2	21.70	71.94	91.60	14.80
15	0	0	0	0	1	0	0	3	10.40	72.15	72.80	7.80
16	0	0	0	0	1	0	0	4	17.10	71.76	96.90	6.50
17	0	0	0	0	1	0	0	5	20.50	72.91	76.00	6.90
18	0	0	0	0	1	0	0	6	19.30	75.32	53.00	6.90
19	0	0	0	0	0	1	0	1	14.30	78.39	85.00	18.30
20	0	0	0	0	0	1	0	2	14.80	80.57	72.00	14.20
21	0	0	0	0	0	1	0	3	13.50	79.99	57.90	15.20
22	0	0	0	0	0	1	0	4	13.20	80.59	25.20	17.80
23	0	0	0	0	0	1	0	5	13.00	80.72	25.50	23.80
24	0	0	0	0	0	1	0	6	17.90	80.59	27.90	21.90
25	0	0	0	0	0	0	1	1	51.80	67.48	86.00	24.00
26	0	0	0	0	0	0	1	2	45.60	72.31	115.00	31.00

OBS	MSR5	MSR6	MSR7	MSR8	MSR9	MSR10	MSR11	MSR12	MSR13
1	9.95	48.3	52	97.40	2.00	98.5	95.7	96.6	98.89
2	9.50	49.6	100	100.00	0.70	98.1	95.6	93.9	98.80
3	9.97	48.8	87	99.10	3.30	98.6	94.3	96.5	99.90
4	10.72	49.2	131	98.90	2.30	98.0	94.4	94.7	99.82
5	10.56	48.4	90	96.50	2.80	97.1	94.2	96.7	99.83
6	11.35	41.1	103	98.90	3.70	96.8	94.5	98.1	99.92
7	6.09	30.5	75	88.50	3.76	92.0	95.6	95.6	99.60
8	5.90	29.3	82	79.40	1.76	93.9	94.2	94.6	98.89
9	6.70	28.9	86	83.10	1.19	89.9	95.4	91.0	99.59
10	6.30	30.5	89	72.60	1.75	86.9	95.0	97.2	99.33
11	7.56	29.6	78	81.50	1.30	100.0	96.0	92.3	99.68
12	7.00	31.2	64	76.40	0.91	97.7	95.6	97.6	99.72
13	18.00	47.1	19	96.97	1.70	92.9	94.5	93.9	83.30
14	19.70	45.9	28	77.42	1.66	89.0	95.8	88.6	80.40
15	17.20	46.9	81	82.81	1.00	96.4	93.4	95.5	89.60
16	17.60	47.0	24	98.04	2.46	91.4	94.1	94.0	85.50
17	18.30	44.9	100	97.22	1.97	94.7	93.4	94.4	88.90
18	14.60	45.6	73	98.00	2.20	94.5	94.9	98.9	91.60
19	17.60	42.9	69	99.24	0.80	95.5	95.0	95.5	98.90
20	16.60	43.8	57	98.45	0.80	97.7	94.6	94.7	100.00
21	16.30	43.8	74	97.80	0.00	96.6	93.9	97.2	100.00
22	16.90	42.4	43	100.00	0.00	99.1	95.3	99.0	99.90
23	17.20	41.9	48	96.59	0.00	95.5	96.4	95.5	99.70
24	16.20	41.7	80	99.30	1.90	95.4	95.8	98.2	99.70
25	22.00	35.3	91	75.60	0.90	94.1	90.1	87.2	95.60
26	26.00	34.5	67	71.60	1.70	96.2	92.9	87.6	97.10

OBS	B1	B2	B3	B4	B5	B6	B7	MONTH	MSR1	MSR2	MSR3	MSR4
27	0	0	0	0	0	0	1	3	50.60	66.45	100.00	26.00
28	0	0	0	0	0	0	1	4	47.00	64.51	123.00	26.00
29	0	0	0	0	0	0	1	5	49.60	64.88	127.00	29.00
30	0	0	0	0	0	0	1	6	46.40	77.20	91.00	23.00
31	-1	-1	-1	-1	-1	-1	-1	1	23.90	75.18	48.00	19.00

32	-1	-1	-1	-1	-1	-1	-1	2	31.60	77.16	50.00	21.00
33	-1	-1	-1	-1	-1	-1	-1	3	23.20	79.22	36.00	15.00
34	-1	-1	-1	-1	-1	-1	-1	4	24.90	79.17	38.00	18.00
35	-1	-1	-1	-1	-1	-1	-1	5	25.90	81.80	40.00	19.00
36	-1	-1	-1	-1	-1	-1	-1	6	21.00	86.78	44.00	12.00

OBS	MSR5	MSR6	MSR7	MSR8	MSR9	MSR10	MSR11	MSR12	MSR13
27	24.00	34.2	76	87.50	0.00	95.0	93.4	92.1	94.60
28	26.00	34.3	98	55.70	0.00	96.9	87.2	82.9	94.00
29	29.00	32.3	135	81.00	1.20	94.0	95.1	88.4	95.50
30	30.00	31.0	102	85.20	5.60	94.1	93.0	94.5	95.70
31	17.00	29.6	59	64.40	2.90	95.0	96.2	96.0	95.60
32	17.00	29.9	43	93.90	1.20	96.4	95.6	94.5	97.10
33	13.00	30.4	63	91.00	0.00	95.8	95.5	96.3	94.60
34	15.00	29.8	87	92.30	1.10	95.2	93.4	92.5	94.00
35	15.00	30.0	67	84.60	0.00	93.8	96.0	94.6	95.50
36	14.00	27.2	80	80.00	1.10	97.6	95.2	96.6	95.70

Backward Elimination Procedure for Dependent Variable MSR10

Step 0 All Variables Entered R-square = 0.64258878 C(p) = 19.00000000
NOTE: The model is not of full rank. A subset of the model which is of full rank is chosen.

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	182.58714007	10.14373000	1.70	0.1405
Error	17	101.55591548	5.97387738		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	90.48796723	56.32324156	15.41922994	2.58	0.1266
B1	7.31404712	39.11726127	0.20885022	0.03	0.8539
B3	2.64589939	9.34822509	0.47856908	0.08	0.7806
B4	0.55266712	9.45476434	0.02041184	0.00	0.9541
B5	-6.42666197	10.70790879	2.15187922	0.36	0.5563
B6	-6.53828528	8.14159974	3.85269421	0.64	0.4330
MONTH	0.50502532	0.38608536	10.22153078	1.71	0.2083
MSR1	-0.18539978	0.20159438	5.05263430	0.85	0.3706
MSR2	-0.22149415	0.21594808	6.28466529	1.05	0.3194
MSR3	-0.03361370	0.04289291	3.66874793	0.61	0.4440
MSR4	-0.34889430	0.21776757	15.33407680	2.57	0.1275
MSR5	0.68423498	0.47024333	12.64799181	2.12	0.1639
MSR6	0.30535963	0.38601755	3.73822508	0.63	0.4398
MSR7	-0.04807522	0.02848790	17.01288054	2.85	0.1098
MSR8	0.01721005	0.06965573	0.36467562	0.06	0.8078
MSR9	-0.51599832	0.57572127	4.79875215	0.80	0.3826
MSR11	-0.28019969	0.40128248	2.91266950	0.49	0.4945
MSR12	-0.26171282	0.29718400	4.63292686	0.78	0.3908
MSR13	0.68384410	0.31091668	28.89897734	4.84	0.0420

Bounds on condition number: 1280.709, 39687.02

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Step 1 Variable B4 Removed R-square = 0.64251695 C(p) = 17.00341685

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	182.56672823	10.73921931	1.90	0.0923
Error	18	101.57632732	5.64312930		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	91.28277804	53.13370422	16.66239208	2.95	0.1029

B1	9.28622316	19.23909449	1.31470701	0.23	0.6351
B3	2.25784652	6.39684846	0.70303462	0.12	0.7282
B5	-6.79028592	8.47091779	3.82606170	0.64	0.4332
B6	-6.85623644	5.88758564	7.65278711	1.36	0.2594
MONTH	0.50986882	0.36650139	10.92158518	1.94	0.1811
MSR1	-0.19189360	0.16349870	7.77342453	1.38	0.2558
MSR2	-0.22476357	0.20272278	6.93692088	1.23	0.2821

MSR3	-0.03336620	0.04148500	3.65049198	0.65	0.4317
MSR4	-0.34895132	0.21165119	15.33939716	2.72	0.1166
MSR5	0.66360380	0.30201038	27.24544933	4.83	0.0413
MSR6	0.30260390	0.37237085	3.72664218	0.66	0.4270
MSR7	-0.04792608	0.02757678	17.04420501	3.02	0.0993
MSR8	0.01695314	0.06756511	0.35528372	0.06	0.8047
MSR9	-0.50091414	0.50019930	5.65927013	1.00	0.3299
MSR11	-0.27029861	0.35356771	3.29808947	0.58	0.4545
MSR12	-0.26526707	0.28272962	4.96757093	0.88	0.3605
MSR13	0.68108646	0.29868820	29.34190909	5.20	0.0350

Bounds on condition number: 327.9588, 13641.43

Step 2 Variable B7 Entered R-square = 0.64258878 C(p) = 19.00000000
NOTE: The variable which previously had small tolerance is now allowed to enter after removal of some variables from the model.

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	182.58714007	10.14373000	1.70	0.1405
Error	17	101.55591548	5.97387738		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	91.04063435	54.81407356	16.47944942	2.76	0.1151
B1	10.63004982	30.33737288	0.73345076	0.12	0.7303
B3	2.09323227	7.15881679	0.51075032	0.09	0.7735
B5	-6.97932908	9.29630529	3.36715339	0.56	0.4631
B6	-7.09095240	7.26746746	5.68720983	0.95	0.3429
B7	-0.55266712	9.45476434	0.02041184	0.00	0.9541
MONTH	0.50502532	0.38608536	10.22153078	1.71	0.2083
MSR1	-0.18539978	0.20159438	5.05263430	0.85	0.3706
MSR2	-0.22149415	0.21594808	6.28466529	1.05	0.3194
MSR3	-0.03361370	0.04289291	3.66874793	0.61	0.4440
MSR4	-0.34889430	0.21776757	15.33407680	2.57	0.1275
MSR5	0.68423498	0.47024338	12.64799181	2.12	0.1639
MSR6	0.30535963	0.38601755	3.73822508	0.63	0.4398
MSR7	-0.04807522	0.02848790	17.01288054	2.85	0.1098
MSR8	0.01721005	0.06965573	0.36467562	0.06	0.8078
MSR9	-0.51599832	0.57572127	4.79875215	0.80	0.3826
MSR11	-0.28019969	0.40128248	2.91266950	0.49	0.4945
MSR12	-0.26171282	0.29718400	4.63292686	0.78	0.3908
MSR13	0.68384410	0.31091668	28.89897734	4.84	0.0420

Bounds on condition number: 770.3173, 27665.17

Step 3 Variable B7 Removed R-square = 0.64251695 C(p) = 17.00341685

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	182.56672823	10.73921931	1.90	0.0928
Error	18	101.57632732	5.64312930		
Total	35	284.14305556			

Parameter Standard Type II

Variable	Estimate	Error	Sum of Squares	F	Prob>F
INTERCEP	91.28277804	53.12270422	16.66239205	2.95	0.1029
B1	9.28622316	19.23909449	1.31470701	0.23	0.6351
B3	2.25784652	6.39884848	0.70303482	0.12	0.7282
B5	-6.79028592	8.47091779	3.62606170	0.64	0.4332
B6	-6.85625644	5.88758564	7.65278711	1.36	0.2594
MONTH	0.50986882	0.36650139	10.92158515	1.94	0.1811
MSR1	-0.19189360	0.16349870	7.77342453	1.38	0.2558
MSR2	-0.22476357	0.20272278	6.93692088	1.23	0.2821
MSR3	-0.03336620	0.04148500	3.65049198	0.65	0.4317
MSR4	-0.34895132	0.21165119	15.33939716	2.72	0.1166
MSR5	0.66360380	0.30201038	27.24544933	4.83	0.0413
MSR6	0.30260390	0.37237085	3.72664218	0.66	0.4270
MSR7	-0.04792808	0.02757678	17.04420501	3.02	0.0993
MSR8	0.01695314	0.06756511	0.35528372	0.06	0.8047
MSR9	-0.50091414	0.50019930	5.65927013	1.00	0.3299
MSR11	-0.27029861	0.35356771	3.29808947	0.58	0.4545
MSR12	-0.26526707	0.28272982	4.96757093	0.88	0.3605
MSR13	0.68108646	0.29868820	29.34190909	5.20	0.0350

Bounds on condition number: 327.9588, 13641.43

Step 4 Variable MSR8 Removed R-square = 0.64126658 C(p) = 15.06288973

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	16	182.21144451	11.38821528	2.12	0.0595
Error	19	101.93161104	5.36482163		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	88.41537116	50.58351441	16.39052395	3.06	0.0966
B1	7.95501230	18.03132926	1.04419476	0.19	0.6641
B3	2.52833243	6.14791281	0.90733620	0.17	0.6855
B5	-6.34118434	8.07291721	3.31005376	0.62	0.4419
B6	-6.38768133	5.44414404	7.38554515	1.38	0.2552
MONTH	0.50508088	0.35686490	10.74656047	2.00	0.1732
MSR1	-0.17662511	0.14796360	7.64452328	1.42	0.2473
MSR2	-0.21472883	0.19377618	6.58772140	1.23	0.2816
MSR3	-0.03557837	0.03952509	4.34691886	0.81	0.3793
MSR4	-0.36207640	0.19996426	17.58939824	3.28	0.0860
MSR5	0.66823709	0.29365419	27.86396382	5.19	0.0344
MSR6	0.30734502	0.36260473	3.85425731	0.72	0.4072
MSR7	-0.04783039	0.02688559	16.97946044	3.16	0.0912
MSR9	-0.50501745	0.48744823	5.75852254	1.07	0.3132
MSR11	-0.24278365	0.32773922	2.94399671	0.55	0.4679
MSR12	-0.27020245	0.27500172	5.17920433	0.97	0.3382
MSR13	0.69081260	0.28876890	30.70301070	5.72	0.0272

Bounds on condition number: 303.0192, 12026.46

Step 5 Variable B3 Removed R-square = 0.63807334 C(p) = 13.21477870

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	15	181.30410831	12.08694055	2.35	0.0378
Error	20	102.83894724	5.14194736		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	83.10866590	47.88198812	15.49014058	3.01	0.0980
B1	14.43409773	8.58838358	14.53069335	2.83	0.1083

B5	-8.67410126	5.62329230	12.23475520	2.38	0.1386
B6	-8.13937220	3.31939993	30.91649707	6.01	0.0235
MONTH	0.55596807	0.32769944	14.80048428	2.88	0.1053
MSR1	-0.19371444	0.13902755	9.98274320	1.94	0.1788
MSR2	-0.21174669	0.18957552	6.41499538	1.25	0.2773
MSR3	-0.03619141	0.03886785	4.50441844	0.88	0.3805
MSR4	-0.35714589	0.19541439	17.17535917	3.34	0.0826
MSR5	0.66713336	0.28744613	27.69746514	5.39	0.0310
MSR6	0.44446852	0.13950864	52.19242104	10.15	0.0046
MSR7	-0.04543156	0.02569427	16.07572106	3.13	0.0923
MSR9	-0.42729301	0.43988570	4.85176241	0.94	0.3430
MSR11	-0.22009918	0.31628227	2.49008840	0.48	0.4945
MSR12	-0.27165015	0.26920678	5.23570943	1.02	0.3250
MSR13	0.67877305	0.28124847	29.94997528	5.82	0.0255

Bounds on condition number: 73.79636, 4153.805

Step 6 Variable MSR11 Removed R-square = 0.62930984 C(p) = 11.63160322

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	178.81401991	12.77242999	2.55	0.0258
Error	21	105.32903565	5.01566836		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	61.60354306	36.12504389	14.58557075	2.91	0.1029
B1	15.28344498	8.39377517	16.63298979	3.32	0.0829
B5	-9.09670657	5.52133161	13.61474535	2.71	0.1143
B6	-8.26962205	3.27317076	32.01569295	6.38	0.0196
MONTH	0.51767335	0.31905451	13.20415620	2.63	0.1196
MSR1	-0.18300665	0.13646621	9.02011984	1.80	0.1942
MSR2	-0.22399288	0.18642477	7.24085741	1.44	0.2429
MSR3	-0.03479546	0.03813866	4.17487300	0.83	0.3719
MSR4	-0.37429139	0.19145977	19.16873282	3.82	0.0640
MSR5	0.68659649	0.28254750	29.61754342	5.91	0.0242
MSR6	0.44581014	0.13777176	52.51801160	10.47	0.0040
MSR7	-0.04195349	0.02489208	14.24763240	2.84	0.1067
MSR9	-0.49174249	0.42471247	6.72379192	1.34	0.2599
MSR12	-0.22798672	0.25855813	3.89970265	0.78	0.3879
MSR13	0.64999216	0.27475374	28.07099707	5.60	0.0277

Bounds on condition number: 72.93569, 3792.734

Step 7 Variable MSR12 Removed R-square = 0.61558540 C(p) = 10.28439577

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	13	174.91431726	13.45494748	2.71	0.0190
Error	22	109.22873830	4.96494265		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	44.53041165	30.34312179	10.69318636	2.15	0.1564
B1	13.70247639	8.15798042	14.00708177	2.82	0.1072
B5	-7.75635842	5.28105298	10.70998670	2.16	0.1561
B6	-7.56833866	3.15898015	28.49847092	5.74	0.0255
MONTH	0.38072076	0.27728484	9.35998385	1.89	0.1836
MSR1	-0.14892477	0.13021449	6.49425706	1.31	0.2650
MSR2	-0.17676650	0.17766019	4.91511760	0.99	0.3306
MSR3	-0.02238198	0.03526556	1.99990700	0.40	0.5322
MSR4	-0.30010876	0.17111354	15.27224365	3.08	0.0934
MSR5	0.59479303	0.26133441	25.71892327	5.18	0.0329

MSR6	0.38174573	0.11646343	53.34373537	10.74	0.0034
MSR7	-0.03524605	0.02358114	11.09189506	2.23	0.1492
MSR9	-0.59209206	0.40710643	10.50211535	2.12	0.1600
MSR13	0.57485706	0.25988230	24.29296774	4.89	0.0377

Bounds on condition number: 67.40747, 3164.121

Step 8 Variable MSR3 Removed R-square = 0.60854702 C(p) = 8.61917113

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	12	172.91441026	14.40953419	2.98	0.0118
Error	23	111.22864530	4.83602806		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	41.25976635	29.51155654	9.45274860	1.95	0.1754
B1	11.87669622	7.53417860	12.01733827	2.48	0.1286
B5	-6.69110971	4.94160018	8.86573512	1.83	0.1889
B6	-6.93461750	2.95785757	26.58148989	5.50	0.0281
MONTH	0.42251106	0.26583346	12.21646911	2.53	0.1256
MSR1	-0.14734360	0.12848934	6.35941430	1.32	0.2633
MSR2	-0.14095934	0.16626244	3.47608747	0.72	0.4053
MSR4	-0.25650034	0.15466433	13.30100249	2.75	0.1108
MSR5	0.49073952	0.20085069	28.86982837	5.97	0.0226
MSR6	0.33760368	0.09219426	64.84782517	13.41	0.0013
MSR7	-0.03721735	0.02307021	12.58566993	2.60	0.1203
MSR9	-0.55937968	0.39855206	9.52626724	1.97	0.1738
MSR13	0.58914120	0.25552256	25.70804711	5.32	0.0305

Bounds on condition number: 60.59963, 2460.224

Step 9 Variable MSR2 Removed R-square = 0.59631351 C(p) = 7.20104908

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	169.43834278	15.40348571	3.22	0.0080
Error	24	114.70471277	4.77936303		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	27.84468084	24.76464634	6.04213254	1.26	0.2720
B1	9.54265177	6.97197356	8.95357979	1.87	0.1838
B5	-4.51727390	4.19975018	5.52937387	1.16	0.2928
B6	-6.43245264	2.88091852	23.82655558	4.99	0.0352
MONTH	0.34622471	0.24867212	9.26471261	1.94	0.1766
MSR1	-0.09923199	0.11460135	3.58338908	0.75	0.3951
MSR4	-0.23840491	0.15228444	11.71357243	2.45	0.1306
MSR5	0.50567315	0.19890120	30.89121670	6.46	0.0179
MSR6	0.29294058	0.07521620	72.49470581	15.17	0.0007
MSR7	-0.03617694	0.02290219	11.92558932	2.50	0.1273
MSR9	-0.71537060	0.35145904	19.80000104	4.14	0.0530
MSR13	0.61458737	0.25226268	28.38816614	5.94	0.0226

Bounds on condition number: 50.8524, 1843.233

Step10 Variable MSR1 Removed R-square = 0.58370230 C(p) = 5.80089217

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	165.85495370	16.58549537	3.51	0.0053

Error	25	118.28810185	4.73152407
Total	35	284.14305556	

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	27.62926798	24.63815065	5.94960791	1.26	0.2728
B1	5.36866356	5.01174059	5.4[illegible]945534	1.15	0.2943
B5	-3.09144791	3.84408625	3.06012154	0.65	0.4289
B6	-4.44939514	1.73899441	30.97466610	6.55	0.0169
MONTH	0.35816887	0.24704349	9.94557491	2.10	0.1595
MSR4	-0.25519506	0.15028703	13.64277060	2.88	0.1019
MSR5	0.38449609	0.14063083	35.36908653	7.48	0.0113
MSR6	0.30103873	0.07425803	77.76048045	16.43	0.0004
MSR7	-0.03974355	0.02241570	14.87406642	3.14	0.0884
MSR9	-0.64511594	0.34024977	17.00908369	3.59	0.0696
MSR13	0.60382370	0.25069207	27.44986181	5.80	0.0237

Bounds on condition number: 37.47714, 1037.035

Step11 Variable B5 Removed R-square = 0.57293264 C(p) = 4.31314265

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	162.79483216	18.08831468	3.88	0.0032
Error	26	121.34822339	4.66723936		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	13.43994724	17.08111410	2.88950077	0.62	0.4385
B1	1.74833160	2.18770123	2.98079196	0.64	0.4314
B6	-4.31364865	1.71898517	29.39039015	6.30	0.0187
MONTH	0.29532969	0.23276323	7.51355650	1.61	0.2158
MSR4	-0.17731344	0.11414144	11.26306751	2.41	0.1324
MSR5	0.35076958	0.13331718	32.30960731	6.92	0.0141
MSR6	0.27147445	0.06408008	83.76679823	17.95	0.0003
MSR7	-0.03567530	0.02168857	12.62796492	2.71	0.1120
MSR9	-0.64739549	0.33791874	17.13069031	3.67	0.0664
MSR13	0.74825548	0.17371399	86.59449319	18.55	0.0002

Bounds on condition number: 7.597408, 311.4218

Step12 Variable B1 Removed R-square = 0.56244218 C(p) = 2.81211371

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	159.81404020	19.97675502	4.34	0.0016
Error	27	124.32901536	4.60477835		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	19.99216066	14.88416944	8.30766520	1.80	0.1904
B6	-3.16284267	0.93245888	52.97909420	11.51	0.0022
MONTH	0.26514642	0.22813654	6.22000277	1.35	0.2553
MSR4	-0.15668088	0.11043677	9.26858278	2.01	0.1674
MSR5	0.30963369	0.12215372	29.58637590	6.43	0.0174
MSR6	0.26805654	0.06350792	82.03623569	17.82	0.0002
MSR7	-0.02579761	0.01770235	9.77925908	2.12	0.1566
MSR9	-0.53549318	0.30547750	14.15005637	3.07	0.0910
MSR13	0.67313998	0.14510797	99.09163407	21.52	0.0001

Bounds on condition number: 4.641112, 163.1957

Step13 Variable B2 Entered R-square = 0.57293264 C(p) = 4.31314265
NOTE: The variable which previously had small tolerance is now allowed to enter after removal of some variables from the model.

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	162.79483216	18.08831468	3.88	0.0032
Error	26	121.34822339	4.66723936		

	DF	Sum of Squares	Mean Square	F	Prob>F
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	13.43994724	17.08111410	2.88950077	0.62	0.4385
B2	1.74833160	2.18770123	2.98079196	0.64	0.4314
B6	-4.31364865	1.71898517	29.39039015	6.30	0.0187
MONTH	0.29532969	0.23276323	7.51355650	1.61	0.2158
MSR4	-0.17731344	0.11414144	11.26306751	2.41	0.1324
MSR5	0.35076958	0.13331718	32.30960731	6.92	0.0141
MSR6	0.27147445	0.06408008	83.76679823	17.95	0.0003
MSR7	-0.03567530	0.02168857	12.62796492	2.71	0.1120
MSR9	-0.64739549	0.33791874	17.13069031	3.67	0.0664
MSR13	0.74825548	0.17371399	86.59449319	18.55	0.0002

Bounds on condition number: 7.597408, 311.4218

Step14 Variable B2 Removed R-square = 0.56244218 C(p) = 2.81211371

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	159.81404020	19.97675502	4.34	0.0018
Error	27	124.32901536	4.60477835		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	19.99216066	14.88416944	8.30766520	1.80	0.1904
B6	-3.16284267	0.93245888	52.97909420	11.51	0.0022
MONTH	0.26514642	0.22813654	6.22000277	1.35	0.2553
MSR4	-0.15668088	0.11043677	9.26858278	2.01	0.1674
MSR5	0.30963369	0.12215372	29.58637590	6.43	0.0174
MSR6	0.26805654	0.06350792	82.03623569	17.82	0.0002
MSR7	-0.02579761	0.01770235	9.77925908	2.12	0.1566
MSR9	-0.53549318	0.30547750	14.15005637	3.07	0.0910
MSR13	0.67313998	0.14510797	99.09163407	21.52	0.0001

Bounds on condition number: 4.641112, 163.1957

Step15 Variable MONTH Removed R-square = 0.54055179 C(p) = 1.85331399

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	7	153.59403743	21.94200535	4.71	0.0014
Error	28	130.54901813	4.66246493		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	20.05864711	14.97699973	8.36313698	1.79	0.1912
B6	-3.10640366	0.93701177	51.24643215	10.99	0.0025
MSR4	-0.18083166	0.10914148	12.79925873	2.75	0.1087

MSR5	0.32932169	0.12172882	34.12474482	7.32	0.0115
MSR6	0.26055680	0.06357375	78.31857335	16.80	0.0003
MSR7	-0.01992729	0.01707242	6.35216722	1.36	0.2530
MSR9	-0.52230903	0.30717297	13.48045824	2.89	0.1001
MSR13	0.68139111	0.14583920	101.77941612	21.83	0.0001

Bounds on condition number: 4.551857, 131.7593

Step16 Variable MSR7 Removed R-square = 0.51819627 C(p) = 0.91663799

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	6	147.24187020	24.54031170	5.20	0.0010
Error	29	136.90118535	4.72073053		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	27.10227711	13.79286255	18.22686415	3.86	0.0591
B6	-2.78535210	0.90128989	45.08586582	9.55	0.0044
MSR4	-0.16654067	0.10912811	10.99452813	2.33	0.1378
MSR5	0.29114221	0.11798214	28.74663643	6.09	0.0197
MSR6	0.25196455	0.06353946	74.23369133	15.73	0.0004
MSR9	-0.59496438	0.30267363	18.24071957	3.86	0.0590
MSR13	0.60104293	0.12937193	101.89199560	21.58	0.0001

Bounds on condition number: 4.223191, 94.62532

Step17 Variable MSR4 Removed R-square = 0.47950263 C(p) = 0.75707217

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	5	136.24734207	27.24946841	5.53	0.0010
Error	30	147.89571349	4.92985712		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	39.66342622	11.31027749	60.62730541	12.30	0.0015
B6	-2.38509588	0.88117788	36.11759663	7.33	0.0111
MSR5	0.14211422	0.06766046	21.74901191	4.41	0.0442
MSR6	0.24234650	0.06461140	69.35688215	14.07	0.0008
MSR9	-0.51490772	0.30462419	14.08524344	2.86	0.1013
MSR13	0.46801154	0.09768928	113.14976015	22.95	0.0001

Bounds on condition number: 1.890053, 38.74717

Step18 Variable MSR9 Removed R-square = 0.42993167 C(p) = 1.11487809

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	4	122.16209863	30.54052466	5.84	0.0013
Error	31	161.98095693	5.22519216		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	40.66366603	11.62818686	63.89859697	12.23	0.0014
B6	-2.11881393	0.89257328	29.44422577	5.64	0.0240
MSR5	0.14250730	0.06965725	21.86974994	4.19	0.0493
MSR6	0.22412669	0.06558641	61.01853184	11.68	0.0018
MSR13	0.45650602	0.10032844	108.18004799	20.70	0.0001

Bounds on condition number: 1.829645, 26.34921

All variables left in the model are significant at the 0.1000 level.

Summary of Backward Elimination Procedure for Dependent Variable MSR10

Step	Variable Entered	Variable Removed	Number In	Partial R**2	Model R**2	C(p)	F	Prob>F
1		B4	17	0.0001	0.6425	17.0034	0.0034	0.9541
2	B7		18	0.0001	0.6426	19.0000	0.0034	0.9541
3		B7	17	0.0001	0.6425	17.0034	0.0034	0.9541
4		MSR8	16	0.0013	0.6413	15.0629	0.0630	0.8047
5		B3	15	0.0032	0.6381	13.2148	0.1691	0.6855
6		MSR11	14	0.0088	0.6293	11.6316	0.4843	0.4945
7		MSR12	13	0.0137	0.6156	10.2844	0.7775	0.3879
8		MSR3	12	0.0070	0.6085	8.6192	0.4028	0.5322
9		MSR2	11	0.0122	0.5963	7.2010	0.7188	0.4053
10		MSR1	10	0.0126	0.5837	5.8009	0.7498	0.3951
11		B5	9	0.0108	0.5729	4.3131	0.6468	0.4289
12		B1	8	0.0105	0.5624	2.8121	0.6387	0.4314
13	B2		9	0.0105	0.5729	4.3131	0.6387	0.4314
14		B2	8	0.0105	0.5624	2.8121	0.6387	0.4314
15		MONTH	7	0.0219	0.5406	1.8533	1.3508	0.2553
16		MSR7	6	0.0224	0.5182	0.9166	1.3624	0.2530
17		MSR4	5	0.0387	0.4795	0.7571	2.3290	0.1378
18		MSR9	4	0.0496	0.4299	1.1149	2.8571	0.1013

Backward Elimination Procedure for Dependent Variable MSR11

Step 0 All Variables Entered R-square = 0.66502524 C(p) = 19.00000000
NOTE: The model is not of full rank. A subset of the model which is of full rank is chosen.

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	71.59809488	3.97767194	1.88	0.1008
Error	17	36.06412734	2.12141926		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	76.44083349	30.88464715	12.99547165	6.13	0.0241
B1	-38.61004497	21.37314768	6.92293331	3.26	0.0886
B3	8.57585964	5.18202497	5.81008965	2.74	0.1163
B4	9.72305259	5.11762297	7.65764452	3.61	0.0745
B5	7.91783995	6.15567549	3.50984963	1.65	0.2156
B6	5.59771638	4.75277654	2.94275087	1.39	0.2551
MONTH	0.05508502	0.24100532	0.11082563	0.05	0.8219
MSR1	0.03378199	0.12281251	0.16051356	0.08	0.7866
MSR2	0.04347560	0.13218910	0.22947024	0.11	0.7463
MSR3	-0.00539286	0.02598527	0.09137140	0.04	0.8381
MSR4	0.05314886	0.13862605	0.31183492	0.15	0.7062
MSR5	0.35311480	0.28455491	3.26682736	1.54	0.2315
MSR6	-0.06256385	0.23373751	0.15199054	0.07	0.7922
MSR7	-0.02090987	0.01762535	2.98473494	1.41	0.2519
MSR8	0.05355659	0.03950263	3.89942289	1.84	0.1929
MSR9	-0.16839103	0.34871022	0.49469223	0.23	0.6353
MSR10	-0.09950338	0.14250182	1.03433545	0.49	0.4945
MSR12	-0.08796180	0.17983017	0.50756265	0.24	0.6310
MSR13	0.19172100	0.20478102	1.85945836	0.88	0.3623

Bounds on condition number: 1076.665, 34810.65

Step 1 Variable MSR3 Removed R-square = 0.66417655 C(p) = 17.04307088

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	71.50672348	4.20627785	2.09	0.0647
Error	18	36.15549874	2.00863882		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	74.90838933	29.18092625	13.23623971	6.59	0.0194
B1	-38.70094404	20.79289445	6.95849103	3.46	0.0791
B3	8.50343653	5.03095212	5.73839491	2.86	0.1082
B4	9.63104828	4.96101260	7.57021669	3.77	0.0680
B5	8.14883157	5.89108804	3.84327542	1.91	0.1835
B6	5.71061149	4.59432422	3.10330028	1.54	0.2298
MONTH	0.05348428	0.23439146	0.10458527	0.05	0.8221
MSR1	0.03439774	0.11946853	0.16651546	0.08	0.7767

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
MSR2	0.05228387	0.12131713	0.37001607	0.18	0.6729
MSR4	0.06866354	0.11359604	0.73388487	0.37	0.5531
MSR5	0.32086687	0.23196085	3.84345883	1.91	0.1835
MSR6	-0.07888339	0.21418224	0.27246209	0.14	0.7169
MSR7	-0.02067917	0.01711923	2.93089054	1.46	0.2427
MSR8	0.05533147	0.03752663	4.36683827	2.17	0.1576
MSR9	-0.16310229	0.33840716	0.46659802	0.23	0.6356
MSR10	-0.09414756	0.13636942	0.95738364	0.48	0.4988
MSR12	-0.07419925	0.16265260	0.41800248	0.21	0.6537
MSR13	0.18529994	0.19697590	1.77756800	0.88	0.3593

Bounds on condition number: 1076.213, 32019.69

Step 2 Variable MONTH Removed R-square = 0.66320513 C(p) = 15.09237056

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	16	71.40213821	4.46263364	2.34	0.0397
Error	19	36.26008401	1.90842547		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	71.75287294	25.04689050	15.66196179	8.21	0.0099
B1	-40.80645882	18.16258143	9.63336183	5.05	0.0367
B3	8.97026898	4.48008405	7.65099101	4.01	0.0597
B4	9.91430655	4.68184205	8.55788361	4.48	0.0476
B5	8.90740899	4.74057821	6.73778727	3.53	0.0757
B6	6.19894480	3.96273109	4.67005009	2.45	0.1342
MSR1	0.04558588	0.10619093	0.35169089	0.18	0.6725
MSR2	0.06318118	0.10923431	0.63845827	0.33	0.5698
MSR4	0.07602889	0.10616197	0.97880134	0.51	0.4826
MSR5	0.32576048	0.22513200	3.99574275	2.09	0.1642
MSR6	-0.10152004	0.18502688	0.57452526	0.30	0.5896
MSR7	-0.01904986	0.01518595	3.01106380	1.58	0.2243
MSR8	0.05493573	0.03653945	4.31381043	2.26	0.1492
MSR9	-0.18849556	0.31151170	0.69876110	0.37	0.5523
MSR10	-0.08490408	0.12692399	0.85397412	0.45	0.5116
MSR12	-0.05374111	0.13228287	0.31497970	0.17	0.6891
MSR13	0.18185229	0.19143369	1.72216993	0.90	0.3541

Bounds on condition number: 864.271, 24318.99

Step 3 Variable MSR12 Removed R-square = 0.66027950 C(p) = 13.24084649

	DF	Sum of Squares	Mean Square	F	Prob>F

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	15	71.08715851	4.73914390	2.59	0.0242
Error	20	36.57506371	1.82875319		
Total	35	107.66222222			

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Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	67.86135908	22.65462451	16.40916437	8.97	0.0071
B1	-41.39452851	17.72286178	9.97638672	5.46	0.0300
B3	8.97927097	4.38549738	7.66654235	4.19	0.0540
B4	10.36545614	4.45228410	9.91211183	5.42	0.0305
B5	8.81623776	4.63538656	6.61536050	3.62	0.0717
B6	6.24783844	3.87734248	4.74838965	2.60	0.1228
MSR1	0.05382117	0.10203915	0.50877740	0.28	0.6037
MSR2	0.06429391	0.10689625	0.66156086	0.36	0.5543
MSR4	0.08465514	0.10182249	1.26407936	0.69	0.4156
MSR5	0.33449189	0.21937601	4.25155728	2.32	0.1430
MSR6	-0.08733674	0.17787006	0.44090326	0.24	0.6288
MSR7	-0.01822096	0.01471103	2.80550493	1.53	0.2298
MSR8	0.05597072	0.03568155	4.49976160	2.46	0.1324
MSR9	-0.21546068	0.29793752	0.95640256	0.52	0.4779
MSR10	-0.08654812	0.12418319	0.88826954	0.49	0.4939
MSR13	0.15731732	0.17782566	1.43126250	0.78	0.3868

Bounds on condition number: 858.7814, 22475.81

Step 4 Variable MSR6 Removed R-square = 0.65618426 C(p) = 11.44868056

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	70.64625525	5.04616109	2.86	0.0145
Error	21	37.01596697	1.76266509		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	63.83809840	20.73578928	16.70661814	9.48	0.0057
B1	-39.73372217	17.07985962	9.53937039	5.41	0.0301
B3	7.89102181	3.71523281	7.95177758	4.51	0.0457
B4	10.95966480	4.20652980	11.96510205	6.79	0.0165
B5	7.83759106	4.10867304	6.41404258	3.64	0.0702
B6	5.54000775	3.53376129	4.33227614	2.46	0.1319
MSR1	0.04966500	0.09983315	0.43623571	0.25	0.6240
MSR2	0.06900519	0.10452332	0.76825780	0.44	0.5163
MSR4	0.08578959	0.09993997	1.29885456	0.74	0.4004
MSR5	0.35590933	0.21107535	5.01156667	2.84	0.1066
MSR7	-0.01646173	0.01400788	2.43430903	1.38	0.2531
MSR8	0.05666665	0.03500324	4.61964435	2.62	0.1204
MSR9	-0.18128913	0.28441276	0.71616844	0.41	0.5307
MSR10	-0.08729595	0.12190949	0.90382204	0.51	0.4818
MSR13	0.15911889	0.17454577	1.46485504	0.83	0.3723

Bounds on condition number: 827.5015, 18858.77

Step 5 Variable MSR1 Removed R-square = 0.65213236 C(p) = 9.65431448

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	13	70.21001954	5.40077073	3.17	0.0083
Error	22	37.45220268	1.70237285		
Total	35	107.66222222			

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Parameter	Standard	Type II

Variable	Estimate	Error	Sum of Squares	F	Prob>F
INTERCEP	68.55569046	18.12221783	24.36234055	14.31	0.0010
B1	-33.70398453	11.82625216	13.82683907	8.12	0.0093
B3	6.92579295	3.11369108	8.42253158	4.95	0.0367
B4	9.81927144	3.46620211	13.66172225	8.03	0.0097
B5	6.30923366	2.68108390	9.42729498	5.54	0.0280
B6	4.06467062	1.88845427	7.83664787	4.63	0.0426
MSR2	0.04345878	0.08946864	0.40166882	0.24	0.6320
MSR4	0.09250343	0.09731625	1.53815341	0.90	0.3522
MSR5	0.34727534	0.20673161	4.80384275	2.82	0.1071
MSR7	-0.01492940	0.01342930	2.10393805	1.24	0.2783
MSR8	0.06297807	0.03206039	6.56894626	3.86	0.0622
MSR9	-0.15517269	0.27470352	0.54319633	0.32	0.5779
MSR10	-0.09546297	0.11871511	1.10081052	0.65	0.4299
MSR13	0.15516977	0.17135712	1.39593310	0.82	0.3750

Bounds on condition number: 410.7803, 9286.737

Step 6 Variable MSR2 Removed R-square = 0.64840154 C(p) = 7.84365415

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	12	69.80835072	5.81736256	3.53	0.0045
Error	23	37.85387150	1.64582050		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	72.33857021	16.08942497	33.26911611	20.21	0.0002
B1	-34.75107744	11.43335718	15.20447658	9.24	0.0058
B3	7.30669566	2.96285629	10.00929134	6.08	0.0215
B4	10.00204419	3.38800202	14.34407952	8.72	0.0071
B5	6.18690577	2.62452010	9.14596772	5.56	0.0273
B6	4.37899967	1.74440518	10.37140418	6.30	0.0195
MSR4	0.08384985	0.09406918	1.30765231	0.79	0.3820
MSR5	0.33888927	0.20255878	4.60676400	2.80	0.1079
MSR7	-0.01551888	0.01315033	2.29207946	1.39	0.2500
MSR8	0.06585372	0.03098128	7.43608491	4.52	0.0445
MSR9	-0.11643770	0.25847123	0.33399910	0.20	0.6566
MSR10	-0.09876304	0.11653531	1.18210565	0.72	0.4055
MSR13	0.15250891	0.16840075	1.34984791	0.82	0.3745

Bounds on condition number: 397.1322, 8224.202

Step 7 Variable MSR9 Removed R-square = 0.64529925 C(p) = 6.00109549

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	69.47435162	6.31585015	3.97	0.0023
Error	24	38.18787060	1.59116127		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	73.94835334	15.42488055	36.57022203	22.98	0.0001
B1	-32.41572561	10.01989079	16.65327753	10.47	0.0035
B3	6.57187953	2.43200475	11.61888754	7.30	0.0124
B4	9.28920218	2.94560086	15.82425574	9.95	0.0043
B5	5.78531968	2.42714926	9.04015863	5.68	0.0254
B6	4.27067804	1.69882073	10.05571053	6.32	0.0191
MSR4	0.09632110	0.08839783	1.88918236	1.19	0.2867
MSR5	0.28481100	0.16042251	5.01530222	3.15	0.0685
MSR7	-0.01413049	0.01257000	2.01074946	1.26	0.2721

MSR8	0.06398707	0.03018879	7.14837268	4.49	0.0446
MSR10	-0.07789476	0.10514190	0.87333118	0.55	0.4660
MSR13	0.12441332	0.15380668	1.04111230	0.65	0.4265

Bounds on condition number: 315.4872, 5959.37

Step 8 Variable MSR10 Removed R-square = 0.63718748 C(p) = 4.41276857

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	68.60102044	6.86010204	4.39	0.0013
Error	25	39.06120178	1.56244807		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	70.36389224	14.51367849	36.72402761	23.50	0.0001
B1	-32.74098976	9.91953649	17.02183757	10.89	0.0029
B3	6.45712294	2.40506847	11.26234460	7.21	0.0127
B4	9.62325635	2.88450082	17.39035190	11.13	0.0027
B5	5.76155365	2.40493999	8.96760195	5.74	0.0244
B6	4.39212904	1.67556663	10.73574955	6.87	0.0147
MSR4	0.11139070	0.08524601	2.66781268	1.71	0.2032
MSR5	0.27275459	0.15814842	4.64750672	2.97	0.0969
MSR7	-0.01185924	0.01207993	1.50588223	0.96	0.3356
MSR8	0.06594059	0.02980083	7.64987626	4.90	0.0363
MSR13	0.07968994	0.14018254	0.50492251	0.32	0.5748

Bounds on condition number: 314.8815, 5344.808

Step 9 Variable MSR13 Removed R-square = 0.63249761 C(p) = 2.65078022

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	68.09609793	7.56623310	4.97	0.0006
Error	26	39.56612429	1.52177401		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	78.15403007	4.71830521	417.52343525	274.37	0.0001

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
B1	-31.73326997	9.63198327	16.51765242	10.85	0.0028
B3	6.41181950	2.37225396	11.11707099	7.31	0.0120
B4	9.55790373	2.84444641	17.18224686	11.29	0.0024
B5	4.87633683	1.80872125	11.06099694	7.27	0.0121
B6	4.57206655	1.62383975	12.06393298	7.93	0.0092
MSR4	0.10526379	0.08345400	2.42110628	1.59	0.2184
MSR5	0.25643914	0.15348471	4.24803970	2.79	0.1068
MSR7	-0.00959148	0.01125284	1.10559964	0.73	0.4018
MSR8	0.06840886	0.02909655	8.41185845	5.53	0.0266

Bounds on condition number: 304.8255, 4433.946

Step10 Variable MSR7 Removed R-squrre = 0.62222846 C(p) = 1.17194059

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	66.99049829	8.37381229	5.56	0.0003
Error	27	40.67172393	1.50636015		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F

INTERCEP	77.40017080	4.61113943	424.42029725	281.75	0.0001
B1	-32.85197356	9.49369589	18.03769813	11.97	0.0018
B3	6.29740270	2.35642762	10.75829723	7.14	0.0126
B4	9.58798084	2.82978645	17.29321764	11.48	0.0022
B5	5.51903223	1.63571171	17.14909292	11.38	0.0023
B6	4.90818900	1.56723201	14.77422762	9.81	0.0041
MSR4	0.12841653	0.07850904	4.03024326	2.68	0.1135
MSR5	0.23163626	0.14993588	3.59526383	2.39	0.1340
MSR8	0.06682842	0.02888997	8.06040408	5.35	0.0286

Bounds on condition number: 299.1657, 3821.113

Step11 Variable MSR5 Removed R-square = 0.58883453 C(p) = 0.86668520

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	7	63.39523446	9.05646207	5.73	0.0003
Error	28	44.26698777	1.58096385		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	82.46570911	3.32147443	974.55624591	616.43	0.0001
B1	-20.62941545	5.37602041	23.27951706	14.72	0.0006
B3	3.10469805	1.15990332	11.32705712	7.16	0.0123
B4	5.72266340	1.35437704	28.22533956	17.85	0.0002
B5	4.28099802	1.46084463	13.57700373	8.59	0.0067
B6	3.12148167	1.08355232	13.12029942	8.30	0.0075
MSR4	0.17128429	0.07523865	8.19360575	5.18	0.0307
MSR8	0.06498367	0.02957144	7.63458628	4.83	0.0364

Bounds on condition number: 91.40499, 1036.919

All variables left in the model are significant at the 0.1000 level.

Summary of Backward Elimination Procedure for Dependent Variable MSR11

Step	Variable Removed	Number In	Partial R**2	Model R**2	C(p)	F	Prob>F
1	MSR3	17	0.0008	0.6642	17.0431	0.0431	0.8381
2	MONTH	16	0.0010	0.6632	15.0924	0.0521	0.8221
3	MSR12	15	0.0029	0.6603	13.2408	0.1650	0.6891
4	MSR6	14	0.0041	0.6562	11.4487	0.2411	0.6288
5	MSR1	13	0.0041	0.6521	9.6543	0.2475	0.6240
6	MSR2	12	0.0037	0.6484	7.8437	0.2359	0.6320
7	MSR9	11	0.0031	0.6453	6.0011	0.2029	0.6566
8	MSR10	10	0.0081	0.6372	4.4128	0.5489	0.4660
9	MSR13	9	0.0047	0.6325	2.6508	0.3232	0.5748
10	MSR7	8	0.0103	0.6222	1.1719	0.7265	0.4018
11	MSR5	7	0.0334	0.5888	0.8667	2.3867	0.1340

OBS	B1	B2	B3	B4	B5	B6	B7	MONTH	MSR1	MSR2	MSR3	MSR4
1	0	0	1	0	0	0	0	1	21.90	84.88	48.10	16.32
2	0	0	1	0	0	0	0	2	26.58	85.07	59.31	12.26
3	0	0	1	0	0	0	0	3	26.08	83.60	70.71	16.64
4	0	0	1	0	0	0	0	4	26.18	85.09	82.52	18.40
5	0	0	1	0	0	0	0	5	26.64	84.23	55.28	18.71
6	0	0	1	0	0	0	0	6	24.02	83.89	35.65	16.25
7	0	0	0	1	0	0	0	1	21.10	80.93	15.40	9.30
8	0	0	0	1	0	0	0	2	19.30	83.36	17.60	9.50
9	0	0	0	1	0	0	0	3	20.80	81.61	23.70	11.14
10	0	0	0	1	0	0	0	4	22.30	80.20	14.80	13.30
11	0	0	0	1	0	0	0	5	25.10	75.63	23.90	13.10
12	0	0	0	1	0	0	0	6	19.30	80.76	20.10	10.10
13	0	0	0	0	1	0	0	1	10.20	77.51	51.70	14.60
14	0	0	0	0	1	0	0	2	21.70	71.94	81.60	14.80
15	0	0	0	0	1	0	0	3	10.40	72.15	72.80	7.80
16	0	0	0	0	1	0	0	4	17.10	71.76	96.90	6.50
17	0	0	0	0	1	0	0	5	20.50	72.91	76.00	6.90
18	0	0	0	0	1	0	0	6	19.30	75.32	53.00	6.90
19	0	0	0	0	0	1	0	1	14.30	78.39	85.00	18.30
20	0	0	0	0	0	1	0	2	14.80	80.57	72.00	14.20
21	0	0	0	0	0	1	0	3	13.50	79.99	57.90	15.20
22	0	0	0	0	0	1	0	4	13.20	80.59	25.20	17.80
23	0	0	0	0	0	1	0	5	13.00	80.72	25.50	23.80
24	0	0	0	0	0	1	0	6	17.90	80.59	27.90	21.90
25	0	0	0	0	0	0	1	1	51.80	67.48	86.00	24.00
26	0	0	0	0	0	0	1	2	45.60	72.31	115.00	31.00

OBS	MSR5	MSR6	MSR7	MSR8	MSR9	MSR10	MSR11	MSR12	MSR13
1	9.95	48.3	52	97.40	2.00	98.5	95.7	96.6	98.89
2	9.50	49.6	100	100.00	0.70	98.1	95.6	93.9	98.80
3	9.97	48.8	87	99.10	3.30	98.6	94.3	96.5	99.90
4	10.72	49.2	131	98.90	2.30	98.0	94.4	94.7	99.82
5	10.56	48.4	90	96.50	2.80	97.1	94.2	96.7	99.83
6	11.35	41.1	103	98.90	3.70	96.8	94.5	98.1	99.92
7	6.09	30.5	75	88.50	3.76	92.0	95.6	95.6	99.60
8	5.90	29.3	82	79.40	1.76	93.9	94.2	94.6	98.89
9	6.70	28.9	86	83.10	1.19	89.9	95.4	91.0	99.59
10	6.30	30.5	89	72.60	1.75	86.9	95.0	97.2	99.33
11	7.56	29.6	78	81.50	1.30	100.0	96.0	92.3	99.68
12	7.00	31.2	64	76.40	0.91	97.7	95.6	97.6	99.72
13	18.00	47.1	18	96.97	1.70	92.9	94.5	93.9	83.30
14	19.70	45.9	28	77.42	1.66	89.0	95.8	88.6	80.40
15	17.20	46.9	51	82.81	1.00	96.4	93.4	95.5	89.60
16	17.60	47.0	24	98.04	2.46	91.4	94.1	94.0	85.50
17	18.30	44.9	100	97.22	1.97	94.7	93.4	94.4	88.90
18	14.60	45.6	73	98.00	2.20	94.5	94.9	98.9	91.60
19	17.60	42.9	69	99.24	0.80	95.5	95.0	95.5	99.90
20	16.60	43.8	57	98.45	0.80	97.7	94.6	94.7	100.00
21	16.30	43.8	74	97.80	0.00	96.6	93.9	97.2	100.00
22	16.90	42.4	43	100.00	0.00	99.1	95.3	99.0	99.90
23	17.20	41.9	48	96.59	0.00	95.5	96.4	95.5	99.70
24	16.20	41.7	60	99.30	1.90	95.4	95.8	98.2	99.70
25	22.00	35.5	91	75.60	0.90	94.1	90.1	87.2	95.60
26	26.00	34.5	67	71.60	1.70	96.2	92.9	87.6	97.10

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OBS	B1	B2	B3	B4	B5	B6	B7	MONTH	MSR1	MSR2	MSR3	MSR4
27	0	0	0	0	0	0	1	3	50.60	66.45	100.00	26.00
28	0	0	0	0	0	0	1	4	47.00	64.51	123.00	26.00
29	0	0	0	0	0	0	1	5	49.60	64.88	127.00	29.00
30	0	0	0	0	0	0	1	6	48.40	77.20	91.00	23.00
31	-1	-1	-1	-1	-1	-1	-1	1	23.90	75.18	48.00	19.00

32	-1	-1	-1	-1	-1	-1	-1	2	31.60	77.16	50.00	21.00
33	-1	-1	-1	-1	-1	-1	-1	3	23.20	79.22	36.00	15.00
34	-1	-1	-1	-1	-1	-1	-1	4	24.90	79.17	38.00	18.00
35	-1	-1	-1	-1	-1	-1	-1	5	25.90	81.80	40.00	19.00
36	-1	-1	-1	-1	-1	-1	-1	6	21.00	86.78	44.00	12.00

OBS	MSR5	MSR6	MSR7	MSR8	MSR9	MSR10	MSR11	MSR12	MSR13
27	24.00	34.2	76	87.50	0.00	95.0	93.4	92.1	94.60
28	26.00	34.3	98	55.70	0.00	96.9	87.2	92.9	94.00
29	29.00	32.3	135	81.00	1.20	94.0	95.1	88.4	95.50
30	30.00	31.0	102	85.20	5.60	94.1	93.0	94.5	95.70
31	17.00	29.6	59	64.40	2.90	95.0	96.2	96.0	95.60
32	17.00	29.9	43	93.90	1.20	96.4	95.6	94.5	97.10
33	13.00	30.4	63	91.00	0.00	95.8	95.5	96.3	94.60
34	15.00	29.8	87	92.30	1.10	95.2	93.4	92.5	94.00
35	15.00	30.0	67	84.60	0.00	93.8	96.0	94.6	95.30
36	14.00	27.2	80	80.00	1.10	97.6	95.2	96.6	95.70

Backward Elimination Procedure for Dependent Variable MSR10

Step 0 All Variables Entered R-square = 0.64258878 C(p) = 19.00000000
NOTE: The model is not of full rank. A subset of the model which is of full rank is chosen.

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	182.58714007	10.14373000	1.70	0.1405
Error	17	101.55591548	5.97387738		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	90.48796723	56.32324156	15.41922994	2.58	0.1266
B1	7.31404712	39.11726127	0.20885022	0.03	0.8539
B3	2.64589939	9.34822509	0.47856908	0.08	0.7806
B4	0.55266712	9.45476434	0.02041184	0.00	0.9541
B5	-6.42666197	10.70790879	2.15187922	0.36	0.5563
B6	-6.53828528	8.14159974	3.85269421	0.64	0.4330
MONTH	0.50502532	0.38608536	10.22153078	1.71	0.2083
MSR1	-0.18539978	0.20159438	5.05263430	0.85	0.3706
MSR2	-0.22149415	0.21594808	6.28466529	1.05	0.3194
MSR3	-0.03361370	0.04289291	3.66874793	0.61	0.4440
MSR4	-0.34889430	0.21776757	15.33407680	2.57	0.1275
MSR5	0.68423498	0.47024333	12.64799181	2.12	0.1639
MSR6	0.30535963	0.38601755	3.73822508	0.63	0.4398
MSR7	-0.04807522	0.02848790	17.01288054	2.85	0.1098
MSR8	0.01721005	0.06965573	0.36467562	0.06	0.8078
MSR9	-0.51599832	0.57572127	4.79875215	0.80	0.3826
MSR11	-0.28019969	0.40128248	2.91266950	0.49	0.4945
MSR12	-0.26171282	0.29718403	4.63292686	0.78	0.3908
MSR13	0.68384410	0.31091668	28.89897734	4.84	0.0420

Bounds on condition number: 1280.709, 39667.02

Step 1 Variable B4 Removed R-square = 0.64251695 C(p) = 17.00341685

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	182.56672823	10.73921931	1.90	0.0928
Error	18	101.57632732	5.64312930		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	91.28277804	53.12270422	16.66239205	2.95	0.1029

B1	9.28622316	19.23909449	1.31470701	0.23	0.6351
B3	2.25784652	6.39884846	0.70303462	0.12	0.7282
B5	-6.79028592	8.47001779	3.62606170	0.64	0.4332
B6	-6.85625644	5.88758564	7.65278711	1.36	0.2594
MONTH	0.50986802	0.36650139	10.92158515	1.94	0.1811
MSR1	-0.19189360	0.16349870	7.77342453	1.38	0.2558
MSR2	-0.22476357	0.20272278	6.93692088	1.23	0.2821

MSR3	-0.0333[illegible]0	0.04148500	3.65049198	0.65	0.4317
MSR4	-0.348[illegible]32	0.21165119	15.33939716	2.72	0.1166
MSR5	0.66[illegible]180	0.30201038	27.24544933	4.83	0.0413
MSR6	0.30[illegible]390	0.37237085	3.72664218	0.66	0.4270
MSR7	-0.04[illegible]2608	0.02757678	17.04420501	3.02	0.0993
MSR8	0.01695314	0.06756511	0.35528372	0.06	0.8047
MSR9	-0.50091414	0.50019930	5.65927013	1.00	0.3299
MSR11	-0.27029861	0.35356771	3.29808947	0.58	0.4545
MSR12	-0.26526707	0.28272962	4.96757093	0.88	0.3605
MSR13	0.68108646	0.29868820	29.34190909	5.20	0.0350

Bounds on condition number: 327.9588, 13641.43

Step 2 Variable B7 Entered R-square = 0.64258878 C(p) = 19.00000000
NOTE: The variable which previously had small tolerance is now allowed to enter after removal of some variables from the model.

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	182.58714007	10.14373000	1.70	0.1405
Error	17	101.55591548	5.97387738		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	91.04063435	54.81407356	16.47944942	2.76	0.1151
B1	10.63004982	30.33737288	0.73345076	0.12	0.7303
B3	2.09323227	7.15881679	0.51075032	0.09	0.7735
B5	-6.97932908	9.29630529	3.36715339	0.56	0.4631
B6	-7.09095240	7.26746746	5.68720983	0.95	0.3429
B7	-0.55266712	9.45476434	0.02041184	0.00	0.9541
MONTH	0.50502532	0.38608536	10.22153078	1.71	0.2083
MSR1	-0.18539978	0.20159438	5.05263430	0.85	0.3706
MSR2	-0.22149415	0.21594808	6.28466529	1.05	0.3194
MSR3	-0.03361370	0.04289291	3.66874793	0.61	0.4440
MSR4	-0.34889430	0.21776757	15.33407680	2.57	0.1275
MSR5	0.68423498	0.47024333	12.64799181	2.12	0.1639
MSR6	0.30535963	0.38601755	3.73822508	0.63	0.4398
MSR7	-0.04807522	0.02848790	17.01288054	2.85	0.1098
MSR8	0.01721005	0.06965573	0.36467562	0.06	0.8078
MSR9	-0.51599832	0.57572127	4.79875215	0.80	0.3826
MSR11	-0.28019969	0.40128248	2.91266950	0.49	0.4945
MSR12	-0.26171282	0.29718400	4.63292686	0.78	0.3908
MSR13	0.68384410	0.31091668	28.89897734	4.84	0.0420

Bounds on condition number: 770.3173, 27665.17

Step 3 Variable B7 Removed R-square = 0.64251695 C(p) = 17.00341685

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	182.56672823	10.73921931	1.90	0.0928
Error	18	101.57632732	5.64312930		
Total	35	284.14305556			

Parameter Standard Type II

Variable	Estimate	Error	Sum of Squares	F	Prob>F
INTERCEP	91.28277804	53.12270422	16.66239205	2.95	0.1029
B1	9.28622316	19.23909449	1.31470701	0.23	0.6351
B3	2.25784652	6.39684846	0.70303462	0.12	0.7282
B5	-6.79028592	8.47091779	3.62606170	0.64	0.4332
B6	-6.85625644	5.88758564	7.65278711	1.36	0.2594
MONTH	0.50986882	0.36650139	10.92158515	1.94	0.1811
MSR1	-0.19189360	0.16349870	7.77342453	1.38	0.2558
MSR2	-0.22476357	0.20272278	6.93692088	1.23	0.2821
MSR3	-0.03336620	0.04148500	3.65049198	0.65	0.4317
MSR4	-0.34895132	0.21165119	15.33939716	2.72	0.1166
MSR5	0.66360380	0.30201038	27.24544933	4.83	0.0413
MSR6	0.30260390	0.37237085	3.72664218	0.66	0.4270
MSR7	-0.04792608	0.02757678	17.04420501	3.02	0.0993
MSR8	0.01695314	0.06756511	0.35528372	0.06	0.8047
MSR9	-0.50091414	0.50019930	5.65927013	1.00	0.3299
MSR11	-0.27029861	0.35356771	3.29808947	0.58	0.4545
MSR12	-0.26528707	0.28272962	4.96757093	0.88	0.3605
MSR13	0.68108646	0.29868820	29.34190909	5.20	0.0350

Bounds on condition number: 327.9588, 13641.43

Step 4 Variable MSR8 Removed R-square = 0.64126658 C(p) = 15.06288973

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	16	182.21144451	11.38821528	2.12	0.0595
Error	19	101.93161104	5.36482163		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	88.41537116	50.58351441	16.39052395	3.06	0.0966
B1	7.95501230	18.03132926	1.04419476	0.19	0.6641
B3	2.52833243	6.14791281	0.90733620	0.17	0.6855
B5	-6.34118434	8.07291721	3.31005376	0.62	0.4419
B6	-6.38768133	5.44414404	7.38554515	1.38	0.2552
MONTH	0.50508088	0.35686490	10.74656047	2.00	0.1732
MSR1	-0.17662511	0.14796360	7.64452328	1.42	0.2473
MSR2	-0.21472883	0.19377618	6.58772140	1.23	0.2816
MSR3	-0.03557337	0.03952509	4.34691886	0.81	0.3793
MSR4	-0.36207640	0.19996426	17.58939824	3.28	0.0860
MSR5	0.66923709	0.29365419	27.86396382	5.19	0.0344
MSR6	0.30734502	0.36260473	3.85425731	0.72	0.4072
MSR7	-0.04783039	0.02688559	16.97946044	3.16	0.0912
MSR9	-0.50501745	0.48744823	5.75852254	1.07	0.3132
MSR11	-0.24278365	0.32773922	2.94399671	0.55	0.4679
MSR12	-0.27020245	0.27500172	5.17920433	0.97	0.3382
MSR13	0.69081260	0.28876690	30.70301070	5.72	0.0272

Bounds on condition number: 303.0192, 12026.46

Step 5 Variable B3 Removed R-square = 0.63807334 C(p) = 13.21477370

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	15	181.30410831	12.08694055	2.35	0.0378
Error	20	102.83894724	5.14194736		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	83.10666590	47.88196812	15.49014058	3.01	0.0980
B1	14.43409773	8.58638358	14.53069335	2.83	0.1083

B5	-8.67410126	5.62329230	12.23475520	2.38	0.1386
B6	-8.13937220	3.31939993	30.91649707	6.01	0.0235
MONTH	0.55596807	0.32769944	14.80048428	2.88	0.1053
MSR1	-0.19371444	0.13902755	9.98274320	1.94	0.1788
MSR2	-0.21174669	0.18957552	6.41499538	1.25	0.2773
MSR3	-0.03619141	0.03866785	4.50441844	0.88	0.3605
MSR4	-0.35714589	0.19541439	17.17535917	3.34	0.0826
MSR5	0.66713336	0.28744613	27.69746514	5.39	0.0310
MSR6	0.44446652	0.13950864	52.19242104	10.15	0.0046
MSR7	-0.04543156	0.02569427	16.07572106	3.13	0.0923
MSR9	-0.42729301	0.43988570	4.85176241	0.94	0.3430
MSR11	-0.22009910	0.31626227	2.49008840	0.48	0.4945
MSR12	-0.27165015	0.26920678	5.23570943	1.02	0.3250
MSR13	0.67877305	0.28124847	29.94997528	5.82	0.0255

Bounds on condition number: 73.79636, 4153.805

Step 6 Variable MSR11 Removed R-square = 0.62930984 C(p) = 11.63160322

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	178.81401991	12.77242999	2.55	0.0258
Error	21	105.32903565	5.01566836		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	61.60354306	36.12504389	14.58557075	2.91	0.1029
B1	15.28544498	8.39377517	16.63298979	3.32	0.0829
B5	-9.09670657	5.52133161	13.61474535	2.71	0.1143
B6	-8.26962295	3.27317076	32.01569295	6.38	0.0196
MONTH	0.51767335	0.31905451	13.20415620	2.63	0.1196
MSR1	-0.18300665	0.13646621	9.02011964	1.80	0.1942
MSR2	-0.22399288	0.18642477	7.24085741	1.44	0.2429
MSR3	-0.03479546	0.03813866	4.17487300	0.83	0.3719
MSR4	-0.37429139	0.19145977	19.16873282	3.82	0.0640
MSR5	0.68659649	0.28254750	29.61754342	5.91	0.0242
MSR6	0.44581014	0.13777176	52.51801160	10.47	0.0040
MSR7	-0.04195349	0.02489208	14.24763240	2.84	0.1067
MSR9	-0.49174249	0.42471247	6.72379192	1.34	0.2599
MSR12	-0.22798672	0.25855813	3.89970265	0.78	0.3879
MSR13	0.64999216	0.27475374	28.07099707	5.60	0.0277

Bounds on condition number: 72.93569, 3792.734

Step 7 Variable MSR12 Removed R-square = 0.61556540 C(p) = 10.28439577

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	13	174.91431726	13.45494748	2.71	0.0190
Error	22	109.22873830	4.96494265		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	44.53041165	30.34312179	10.69318636	2.15	0.1564
B1	13.70247639	8.15798042	14.00706177	2.82	0.1072
B5	-7.75635842	5.28105295	10.70998670	2.16	0.1561
B6	-7.56833866	3.15898015	28.49847092	5.74	0.0255
MONTH	0.38072076	0.27728484	9.35998385	1.89	0.1836
MSR1	-0.14892477	0.13021449	6.49425706	1.31	0.2650
MSR2	-0.17676650	0.17766019	4.91511760	0.99	0.3306
MSR3	-0.02238198	0.03526556	1.99990700	0.40	0.5322
MSR4	-0.30010876	0.17111354	15.27224365	3.08	0.0934
MSR5	0.59479303	0.26133441	25.71892327	5.18	0.0329

MSR6	0.38174573	0.11646343	53.34373537	10.74	0.0034
MSR7	-0.03524605	0.02358114	11.09189506	2.23	0.1492
MSR9	-0.59209206	0.40710643	10.50211535	2.12	0.1600
MSR13	0.57485706	0.25988230	24.29296774	4.89	0.0377

Bounds on condition number: 67.40747, 3164.121

Step 8 Variable MSR3 Removed R-square = 0.60854702 C(p) = 8.61917113

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	12	172.91441026	14.40953419	2.98	0.0118
Error	23	111.22864530	4.83602806		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	41.25976635	29.51155654	9.45274860	1.95	0.1754
B1	11.87669622	7.53417860	12.01733827	2.48	0.1286
B5	-6.69110971	4.94180018	8.86573512	1.83	0.1889
B6	-6.93461750	2.95785757	26.58148989	5.50	0.0281
MONTH	0.42251106	0.26583346	12.21646911	2.53	0.1256
MSR1	-0.14734360	0.12848934	6.35941430	1.32	0.2633
MSR2	-0.14095934	0.16626244	3.47606747	0.72	0.4053
MSR4	-0.25650034	0.15466433	13.30100249	2.75	0.1108
MSR5	0.49073952	0.20085069	28.86982837	5.97	0.0226
MSR6	0.33760368	0.09219426	64.84782517	13.41	0.0013
MSR7	-0.03721735	0.02307021	12.58566993	2.60	0.1203
MSR9	-0.55937368	0.39855206	9.52626724	1.97	0.1738
MSR13	0.58914120	0.25552256	25.70804711	5.32	0.0305

Bounds on condition number: 60.59863, 2460.224

Step 9 Variable MSR2 Removed R-square = 0.59631351 C(p) = 7.20104908

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	169.43834278	15.40348571	3.22	0.0080
Error	24	114.70471277	4.77936303		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	27.84468084	24.76464634	6.04213254	1.26	0.2720
B1	9.54265177	6.97197356	8.95357979	1.87	0.1838
B5	-4.51727390	4.19975018	5.52937387	1.16	0.2928
B6	-6.43245264	2.88091852	23.82655558	4.99	0.0352
MONTH	0.34622471	0.24887212	9.26471261	1.94	0.1766
MSR1	-0.09923199	0.11480135	3.58338908	0.75	0.3951
MSR4	-0.23840491	0.15228444	11.71357243	2.45	0.1306
MSR5	0.50567315	0.19890120	30.89121670	6.46	0.0179
MSR6	0.29294056	0.07521620	72.49470581	15.17	0.0007
MSR7	-0.03617694	0.02290219	11.92558932	2.50	0.1273
MSR9	-0.71537080	0.35145904	19.80080104	4.14	0.0530
MSR13	0.61458737	0.25228268	28.36816614	5.94	0.0226

Bounds on condition number: 50.8524, 1843.233

Step10 Variable MSR1 Removed R-square = 0.58370230 C(p) = 5.80089217

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	165.85495370	16.58549537	3.51	0.0053

	DF	Sum of Squares	Mean Square		
Error	25	118.28810185	4.73152407		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	27.62926798	24.63915065	5.94960791	1.26	0.2728
B1	5.36866356	5.01174059	5.42945534	1.15	0.2943
B5	-3.09144781	3.84408625	3.06012154	0.65	0.4289
B6	-4.44939514	1.73899441	30.97466610	6.55	0.0169
MONTH	0.35816887	0.24704349	9.94557491	2.10	0.1595
MSR4	-0.25519506	0.15028703	13.64277060	2.88	0.1019
MSR5	0.38449609	0.14063083	35.36908653	7.48	0.0113
MSR6	0.30103873	0.07425803	77.76048045	16.43	0.0004
MSR7	-0.03974355	0.02241570	14.87406642	3.14	0.0884
MSR9	-0.64511594	0.34024977	17.00908369	3.59	0.0696
MSR13	0.60382370	0.25069207	27.44986181	5.80	0.0237

Bounds on condition number: 37.47714, 1037.035

Step11 Variable B5 Removed R-square = 0.57293264 C(p) = 4.31314265

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	162.79483216	18.08831468	3.88	0.0032
Error	26	121.34822339	4.66723936		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	13.43994724	17.08111410	2.88950077	0.62	0.4385
B1	1.74833160	2.18770123	2.98079196	0.64	0.4314
B6	-4.31364865	1.71898517	29.39039015	6.30	0.0187
MONTH	0.29532969	0.23276323	7.51355650	1.61	0.2158
MSR4	-0.17731344	0.11414144	11.26306751	2.41	0.1324
MSR5	0.35076958	0.13331718	32.30960731	6.92	0.0141
MSR6	0.27147445	0.06408008	83.76679823	17.95	0.0003
MSR7	-0.03567530	0.02168857	12.62796492	2.71	0.1120
MSR9	-0.64739549	0.33791874	17.13069031	3.67	0.0664
MSR13	0.74825548	0.17371399	86.59449319	18.55	0.0002

Bounds on condition number: 7.597408, 311.4218

Step12 Variable B1 Removed R-square = 0.56244218 C(p) = 2.81211371

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	159.81404020	19.97675502	4.34	0.0018
Error	27	124.32901536	4.60477835		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	19.99216066	14.88416944	8.30766520	1.80	0.1904
B6	-3.16284267	0.93245888	52.97909420	11.51	0.0022
MONTH	0.26514642	0.22813654	6.22000277	1.35	0.2553
MSR4	-0.15668088	0.11043677	9.26858278	2.01	0.1674
MSR5	0.30963369	0.12215372	29.58637590	6.43	0.0174
MSR6	0.26805654	0.06350792	82.03623569	17.82	0.0002
MSR7	-0.02579761	0.01770235	9.77925908	2.12	0.1566
MSR9	-0.53549318	0.30547750	14.15005637	3.07	0.0910
MSR13	0.67313998	0.14510797	99.09163407	21.52	0.0001

Bounds on condition number: 4.641112, 163.1957

```
Step13   Variable B2 Entered        R-square = 0.57293264   C(p) =  4.31314265
NOTE: The variable which previously had small tolerance is now allowed to enter
      after removal of some variables from the model.
```

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	162.79483216	18.08831468	3.88	0.0032
Error	26	121.34822339	4.66723936		

	DF	Sum of Squares			
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	13.43994724	17.08111410	2.88950077	0.62	0.4385
B2	1.74833160	2.18770123	2.98079186	0.64	0.4314
B6	-4.31364865	1.71898517	29.39039015	6.30	0.0187
MONTH	0.29532969	0.23276323	7.51355650	1.61	0.2158
MSR4	-0.17731344	0.11414144	11.26306751	2.41	0.1324
MSR5	0.35076958	0.13331718	32.30960731	6.92	0.0141
MSR6	0.27147445	0.06408008	83.76679823	17.95	0.0003
MSR7	-0.03567530	0.02168857	12.62798492	2.71	0.1120
MSR9	-0.64739549	0.33791874	17.13069031	3.67	0.0664
MSR13	0.74825548	0.17371399	86.59449319	18.55	0.0002

Bounds on condition number: 7.597405, 311.4218

```
Step14   Variable B2 Removed        R-square = 0.56244218   C(p) =  2.81211371
```

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	159.81404020	19.97675502	4.34	0.0018
Error	27	124.32901536	4.60477835		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	19.99216066	14.88416944	8.30766520	1.80	0.1904
B6	-3.16284267	0.93245888	52.97909420	11.51	0.0022
MONTH	0.26514642	0.22813654	6.22000277	1.35	0.2553
MSR4	-0.15868088	0.11043677	9.25858278	2.01	0.1674
MSR5	0.30963369	0.12215372	29.58637590	6.43	0.0174
MSR6	0.26805654	0.06350792	82.03623569	17.82	0.0002
MSR7	-0.02579761	0.01770235	9.77925908	2.12	0.1566
MSR9	-0.53549318	0.30547750	14.15005637	3.07	0.0910
MSR13	0.67313995	0.14510797	99.09163407	21.52	0.0001

Bounds on condition number: 4.641112, 163.1957

```
Step15   Variable MONTH Removed     R-square = 0.54055179   C(p) =  1.85331399
```

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	7	153.59403743	21.94200535	4.71	0.0014
Error	28	130.54901813	4.66246493		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	20.05864711	14.97699973	8.36313698	1.79	0.1912
B6	-3.10648366	0.93701177	51.24643215	10.99	0.0025
MSR4	-0.18083166	0.10914148	12.79925873	2.75	0.1087

MSR5	0.32932169	0.12172882	34.12474482	7.32	0.0115
MSR6	0.26055680	0.06357375	78.31857335	16.80	0.0003
MSR7	-0.01992729	0.01707242	6.35216722	1.36	0.2530
MSR9	-0.52230903	0.30717297	13.48045824	2.89	0.1001
MSR13	0.68139111	0.14583920	101.77941612	21.83	0.0001

Bounds on condition number: 4.551857, 131.7593

Step16 Variable MSR7 Removed R-square = 0.51818627 C(p) = 0.91663799

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	6	147.24187020	24.54031170	5.20	0.0010
Error	29	136.90118535	4.72073053		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	27.10227711	13.79286255	18.22686415	3.86	0.0591
B6	-2.78535210	0.90128989	45.08586582	9.55	0.0044
MSR4	-0.16654067	0.10912811	10.99452813	2.33	0.1378
MSR5	0.29114221	0.11798214	28.74663643	6.09	0.0197
MSR6	0.25196455	0.06353946	74.23369133	15.73	0.0004
MSR9	-0.59496438	0.30267363	18.24071957	3.86	0.0590
MSR13	0.60104293	0.12937193	101.89199560	21.58	0.0001

Bounds on condition number: 4.223191, 94.62532

Step17 Variable MSR4 Removed R-square = 0.47950263 C(p) = 0.75707217

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	5	136.24734207	27.24946841	5.53	0.0010
Error	30	147.89571349	4.92985712		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	39.66342622	11.31027748	60.62730541	12.30	0.0015
B6	-2.38509588	0.88117788	36.11759663	7.33	0.0111
MSR5	0.14211422	0.06766046	21.74901191	4.41	0.0442
MSR6	0.24234650	0.06461140	69.35688215	14.07	0.0008
MSR9	-0.51490772	0.30462419	14.08524344	2.86	0.1013
MSR13	0.46801154	0.09768928	113.14976015	22.95	0.0001

Bounds on condition number: 1.890053, 38.74717

Step18 Variable MSR9 Removed R-square = 0.42993167 C(p) = 1.11487809

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	4	122.16209863	30.54052466	5.84	0.0013
Error	31	161.98095693	5.22519216		
Total	35	284.14305556			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	40.66366603	11.62818686	63.89859697	12.23	0.0014
B6	-2.11881393	0.89257328	29.44422577	5.64	0.0240
MSR5	0.14250730	0.06965725	21.86974994	4.19	0.0493
MSR6	0.22412669	0.06558841	61.01853184	11.68	0.0018
MSR13	0.45650602	0.10032844	108.18004799	20.70	0.0001

Bounds on condition number: 1.829845, 26.34921

All variables left in the model are significant at the 0.1000 level.

Summary of Backward Elimination Procedure for Dependent Variable MSR10

Step	Variable Entered	Variable Removed	Number In	Partial R**2	Model R**2	C(p)	F	Prob>F
1		B4	17	0.0001	0.6425	17.0034	0.0034	0.9541
2	B7		18	0.0001	0.6426	19.0000	0.0034	0.9541
3		B7	17	0.0001	0.6425	17.0034	0.0034	0.9541
4		MSR8	16	0.0013	0.6413	15.0629	0.0630	0.8047
5		B3	15	0.0032	0.6381	13.2148	0.1691	0.6855
6		MSR11	14	0.0088	0.6293	11.6316	0.4843	0.4945
7		MSR12	13	0.0137	0.6156	10.2844	0.7775	0.3879
8		MSR3	12	0.0070	0.6085	8.6192	0.4028	0.5322
9		MSR2	11	0.0122	0.5963	7.2010	0.7188	0.4053
10		MSR1	10	0.0126	0.5837	5.8009	0.7498	0.3951
11		B5	9	0.0108	0.5729	4.3131	0.6468	0.4289
12		B1	8	0.0105	0.5624	2.8121	0.6387	0.4314
13	B2		9	0.0105	0.5729	4.3131	0.6387	0.4314
14		B2	8	0.0105	0.5624	2.8121	0.6387	0.4314
15		MONTH	7	0.0219	0.5406	1.8533	1.3508	0.2553
16		MSR7	6	0.0224	0.5182	0.9166	1.3624	0.2530
17		MSR4	5	0.0387	0.4795	0.7571	2.3290	0.1378
18		MSR9	4	0.0496	0.4299	1.1149	2.8571	0.1013

Backward Elimination Procedure for Dependent Variable MSR11

Step 0 All Variables Entered R-square = 0.66502524 C(p) = 19.00000000
NOTE: The model is not of full rank. A subset of the model which is of full rank is chosen.

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	18	71.59809488	3.97767194	1.88	0.1008
Error	17	36.06412734	2.12141926		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	76.44083349	30.88464715	12.99547165	6.13	0.0241
B1	-38.61004497	21.37314768	6.92293331	3.26	0.0886
B3	8.57585964	5.18202497	5.81008965	2.74	0.1163
B4	9.72305259	5.11762297	7.65764452	3.61	0.0745
B5	7.91783995	6.15567549	3.50984963	1.65	0.2156
B6	5.59771638	4.75277654	2.94275087	1.39	0.2551
MONTH	0.05508502	0.24100532	0.11082563	0.05	0.8219
MSR1	0.03378199	0.12281251	0.16051356	0.08	0.7866
MSR2	0.04347560	0.13218910	0.22947024	0.11	0.7463
MSR3	-0.00539286	0.02598527	0.09137140	0.04	0.8381
MSR4	0.05314886	0.13862605	0.31183492	0.15	0.7062
MSR5	0.35311480	0.28455491	3.26682736	1.54	0.2315
MSR6	-0.06256385	0.23373751	0.15199054	0.07	0.7922
MSR7	-0.02090987	0.01762835	2.98473494	1.41	0.2519
MSR8	0.05355659	0.03950263	3.89942289	1.84	0.1929
MSR9	-0.16839103	0.34871022	0.49469223	0.23	0.6353
MSR10	-0.09950338	0.14250182	1.03433545	0.49	0.4945
MSR12	-0.08796180	0.17983017	0.50756265	0.24	0.6310
MSR13	0.19172100	0.20478102	1.85945836	0.88	0.3623

Bounds on condition number: 1076.665, 34810.65

Step 1 Variable MSR3 Removed R-square = 0.66417655 C(p) = 17.04307088

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	17	71.50672348	4.20627785	2.09	0.0647
Error	18	36.15549874	2.00863882		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	74.90838933	29.18092625	13.23823971	6.59	0.0194
B1	-38.70054404	20.79289445	6.95849103	3.46	0.0791
B3	8.50343653	5.03095212	5.73839491	2.86	0.1082
B4	9.63104828	4.96101260	7.57021669	3.77	0.0680
B5	8.14883157	5.89108804	3.84327542	1.91	0.1835
B6	5.71061149	4.59432422	3.10330028	1.54	0.2298
MONTH	0.05348428	0.23439146	0.10458527	0.05	0.8221
MSR1	0.03439774	0.11946853	0.16651546	0.08	0.7767

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
MSR2	0.05228387	0.12181713	0.37001607	0.18	0.6729
MSR4	0.06866354	0.11359604	0.73388487	0.37	0.5531
MSR5	0.32086687	0.23196085	3.84345883	1.91	0.1835
MSR6	-0.07888339	0.21418224	0.27246209	0.14	0.7169
MSR7	-0.02067917	0.01711923	2.93089054	1.46	0.2427
MSR8	0.05533147	0.03752683	4.36683827	2.17	0.1576
MSR9	-0.16310229	0.33840716	0.46659802	0.23	0.6356
MSR10	-0.09414756	0.13636942	0.95738364	0.48	0.4988
MSR12	-0.07419925	0.16265260	0.41800248	0.21	0.6537
MSR13	0.18529994	0.19697590	1.77756800	0.88	0.3593

Bounds on condition number: 1076.213, 32019.69

Step 2 Variable MONTH Removed R-square = 0.66320513 C(p) = 15.09237056

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	16	71.40213821	4.46263364	2.34	0.0397
Error	19	36.26008401	1.90842547		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	71.75287294	25.04689050	15.66196179	8.21	0.0099
B1	-40.80645882	18.18258143	9.63336183	5.05	0.0367
B3	8.97026898	4.48006405	7.65099101	4.01	0.0597
B4	9.91430655	4.68184205	8.55788361	4.48	0.0476
B5	8.90740899	4.74057821	6.73775727	3.53	0.0757
B6	6.19894480	3.96273109	4.67005009	2.45	0.1342
MSR1	0.04558588	0.10619093	0.35169089	0.18	0.6725
MSR2	0.06318118	0.10923431	0.63845827	0.33	0.5698
MSR4	0.07602889	0.10616197	0.97880134	0.51	0.4826
MSR5	0.32576048	0.22513200	3.99574275	2.09	0.1642
MSR6	-0.10152004	0.18502688	0.57452526	0.30	0.5896
MSR7	-0.01904986	0.01518595	3.01106380	1.58	0.2243
MSR8	0.05493573	0.03653945	4.31381043	2.26	0.1492
MSR9	-0.18849556	0.31151170	0.69876110	0.37	0.5523
MSR10	-0.08490406	0.12692399	0.85397412	0.45	0.5116
MSR12	-0.05374111	0.13228267	0.31497970	0.17	0.6891
MSR13	0.18185229	0.19143369	1.72216993	0.90	0.3541

Bounds on condition number: 864.271, 24318.99

Step 3 Variable MSR12 Removed R-square = 0.66027950 C(p) = 13.24084649

	DF	Sum of Squares	Mean Square	F	Prob>F

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	15	71.08715851	4.73914390	2.59	0.0242
Error	20	36.57506371	1.82875319		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	67.86135908	22.65462451	16.40916437	8.97	0.0071
B1	-41.39452851	17.72286178	9.97638672	5.46	0.0300
B3	8.97927097	4.38549738	7.66654235	4.19	0.0540
B4	10.36545614	4.45228410	9.91211183	5.42	0.0305
B5	8.81623776	4.63536656	6.61536050	3.62	0.0717
B6	6.24783844	3.87734248	4.74838965	2.60	0.1228
MSR1	0.05382117	0.10203915	0.50877740	0.28	0.6037
MSR2	0.06429391	0.10689625	0.66156086	0.36	0.5543
MSR4	0.08465514	0.10132249	1.26407936	0.69	0.4156
MSR5	0.33449169	0.21937601	4.25155728	2.32	0.1430
MSR6	-0.08733674	0.17787006	0.44090326	0.24	0.6288
MSR7	-0.01822096	0.01471103	2.80550493	1.53	0.2298
MSR8	0.05597072	0.03568155	4.49976160	2.46	0.1324
MSR9	-0.21546068	0.29793752	0.95640256	0.52	0.4779
MSR10	-0.08654812	0.12418319	0.88826954	0.49	0.4939
MSR13	0.15731732	0.17782566	1.43126250	0.78	0.3868

Bounds on condition number: 858.7814, 22475.81

Step 4 Variable MSR6 Removed R-square = 0.65618426 C(p) = 11.44868058

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	14	70.64625525	5.04616109	2.86	0.0145
Error	21	37.01596697	1.76266509		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	63.83809840	20.73578928	16.70661814	9.48	0.0057
B1	-39.73372217	17.07985962	9.53937039	5.41	0.0301
B3	7.89102181	3.71523281	7.95177758	4.51	0.0457
B4	10.95966480	4.20652980	11.96510205	6.79	0.0165
B5	7.83759106	4.10867304	6.41404258	3.64	0.0702
B6	5.54000775	3.53376129	4.33227614	2.46	0.1319
MSR1	0.04966500	0.09983315	0.43623571	0.25	0.6240
MSR2	0.06900519	0.10452332	0.76825780	0.44	0.5163
MSR4	0.08578959	0.09993997	1.29885456	0.74	0.4004
MSR5	0.35590933	0.21107535	5.01156667	2.84	0.1066
MSR7	-0.01646173	0.01400788	2.43430903	1.38	0.2531
MSR8	0.05666665	0.03500324	4.61964435	2.62	0.1204
MSR9	-0.18128913	0.28441276	0.71616844	0.41	0.5307
MSR10	-0.08729595	0.12190949	0.90382204	0.51	0.4818
MSR13	0.15911889	0.17454577	1.46485504	0.83	0.3723

Bounds on condition number: 827.5015, 18858.77

Step 5 Variable MSR1 Removed R-square = 0.65213236 C(p) = 9.65431446

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	13	70.21001954	5.40077073	3.17	0.0083
Error	22	37.45220268	1.70237285		
Total	35	107.66222222			

Parameter Standard Type II

Variable	Estimate	Error	Sum of Squares	F	Prob>F
INTERCEP	68.55569046	18.12221783	24.36234055	14.31	0.0010
B1	-33.70398453	11.82625216	13.82683907	8.12	0.0093
B3	6.92579295	3.11369108	8.42253158	4.95	0.0367
B4	9.81927144	3.46620211	13.66172225	8.03	0.0097
B5	6.30923366	2.68108390	9.42729498	5.54	0.0280
B6	4.06467062	1.88845427	7.88664797	4.63	0.0426
MSR2	0.04345878	0.08946864	0.40166882	0.24	0.6320
MSR4	0.09250343	0.09731825	1.53815341	0.90	0.3522
MSR5	0.34727534	0.20673161	4.80384275	2.82	0.1071
MSR7	-0.01492940	0.01342930	2.10393805	1.24	0.2783
MSR8	0.06297807	0.03206039	6.56894626	3.86	0.0622
MSR9	-0.15517269	0.27470352	0.54319633	0.32	0.5779
MSR10	-0.09546297	0.11871511	1.10081052	0.65	0.4299
MSR13	0.15516977	0.17135712	1.39593310	0.82	0.3750

Bounds on condition number: 410.7803, 9286.737

Step 6 Variable MSR2 Removed R-square = 0.64840154 C(p) = 7.84365415

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	12	69.80835072	5.81736256	3.53	0.0045
Error	23	37.85387150	1.64582050		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	72.33857021	16.08942497	33.26911611	20.21	0.0002
B1	-34.75107744	11.43335718	15.20447658	9.24	0.0058
B3	7.30669566	2.96285629	10.00929134	6.08	0.0215
B4	10.00204419	3.38800202	14.34407952	8.72	0.0071
B5	6.18690577	2.62452010	9.14596772	5.56	0.0273
B6	4.37899967	1.74440518	10.37140418	6.30	0.0195
MSR4	0.08384985	0.09406918	1.30765231	0.79	0.3820
MSR5	0.33888927	0.20255878	4.60676400	2.80	0.1079
MSR7	-0.01551888	0.01315033	2.29207946	1.39	0.2500
MSR8	0.06585372	0.03098128	7.43608491	4.52	0.0445
MSR9	-0.11643770	0.25847123	0.33399910	0.20	0.6566
MSR10	-0.09876304	0.11653531	1.18210565	0.72	0.4055
MSR13	0.15250891	0.16840075	1.34984791	0.82	0.3745

Bounds on condition number: 397.1322, 8224.202

Step 7 Variable MSR9 Removed R-square = 0.64520925 C(p) = 6.00109549

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	11	69.47435162	6.31585015	3.97	0.0023
Error	24	38.18787060	1.59116127		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	73.94835334	15.42488055	36.57022203	22.98	0.0001
B1	-32.41572561	10.01989079	16.65327753	10.47	0.0035
B3	6.57187953	2.43200475	11.61888754	7.30	0.0124
B4	9.28920218	2.94560066	15.82425574	9.95	0.0043
B5	5.78531968	2.42714926	9.04015663	5.68	0.0254
B6	4.27067804	1.69882073	10.05571053	6.32	0.0191
MSR4	0.09632110	0.08839783	1.88918236	1.19	0.2867
MSR5	0.28481100	0.16042251	5.01530222	3.15	0.0885
MSR7	-0.01413049	0.01257000	2.01074946	1.26	0.2721

,R8	0.06398707	0.03018879	7.14837268	4.49	0.0446
MSR10	-0.07789476	0.10514190	0.87333118	0.55	0.4660
MSR13	0.12441332	0.15380868	1.04111230	0.65	0.4265

Bounds on condition number: 315.4872, 5959.37

Step 8 Variable MSR10 Removed R-square = 0.63718748 C(p) = 4.41276857

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	10	68.60102044	6.86010204	4.39	0.0013
Error	25	39.06120178	1.56244807		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	70.36389224	14.51367849	36.72402761	23.50	0.0001
B1	-32.74098976	9.91953649	17.02183757	10.89	0.0029
B3	6.45712294	2.40506847	11.26234460	7.21	0.0127
B4	9.62325635	2.88450082	17.39035190	11.13	0.0027
B5	5.76155365	2.40493999	8.96760195	5.74	0.0244
B6	4.39212904	1.67556663	10.73574955	6.87	0.0147
MSR4	0.11139070	0.08524601	2.66781268	1.71	0.2032
MSR5	0.27275459	0.15814842	4.64750672	2.97	0.0969
MSR7	-0.01185924	0.01207993	1.50588223	0.96	0.3356
MSR8	0.06594059	0.02980083	7.64987626	4.90	0.0363
MSR13	0.07968994	0.14018254	0.50492251	0.32	0.5748

Bounds on condition number: 314.8815, 5344.808

Step 9 Variable MSR13 Removed R-square = 0.63249761 C(p) = 2.65078022

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	9	68.09609793	7.56623310	4.97	0.0006
Error	26	39.56612429	1.52177401		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	78.15403007	4.71830521	417.52343525	274.37	0.0001

B1	-31.73326997	9.63196387	16.51765242	10.85	0.0028
B3	6.41181950	2.37225396	11.11707099	7.31	0.0120
B4	9.55790373	2.84444641	17.18224686	11.29	0.0024
B5	4.87633683	1.80872125	11.06099694	7.27	0.0121
B6	4.57206655	1.62383975	12.06393298	7.93	0.0092
MSR4	0.10526379	0.08345400	2.42110628	1.59	0.2184
MSR5	0.25643914	0.15348471	4.24803970	2.79	0.1068
MSR7	-0.00959148	0.01125284	1.10559964	0.73	0.4018
MSR8	0.06840886	0.02909655	8.41185845	5.53	0.0266

Bounds on condition number: 304.8255, 4633.946

Step10 Variable MSR7 Removed R-square = 0.62222846 C(p) = 1.17194059

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	8	66.99049829	8.37381229	5.56	0.0003
Error	27	40.67172393	1.50636015		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F

INTERCEP	77.40017080	4.61113943	424.42029725	281.75	0.0001
B1	-32.85197356	9.49369589	18.03769813	11.97	0.0018
B3	6.29740270	2.35642762	10.75829723	7.14	0.0126
B4	9.58798084	2.82978645	17.29321764	11.48	0.0022
B5	5.51903223	1.63571171	17.14909292	11.38	0.0023
B6	4.90818900	1.56723201	14.77422762	9.81	0.0041
MSR4	0.12841653	0.07850904	4.03024326	2.68	0.1135
MSR5	0.23163626	0.14993588	3.59526383	2.39	0.1340
MSR8	0.06682842	0.02888997	8.06040408	5.35	0.0286

Bounds on condition number: 299.1657, 3821.113

Step11 Variable MSR5 Removed R-square = 0.58883453 C(p) = 0.86668520

	DF	Sum of Squares	Mean Square	F	Prob>F
Regression	7	63.39523446	9.05646207	5.73	0.0003
Error	28	44.26698777	1.58096385		
Total	35	107.66222222			

Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
INTERCEP	82.46570911	3.32147443	974.55624591	616.43	0.0001
B1	-20.62941545	5.37602041	23.27951706	14.72	0.0006
B3	3.10469805	1.15990332	11.32705712	7.16	0.0123
B4	5.72266340	1.35437704	28.22533956	17.85	0.0002
B5	4.28099802	1.46084463	13.57700373	8.59	0.0067
B6	3.12148167	1.08355232	13.12029942	8.30	0.0075
MSR4	0.17128429	0.07523865	8.19360575	5.18	0.0307
MSR8	0.06498367	0.02957144	7.63458626	4.83	0.0364

Bounds on condition number: 91.40499, 1036.919

All variables left in the model are significant at the 0.1000 level.

Summary of Backward Elimination Procedure for Dependent Variable MSR11

Step	Variable Removed	Number In	Partial R**2	Model R**2	C(p)	F	Prob>F
1	MSR3	17	0.0008	0.6642	17.0431	0.0431	0.8381
2	MONTH	16	0.0010	0.6632	15.0924	0.0521	0.8221
3	MSR12	15	0.0029	0.6603	13.2408	0.1650	0.6891
4	MSR6	14	0.0041	0.6562	11.4487	0.2411	0.6288
5	MSR1	13	0.0041	0.6521	9.6543	0.2475	0.6240
6	MSR2	12	0.0037	0.6484	7.8437	0.2359	0.6320
7	MSR9	11	0.0031	0.6453	6.0011	0.2029	0.6566
8	MSR10	10	0.0081	0.6372	4.4128	0.5489	0.4660
9	MSR13	9	0.0047	0.6325	2.6508	0.3232	0.5748
10	MSR7	8	0.0103	0.6222	1.1719	0.7265	0.4018
11	MSR5	7	0.0334	0.5888	0.8667	2.3867	0.1340

<u>BIBLIOGRAPHY</u>

1. Belcher, John G. Jr. <u>Productivity Plus.</u> Houston: Gulf Publishing Company, 1987.

2. Nash, Colleen A. "Spending, Mending, Defending and Pretending," <u>Air Force Magazine.</u> 34-36 (February 1990).

3. Towell, Pat "The Pentagon vs. Congress," <u>Air Force Magazine.</u> 42-45 (February 1990).

4. Dudney, Robert S. "The Air Force's Quandry" <u>Air Force Magazine.</u> 12-14 (February 1990).

5. Defense Logistics Agency. <u>Productivity Measurement Methods: Classification, Critique and Implications for the Air Force.</u> AFHRL-TR-81-9, AD A105 627. Brooks AFB TX: Manpower and Personnel Division, Air Force Human Resources Laboratory, October 1980.

6. Office of the Press Secretary. Productivity Improvement Program for the Federal Government. Executive Order 12552. Washington: Government Printing Office, 1986.

7. Department of the Air Force. <u>Air Force Productivity Improvement Program</u> (PIP). AFR 25-3. Washington: HQ USAF, 15 March 1989.

8. Wyatt, Milton R. and Carroll M. Staten. "Maintenance in the U.S. Air Force," <u>Logistics Management LOG 224, Volume I</u>, 17.23-17.46. Edited by Dennis L. Hull and Albert H. Rogers. Wright-Patterson AFB OH: Air Force Institute of Technology, 1985.

9. Mother Mary Maurita Englaub, R.S.M., Thomas R. O'Donovan, & Arthur X. Dugan. <u>Fundamentals of Managment.</u> Detroit MI: McMurry Press, 1964.

10. Dalton E. McFarland, <u>Management Principles and Practices.</u> (Fourth Edition). NY: MacMillan Publishing Co, 1974.

11. Malachi 3:10, Holy Bible.

12. Durant, Will. <u>The Story of Philosophy.</u> NY: Washington Square Press, 1965.

13. Cohen M. R. and Nagel Enrist. <u>An Introduction to Logic and Scientific Method.</u> NY: Harper and Brothers, 1934.

14. Hicks, Herbert G. and Gullett, Ray C. Management. (Fourth Edition). NY: McGraw-Hill, 1981.

15. George, Charles. The History of Management Thought. Englewood Cliffs NJ: Prentice-Hall, 1968.

16. Lane, Francis. Venetian Ships and Shipbuilders of the Renaissance. Baltimore: John Hopkins Press, 1934.

17. Dowley, Tim. The History of Christianity. Herts England: Lion Publishing Co. 1977.

18. Singer, Charles et al. The History of Technolog. 1750-1850. Oxford University Press, London. 1958.

19. Oliver, John W. History of American Technology. NY: National Industrial Conference Board, 1929.

20. Huse, Edgar F. Management. (Second Editon). St. Paul MN: West Publishing Co. 1982.

21. Daft, Richard L. and Richard M. Steers. Organizations. A Micro/Macro Approach. Glenview IL: Scott, Foresman and Co. 1986.

22. Filipetti, Gregory. Industrial Management in Transition. Chicago: Irwin, 1949.

23. Taylor, Frederic W. "Shop Management" Scientific Management. NY: Harper and Brothers, 1947.

24. Fayol, Henrey. General and Industrial Management. London: Sir Issac Pittman and Sons Ltd. 1949.

25. Bendix, Reinhard. Work and Athority in Industry. NY: John Wiley Publishing Co. 1956.

26. Roethlisberger, Fritz and William J. Dickson. Management and the Worker. Cambridge MA: Harvard University Press, 1941.

27. Garder, Burliegh. Human Relations in Industry. Homewood IL: Irwin, 1945.

28. Sheldon, Oliver. The Philosophy of Management. London: Sir Issac Pittman and Sons Ltd. 1923.

29. Katz, Daniel et al. "Productivity, Supervision and Morale Among Railway Workers," Personnel Psycology (May 1959).

30. McMurry, Robert. "The Case For Bonevelent Autocracy" Harvard Business Review, 36: 82-90 (January-Februa 958).

31. Viola, Richard H. Organizations in a Changing Society: Administration and Human Values. Philedelphia: Sauders Publishing Co. 1977.

32. Churchman, Carl. The Systems Approach. NY: Dell Publishing, 1968.

33. Chase, Richard B. and Nicholas J. Aquilano. Production and Operations Manangement: A LIfe Cycle Approach. Boston: Irwin, 1989.

34. Summanth, David J. and Kitty Tang. "A Review of Some Approaches to the Management of Total Productivity in a Company/Organization," Institute of Industrial Engineering Conference Proceedings, Fall 1984.

35. Hoseman, Wilbur C. Management Uses of Accounting. Boston: Allyn and Bacon Inc. 1963.

36. Benninger, Lawrence J. "Cost Accounting", Handbook of Business Administration, NY: McGraw- Hill Inc. 1967.

37. Holzer, Peter. "Management Accounting 1980," Proceedings From the University of Illinois Management Accounting Symposium.Champaign-Urbana: University of Illinois Press, 1981.

38. Goldratt, Eliyahu and Robert Fox. "Revolutionizing the Factory Floor," Management Accounting. NY: APICS, 1987.

39. Blotter, Thomas P. Introduction to Engineering. NY: John Wiley and Sons, 1981.

40. U. S. Dept. of Labor. Bureau of Labor Statistics, Monthly Labor Review. Washington: Government Printing Office, July 1979.

41. Jones, Franklin D. Engineering Encyclopedia. NY: The Industrial Press, 1943.

42. Cohen, William A. Principles of Technical Management. NY: AMACOM, 1980.

43. Tobias, Paul A. and David C. Trindale. Applied Reliability. NY: Van Nostrand Reinhold Co. 1986.

44. Katzell, William C. et. al. Work, Productivity and Job Satisfaction. NY: The Psychological Corporation, 1975.

45. Riggs, James L. and Glen H. Felix. Productivity by Objectives. Englewood Cliffs NJ: Prentice-Hall, 1983.

46. Case Study 31: Southern Company Services. Houston TX: American Productivity Center Press, 1984.

47. Fabricant, Soloman et al. Measuring Productivity Trends and Comparisons From The First International Productivity Symposium. NY: Unipub, 1984.

48. Dertouzos, Michael L. et. al. Made in America : Regaining the Productive Edge (Second Edition). Cambride MA: The MIT Press, 1989.

49. Walton, Mary. The Deming Manangement Method. NY: The Putnam Publishing Group, 1986.

50. Deming, W. Edwards. Quality, Productivity and Competitive Position. Cambridge MA: MIT Center for Advanced Engineering, 1982.

51. Deming, W. Edwards. Out of Crisis. Cambridge MA: MIT Center for Advanced Engineering, 1989.

52. Feigenbaum, Armand V. Total Quality Control. NY: McGraw-Hill, 1983.

53. Aggarqal, Steven "MRP, JIT, OPT, FMS?," Harvard Business Review, September-October 1985.

54. Bylinski, Gene. "An Efficiency Guru," Fortune Magazine, Vol 108, No. 5, September 1985.

55. Powell, Bill. "Boosting Shop Floor Productivity by Breaking All the Rules." Business Week, 26 November 1984.

56. Goldratt, Eliyahu and James Cox. The Goal. NY: North River Press, 1984.

57. Ishikawa, Kaoru. What is Total Quality Control the Japanese Way. NJ: Prentice-Hall, 1985.

58. Cox, James F. and Timothy Fry. "Manufacturing Performance: Local versus Global Measures," Production and Inventory Management Journal, Second Quarter 1989.

59. Peterson, Wallace C. Income, Employment and Economic Growth. NY: W.W. Norton and Company, 1988.

60. Tobin, James. "Economic Growth as an Objective of Government Policy," Perspectives on the Economic Problem. Edited by Authur McEwan and Thomas E. Wiesskopf. NJ: Prentice-Hall, 1973.

61. The United States Government Manual 1988/89. Office of the Federal Register National Archives and Records Administration, U. S. Government Printing Office, Washington DC, 1989.

62. Department of Defence. DoD Productivity Program. DoD Directive 5010.31. Washington: Government Printing Office, 27 April 1979.

63. Department of Defence. Productivity Enhancement, Measurement, and Evaluation Operating Guideline and Reporting Instruction. DoD Instruction 5010.34. Washington DC, 27 April 1979.

64. Department of the Air Force. Air Force Productivity Enhancment Program (PEP). MAC Supplement 1, AFR 25-3. Scott AFB IL: HQ MAC, 1 August 1984.

65. Department of the Air Force. MAC Management System. MACR 173-1. Scott AFB IL, 20 July 1989.

66. White, Capt Patricia L., Productivity Branch Chief. Personal Interview. HQ Military Airlift Command, Scott AFB IL, 7 February 1990.

67. Hayden, Lt Col John E., Chief, Policy and Doctrine Division. Personal Interview. HQ Military Airlift Command, Scott AFB IL, 7 February 1990.

68. Department of the Air Force. Maintenance Management, Aircraft Maintenance. MACR 66-1 Volume II. HQ MAC, Scott AFB IL: 14 March 1989.

69. Tuttle, Thomas C. et al. Measuring and Enhancing Organizational Productivity: An Annotated Bibliography. (AFHRL-TR-86-6). Brooks AFB TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

70. Steers, R., Porter L., R. Mowday, and E. Stone. Problems in the Measurement of Organizational Effectiveness. TR No.1, Contract No.N00014-76-C-0164. Eugene OR: University of Oregon, Office of Naval Research, 1975 (AD-A018 709).

71. Young, Hewitt H. Development of an Effective Planning and Evaluation Model for Air Force Maintenance Organization. Final Report for AFOSR. Contract 79-011. Tempe AZ: Arizona State University, Department of Industrial and Management Systems Engineering, 1980.

72. Pritchard, Robert D. et al. Feedback, Goal Setting and Incentives Effect on Organizational Productivity. AFHRL-TR-87-3. Brooks AFB TX: Manpower and Personnel Division, Air Force Human Resources Laboratory, June 1987.

73. Pritchard, Robert D. et al. "The Evaluation of an Integrated Approach to Measuring Organizational Productivity," Personnel Psycology, 42: 69-115 (Spring 1989).

74. Tuttle, Thomas C and Charles N. Weaver. Methodology For Generating Efficiency and Effectiveness Measures (MGEEM): A Guide For Commanders, Manangers and Supervisors. AFHRL-TP-86-26. Brooks AFB TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

VITA

Captain Billy J. Gililland was born on 30 July 1959 in Tucson, Arizona. He graduated from Saints Peter and Paul High school in St. Thomas U. S. Virgin Islands in 1977. In 1981 Captain Gililland enlisted in the Air Force and was trained as a avionics communications specialists at Keesler AFB, Mississippi. In 1985, then Staff Sergeant Gililland, attended Officer's Training School and was subsequently commissioned a Second Lieutenant. After attending the aircraft maintenance officer's course, he was assigned to Norton AFB, California. He served there from 1986 to 1989 as Officer in Charge of the Aerospace Ground Equipment branch, Field Maintenance Squadron, Officer in Charge of The Isochronal Inspection branch and the Officer in Charge of the Flightline branch in the Organizational Maintenance Squadron. In June 1989 Captain Gililland entered the School of Systems and Logistics, Air Force Institute of Technology. He is married to the lovely Jenny Lee Gililland and is the proud father of Justin Lee and Brain James.

Permanent address: 4310 Troy Rd.
Wylie, Texas 75098

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This research was undertaken to explore productivity measurement in aircraft maintenance units and to examine the relationships of the measures used to evaluate a unit's productivity. Review of current literature and regulatory guidance concerning productivity measurement provided the basis for the development of an interview questionnaire. A questionnaire was administered to DCMs and chiefs of analysis at ten MAC wings. Additionally, managers in the maintenance management, cost and manpower divisions at Headquarters MAC were interviewed. From these interviews, information concerning current productivity measurement methodology was gathered and thirteen measures were identified for analysis. Of the thirteen measures evaluated, eight produced the strongest explainable model reflecting maintenance productivity. Manhours per flying hour was the predominant output when viewed as a result of the influence of mission capable rates and maintenance scheduling effectiveness. Cannibalization rates, delayed discrepancies (both awaiting parts and awaiting maintenance) and the average number of aircraft possessed were the inputs which appeared to contribute most significantly to mission capable rates and maintenance scheduling effectiveness.

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