APPLICATION OF INFORMATION THEORY CONCEPTS IN THE INVESTIGATION OF THE GROWTH PATTERN OF PRODUCTION, DISTRIBUTION, AND VELOCITY OF INFORMATION.

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The objective of this research is the investigation of the patterns of information growth to test whether there has been an "information explosion." To tackle the main problem, there are three issues which need to be addressed: (1) the concept of information dimensionality; (2) determination of common parameters to measure the amount of information within each dimension; and (3) a working definition of "explosiveness."

The independent variable is time. The dependent variables are: (1) information production--operationalized by the yearly growth of copyrights, inventions, designs, Doctorates, and Library of Congress holdings; (2) information distribution--operationalized by the yearly growth of telephones, miles of telephone wire, radio and television stations, and post offices; (3) information flow--operationalized by the yearly growth of average daily telephone conversations, pieces of matter handled in post offices, number of periodicals, number of radio and television sets, and number of books.

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Preliminary analysis of the findings reveals that there has not been an explosive increase in the information production area. The criterion of the whole period to be explosive has not been met by any of the information production variables.

Contrary to the findings in the information production, there has been an explosive growth in the information distribution. Most of the variables have met the criterion of explosiveness for the whole curve covering the span of this study.

As for the information flow, the findings reveal that there have been explosive and unexplosive increases as well as unexplosive decreases at different points for most of the variables. Only one variable has met the criterion of explosiveness for the whole curve, signifying that the overall degree of explosiveness for the information flow falls between information distribution and information production. The general conclusion is that for the last one hundred and twenty-five years, the American society has witnessed an explosive growth in the distribution of information, a lesser degree in the velocity of information, and none in the real generation of information.

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CHAPTER I

INTRODUCTION

1.1 Introduction

The study investigates quantitatively the pattern of information growth from 1860 to 1984 in the USA. In particular, it evaluates whether there has been an information explosion in three dimensional contexts: information production, information distribution, and information flow.

There is a common assumption that there has been an explosive increase in the amount of information (e.g., 9, 16, 31). This belief has been coined "Information Explosion"--a notion that receives particular attention concerning its impact on industry and society. Examples of such attention are the numerous studies (e.g., 10, 11) on how the information age will affect educational institutions and how the flow of information across international boundaries necessitates the creation of international information control mechanisms.

Despite great attention devoted to the study of the implications of the information explosion, there have been very few quantitative studies investigating the nature of this growth (e.g., 22, 24). The importance of such work stems from the fact that understanding and measuring the behavior of any phenomenon is necessary to predict its behavior and impact.

The objective of this research is to investigate the pattern of information growth in order to test whether there really has been an "information explosion." As a part of this study, the concept of information dimensionality is addressed. Although it is established that information dimensionality is not limited to a specific number of dimensions, only three dimensions are chosen for investigation.

As stated by Hammer (12), the lack of well established definitions of basic terms has led researchers to develop "working definitions" of the terms used in the information field. In the introduction to his edited book, Hammer (12) notes that "since we do not sanctify these definitions with consistent usage, the terms under present circumstances are very ambiguous" (12, p. viii). Nevertheless, considering the disagreement or non-existence of common definitions for these terms in the literature, this study must adapt working definitions of information, information production, information distribution, information flow, and information explosion.

In order to achieve the major objective, several metrics are used to quantify the amount of information in its three dimensional contexts: production, distribution, and flow. These metrics constitute the basic forms of communications in the USA since the later half of the nineteenth century (the starting point for the study).

Hammer (12) believes that the lack of common definitions stems from the absence of a strong philosophical foundation for the field, that is, "a theory that would define the properties of information as a discernible precept and would identify its functions and roles in human affairs" (12, p. viii). The study will introduce the mathematical theory of communication developed by Shannon and Weaver (25) as the needed theoretical base for understanding the nature and structure of the information explosion. So, Shannon's information theory, which concerns the measurement of information contained in a transmitted message, is applied along with its logarithmic transformation to the production and flow metrics.

Although several published studies (e.g., 21, 22, 24, 30) have examined the growth pattern of information, no published research investigates the information growth in its multi-dimensional context. Also there is no published research associating the concept of an information theory with the metrics of information production and information flow. This study explores the application of some concepts of information theory to establish an objective measurement for testing if there has been information explosion and, if so, how it might be described.

1.2 The Research Problem

There are many demands today for more information, not only by organizations, but by society. These needs are aggravated by the technological complexity of modern society and the rate of technical and environmental changes. Simon (26) refers to this explosion of information demands as the third revolution following the emergence of written English and the invention of the printed books (26, p. 1185). Zmud (32) points out that while other concerns predominated in earlier decades, the information function is likely to become a critical corporate function, as well as a major competitive tool, in the 1980s and beyond (32, p. 5).

Although this apparent growth phenomenon has triggered many researchers to examine its impact on society (e.g., 8, 14, 17), there have been very few studies investigating the measurement and characterization of the growth pattern. The reason may be due, in part, to the wide range of definitions and interpretations of the terms information, information generation, distribution, and flow.

Machlup (22) observes that studying the creation and distribution of knowledge involves a cluster of disciplines (e.g., computer science and information systems) he calls "the sciences of information" (22, p. 5). It is not surprising then that each discipline could have a different meaning for the term "information." Other problems facing the measurement of information are (1) the lack of a working definition for information growth; and (2) the lack of quantitative metrics to measure this growth. Given the importance of investigating information explosion, there are many research questions that can be directed at investigating different dimensions of this problem.

For the purpose of this study, the research question is to test whether there has been an information explosion and, if so, how it might be described. This general statement can be restated as the following questions:

1. How is the amount of information defined?
2. How are the dimensions of information (e.g., production, distribution, and flow) measured?
3. What surrogates can be used to measure each dimension?
4. What quantitative metrics should be applied for each dimension?

1.3 Objective of Research

The objective of this research is to investigate the growth pattern of information. This general goal can be operationally achieved by formulating

1. an operational definition of the amount of information in its three dimensional context (production, distribution, and flow);
2. an operational definition of the concept "information explosion"; and
3. quantitative metrics to measure the amount of information.

Definitions of the terms "information" and "explosion," as well as working definitions of information production, i.e., the creation of new ideas, distribution, the geographical dispersion and flow, the rate of distribution, will be provided in sections 2.1 and 2.2.

The "mathematical theory of communication" introduced by Shannon and Weaver (25) was fully developed for use in the field of electrical engineering to define and measure the amount of information contained in a message. Among the major objectives of the theory are

1. to measure the amount of information transmitted through communication systems in order to analyze the capacity of transmission channels;

2. to measure the amount of "noise," i.e., the effect of distortion in a specific channel, in order to minimize its undesirable effect; and
3. to measure the amount of "redundancy," i.e., repeated signals, in order to economize its size.

Lev (18) points out that since these objectives are also shared by the social sciences, Shannon's informational concepts can be applied to psychology, sociology, and linguistics (18, p. 1). The idea of extending the application of information theory to the natural and behavioral sciences has also been supported (e.g., 3, 13, 19, 23). One major argument for this extension is the generality of information theory concepts. "This is a theory so general that one does not need to say what kinds of symbols are being considered--whether written letters or words, or musical notes, or spoken words, or symphonic music, or pictures" (25, p. 114). The level of information expression is ignored by Shannon's theory. In other words, all symbols are considered equivalent in terms of information content.

So, to achieve the main objective of this research, the logarithmic transformation of information theory is applied to the production and flow metrics. Distribution of information, though intuitive, is not a commonplace in information theory. Metrics for distribution are, however, defined and used as necessary and are important factors for the use of information. Discussions of the basic concepts of information theory, as well as the rationale for using specific metrics in the context of viewing information growth as a communication process, will be provided in Chapter III.

1.4 Significance of Research

A major challenge facing information systems and information science research communities is the definition of a theory of information growth. Such a theory would have to rely on contributions from different disciplines. An important part of such a theory would be development of quantitative metrics to measure the amount of information within its different dimensions.

It is surprising that, despite the importance of such a topic, there have been very few studies dealing with the dimensions of information growth (e.g., 22, 24). The reason may be the common notion that "information" is an unmeasurable product. It is not consumed by use like other products. Bell (6) states that "Information, or knowledge, even when it is sold, remains with the producer. It is a "collective good" in that once it has been created, it is by its nature available to all" (6, p. 412).

One significance of the present study is the use of information theory concepts to measure the amount of information in society. Since the inception of the information theory in 1948, there have been many attempts to apply it to different disciplines in social sciences (e.g., 1, 3, 29). This study stands on that side which tries to expand the application of information theory in social sciences into the information growth area.

Another significance of this study is the investigation of different dimensions of information. There is a view supporting single dimensionality of information by combining the processes of production, distribution, and flow into one dimension and arguing that once information is generated it is already available to users. This idea has the convenience of dealing only with one dimension. Machlup (22) supports this single dimensionality and considers distribution of knowledge as a part of its production function (22, p. 7). This study, however, will move away from this direction by delineating three dimensions of information growth: production, distribution, and flow.

It is hypothesized that the outcome of the study will reveal different growth patterns for each dimension of information growth. One important reason for this expectation is that advancements in communications technology should lead to a substantial increase in distribution channels or better information flow within the existing channels. So, the information explosion might really be a distribution or a flow explosion instead of an explosion of production.

1.5 Plan of Research

Information explosion is discussed in Chapter II. This chapter will present several views for the definition of data, information, and knowledge and develop working definitions of the terms used in the research as well as the concept of information dimensionality. In addition, a framework of dimensions of information used in the research will be presented. An overview of the measurement of information growth as well as the results of previous research will be addressed.

Chapter III will complete the literature review by addressing the basic concepts of information theory delineating the metrics that will be used in the research. The discussion will not only be restricted to review the literature but it will be extended to develop a model viewing the information growth in its three dimensional contexts as a communication process.

Chapter IV is fully devoted to the description of research variables, metrics used to measure the variables, and research hypotheses. The methodology to collect the data as well as the statistical procedures to test the hypotheses will also be discussed. The basic assumptions as well as the basic limitations of the study will be addressed.

In Chapter V, the statistical analysis of the data and the results of testing the hypotheses will be presented. In Chapter VI, the interpretations of the hypotheses test results and the conclusions based on the interpretations will be presented. Implications of the study as well as future research will be addressed in the light of the findings of the study.

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CHAPTER II

INFORMATION EXPLOSION: DEFINITIONS, SCOPE, AND PREVIOUS RESEARCH

2.1 Information: An Elusive Term

As stated by Fox (2Ø), Stern (46), Hammer (23), and Saracevic (42), there have been many attempts to provide a definition of information that is generally accepted by the researchers in all fields of information. But all the attempts ended up with definitions that lack an accepted characterization of the nature of information. Consequently, the literature of all fields of information is full of divergent definitions. The reason may be that the term "information" has a wide range of meanings because of its interdisciplinary nature. Reviewing the literature reveals not only such diversity of opinions regarding the notion of information but also the difficulty of drawing a clear-cut boundary between information and other terms such as knowledge and data.

Wellish (49) reviews the literature to find out what Information Science is. With respect to information, he comments that the concept of information is highly ambiguous and mostly ill-defined. He also states that all the researchers do not succeed to arrive at an agreed-upon definition, nor do their definitions have any common elements (49, p. 11).

Another review of the definitions of information is conducted by Wersing and Neveling (52). They state that they have used a semantic analysis to characterize and group the definitions reviewed. The semantic analysis used showed that there are at least six different approaches to the use and understanding of the term information in the field of discipline (52, p. 129). Fox (20), in his efforts to describe the divergence of opinions about information, comments that even within these six categories mentioned by Wersing and Neveling, the definitions are typically very different from one another (20, p.41).

Belkin (2) questions whether the myriad one-line information definitions can really be plausibly classified into categories characterized by having a well developed approach. Belkin surveyed representatives of the wide diversities of the views in the field. He distinguishes eleven approaches to an information concept and examines sixteen definitions of information, grouping them into eleven schools of thought which clearly reflects a wide diversity of opinions about the nature of information.

These three major reviews of information definitions show enough evidence that the information disciplines clearly lack an accepted characterization of the nature of information, and that the literature of the fields is full of divergent proposals on the concept, none receiving support from more than a few investigators. There is also a difficulty of drawing a clear-cut boundary between information and knowledge which adds more divergence of opinions about information.

Machlup (32) states that the terms "information" and "knowledge" are synonymous and suggests to get rid of the duplication that only one term "knowledge" should be used. He defines knowledge as "an interrelated system . . . which illuminates the basic causal structure of some field of operations" (p. 8). He, however, in his book Knowledge: its Creation, Distribution, and Economic Significance (30), presents a different opinion by stating that the terms "information" and "knowledge" have different meanings. "To inform and to know have different meanings: informing is a process or activity, whereas knowing is a state of mind (30, p. 8).

In his discussion of the manufacture of knowledge, Knorr-Cetina (29) emphasizes an epistemological attitude when he states that the objectivism school of epistemology (as described by Bhasker (6), and Fraasen (21)) views the world as composed of facts and sees the goal of knowledge as providing a literal account of what the world is like. The constructivism school, however, regards scientific inquiry as a process of production: "Rather than considering scientific products as somehow capturing what is, we will consider them as selectively carved out, transformed and constructed from whatever is" (29, p. 3).

Hammer (23) defines and describes the relationships of the three terms, data-information-knowledge, as "data is the raw unprocessed, usually unorganized elements of which "information" is composed. The latter, it follows, is the used, and later stored, becomes knowledge" (23, p. viii). He points out that these terms are very ambiguous because of the lack of consistency in defining these terms.

Saracevic (42) addresses the same data-information-knowledge triangle in the context of communication process as described by Goffman (22) and Shannon and Weaver (45). Communication is a process where information is transmitted from one object to another. He suggests that the connotations of communication and information can be extended to data and knowledge as used in the theory of knowledge (42, p. 88). The point that Saracevic tries to make is that in communication systems knowledge is communicated from a source to a destination through transmitting information. "Communication of knowledge is effective when and if information transmitted from one file results in changes in another" (42, p. 88).

Farradane (18) has a similar definition to the previous one regarding information as "any physical form or representation, or surrogates, of knowledge, or of a particular thought, used for communication (18, p. 13).

Contrary to what Machlup (30, p. 15) concludes, that all information is knowledge but not all knowledge may be called information, Libbey (28) considers anything that is communicated falls within the broad concept of information. Furthermore, Saracevic points out that even though he uses the term "communication of knowledge," strictly speaking it is not knowledge but data (42, p. 88).

Another example of the controversy over definitions is Bell's definition of the term knowledge. Bell (cited in 48, pp. 554, 555) defines knowledge as

> an organized set of statements of facts or ideas, presenting a reasoned judgement or an experiment result, which is transmitted to others through some communication medium in some systematic form. Thus, I distinguish knowledge from news or entertainment. Knowledge consists of new judgements (research and scholarship) or presentations of older judgements (textbooks, teaching, and library and archive materials).

While Weizenbaum (48) criticizes this definition as being circular and incomplete because it systematically excludes almost everything called knowledge in everyday life (48, p. 555), Saracevic (42) considers the definition appropriate for delineating the concept of knowledge (42, p. 88).

The above discussions seem sufficient to conclude that there is no agreement on the definition of information nor on the boundaries between information and related terms such as knowledge and data. This conclusion justifies the adoption of "working definitions" of information and other terms in the contexts of the related studies. These working definitions include the characteristics needed for the purpose of the study. Fox (2Ø) refers implicitly to these definitions as discipline-specific characterizations of information which exclude from considerations various features of information not needed for a specific purpose (2Ø, p. 4).

The realization of this fact is mainly behind developing working definitions of information, information production, information distribution, and information flow in the context of the study framework. These working definitions as well as the study framework are presented in Section 2.3. But for the purpose of completing the discussion, common definitions of the term "information" are presented in the next section.

2.2 Information Definition: Literature Review

The review of information definition is not exhaustive due to the numerous definitions proposed in the literature. For example, Wersing and Neveling (52) review seventeen definitions of information while Belkin (2) reviews sixteen definitions, and their work is still considered as only a representative portion of the literature on the topic.

As stated by Fox (2Ø), the following are the major approaches to define information:

1) the spatio-temporal entity based approach;
2) the information theory based approach.

A brief discussion of each of selected definitions representing the two approaches is in order.

It is frequently proposed that information is some sort of spatio-temporal entity such as tokens and process or event (Fox 2Ø, p. 43). Fitting into that concept, Farradane (17) defines information as "any physical form or representation, or surrogate, of knowledge, or of a particular thought, used for communication" (17, p. 13). Although Farradane does not use the word "tokens," his definition implicitly describes information as tokens used in communication to express or transfer someone's knowledge or beliefs.

Viewing information as a process is implicitly expressed by Otten (35) and Dow (13) but clearly stated by Debons in (1Ø). Debons' position is based on a distinction between two senses of information: information as a commodity and information as a process.

Regarding information as a commodity (tokens), Debons has a definition similar to Farradane's. "In this sense, information is the physical representation of events and states in the environment, structured so as to be intelligible to a user or group of users" (19, p. 2).

Regarding the information as a process, Debons describes it as a mental process carried out by a sender and a receiver communicating with each other. "Information is a process whereby data are received and interpreted by an intelligent being, which transforms the data in light of its existing view of the world, thus leading to change in state of receiver, who is then informed" (10, p. 2).

According to Debons' view, the process of information encompasses the entire procedure of gathering, arranging, and disseminating data to users in such a way to change their state of knowledge about the environment.

> Information, then, is viewed as a process through which data from the environment are captured, and processed to facilitate interpretation by a user (the commodity of information); and then transformed by a user in such a way as to change his state of knowledge about the environment (the process of information) (10, p. 2).

Pratt's position regarding information is slightly different than Debons' view even though both positions consider information as a communication process. Pratt's view is based on a model of communication which in turn is based on a model of human understanding and cognition presented by Kenneth Boulding (7).

The central notion of Pratt's model, as described in (38), is the "image." An image is an individual's view of looking at and thinking about the world phenomena. Everyone's image is different from everyone else's because of the unique experiences everyone has. Pratt continues to further explain his concept of communication by describing some constraints that might exist. An example of such constraints is having certain congruence between the images of senders and receivers; otherwise people involved in communication will not understand or believe each other.

By exploring such constraints on the communication process, Pratt establishes his model of communication as the factors involved in the process of a person's succeeding in altering the image of another. Once the model is constructed, Pratt considers information as the consequences of the communication process in the light of his concept of communication.

> Information is the alteration of the image which occurs when it receives a message. Information is thus an event; an event which occurs at some unique point in time and space, to some particular individual. More precisely, "information" is the same of a class of events, like the word "explosion" (38, p. 215).

The other major class of defining information is the information theoretic approach based on the mathematical theory of communication developed by Shannon and Weaver (45). Since the theory was introduced in 1948, there has been a lot of excitement over the importance of applying the theory to myriad problems in human communications, ranging from physiology of perception to the semantics of natural language (20, p. 51).

Rapoport (41) best describes that attitude when he points out how information theory can be applied in the seemingly different contexts by stating that:

> It may be true that the technical problems of long range communication (radio, television, etc.) can be

> treated independently of the semantic content of the messages or the semantic reactions of the audience. But it may also be true that the methods involved in treating these problems (for example, the mathematical theory of information) can be applied in the seemingly different contexts of the events which interest general semantics, psychologists, and others (41, p. 9).

Shannon and Weaver (45) provide their definition of information as that "Information is a measure of your freedom of choice when you select a message...Thus greater uncertainty and greater information will go hand in hand" (pp. 100, 104). This definition has been presented in different expressions by many researchers who take that approach to define information (e.g., Faibisoff and Ely (14), Saracevic (42), Murdock and Liston (34).

There is a lot of controversy in the literature regarding the suitability of extending the information theory and its mathematical formation to the communication models in the social sciences. But even with this divergence of opinions, the influence of the information theory on defining the concept of information in social sciences is dominant. An evidence supporting this claim is stating quite a number of information definitions which reveal that the basic features of information theory have been taken as the basis for these definitions. Examples of such information theory based definitions are Wersing and Neveling's (52) and Whittemore and Yovits's (51).

Wersing and Neveling's definition of information is basically based on the notion of "reduction of uncertainty" taken from Shannon and Weaver's work. They, however, do not adopt the whole concept of information theory but they define the information in the context of historical evolution, the development of specific social needs, and the development of new methodologies and techniques. In other words, they base their definition of information in the light of its social contexts.

> The basic term "information" can be understood only if it is defined in relation to these information needs(i.e., the information needs of people involved in social labour). Either as reduction of uncertainty caused by communicated data or as data used for reducing uncertainty (51, p. 138).

Another definition of the term information is also based on the notion of reducing uncertainty but in the context of decision-making. Whittemore and Yovits state that the information theory approach is inadequate to be used in social sciences because it is "too restrictive to be of wide interest" (51, p. 222). They also state that treating information to be synonymous with knowledge is too broad to lead to principles and relationships that are meaningful and useful (51, p. 222).

Consequently, their definition of information is based on a model of decision-making process which considers constraints such as measurability and the need for a feedback about decisions made. In the light of Whittemore and Yovits' model, information is defined as any data which alters a decision maker's uncertainty. In general, information is defined in terms of its value to a decision maker and it could be measured by measuring the uncertainty of the decision maker before and after the receipt of some data (51, p. 222).

On his comments on the confusion of defining information, Fairthorne points out that the term is overused and ill-used, promoting sloppiness and confusion. He recommends that there ought to be a moratorium as a first step in clearing up terminology and clarifying concepts (16, p. 11).

The sloppiness and confusion of defining information may be partially behind the idea presented by Belkin and Robertson (3) that there is not and cannot be a definition of information in general sense.

> Information is that which is capable of transforming structure. This definition, however, is clearly far too broad (particularly in view of the categorical nature of structure), and encompasses many notions for which the term information is never used. So we leave information (in its general sense) undefined; but we discuss the various uses of the term with the idea of transforming of structure in mind (3, p. 198).

The above review of information definition which covers the last three decades reveals that there is no an accepted view of information definition. So, the approach of developing working definitions which encompass the characteristics of information required for the purpose of the study is taken. The working definitions as well as the study' framework of information dimensions is presented in the next section.

2.3 Working Definitions and Study Framework

Accepting the viewpoint, as illustrated by the previous discussion, that information has different meanings in different contexts, it is vital to have a working definition as well as a taxonomic scheme of "information" for the context of the present study.

> Information consists of symbolic fact(s), relationship(s), or theory(ies) which reduce(s) the uncertainty about a given phenomenon.

The greater the uncertainty about a specific phenomenon, the greater is the value assigned to information conveyed in a message about this phenomenon. A taxonomy of three distinct dimensions of information is delineated and defined. These basic dimensions, which are the subject of investigation, are production, distribution, and flow of information.

> Information production is defined as the process of generating new fact(s), relationship(s), or theory(ies) which build upon and may change existing fact(s), relationship(s), and/or theory(ies).

The process of information production can be subdivided into generation and evaluation. Any piece of generated information is usually evaluated by a group authorized for judgments within a specific field. For the purpose of this study, however, the process of evaluation is ignored.

<u>Information distribution is a measure of the geographic dispersion of information. In other words, it is a reflection of the number of distribution points within a geographic region.</u>

<u>The flow component is defined as the velocity of information in a given channel. In other words, it is measured by the frequency of using the distribution points within a given system, or the bandwidth of the channel.</u>

The basic justification behind this taxonomy of information is to separate the dimension of production, which means a real increase in the amount of information from other dimensions which basically relate to the degree of use of the amount of information created during the production process. The impact of information depends not only on production but also on the capabilities of distribution channels to disperse information and on the degree of velocity within these channels. The following example helps clarify this point.

Paper production was discovered in China about AD 1Ø5 (25, p. 3). Due to the lack of distribution channels, this information was confined to China until 751, when Arab armies overran Samarkand and captured a paper-making team sent there by the Chinese emperor. The information of paper-making spread to Iraq during the eighth century, to Egypt during the ninth century, and then to Morocco about AD 112Ø (25, p. 4). From there, the pace of information flow to Europe quickened due to the increase of distribution channels (trade routes and the crusades) through the

Mediterranean. The Byzantine Empire was importing Arab paper at the same time (1150) that Moslem Spain constructed its first paper mill. The Italians were making paper by 1280 (9, p. 100). This example demonstrates that the distribution of a new idea might be very slow due to the lack of adequate distribution channels.

These three noted dimensions are the primary concern of this study, but it must be pointed out that the concept of information dimensionality is not limited to just three dimensions. For example, information utility is another dimension which refers to the degree of utilization of received information (thus reflecting its perceived importance). This perceived importance usually affects the degree of utilization by the information recipient in two ways: (1) the frequency of information utilization within a certain period of time; and (2) the length of time period in which the information is utilized.

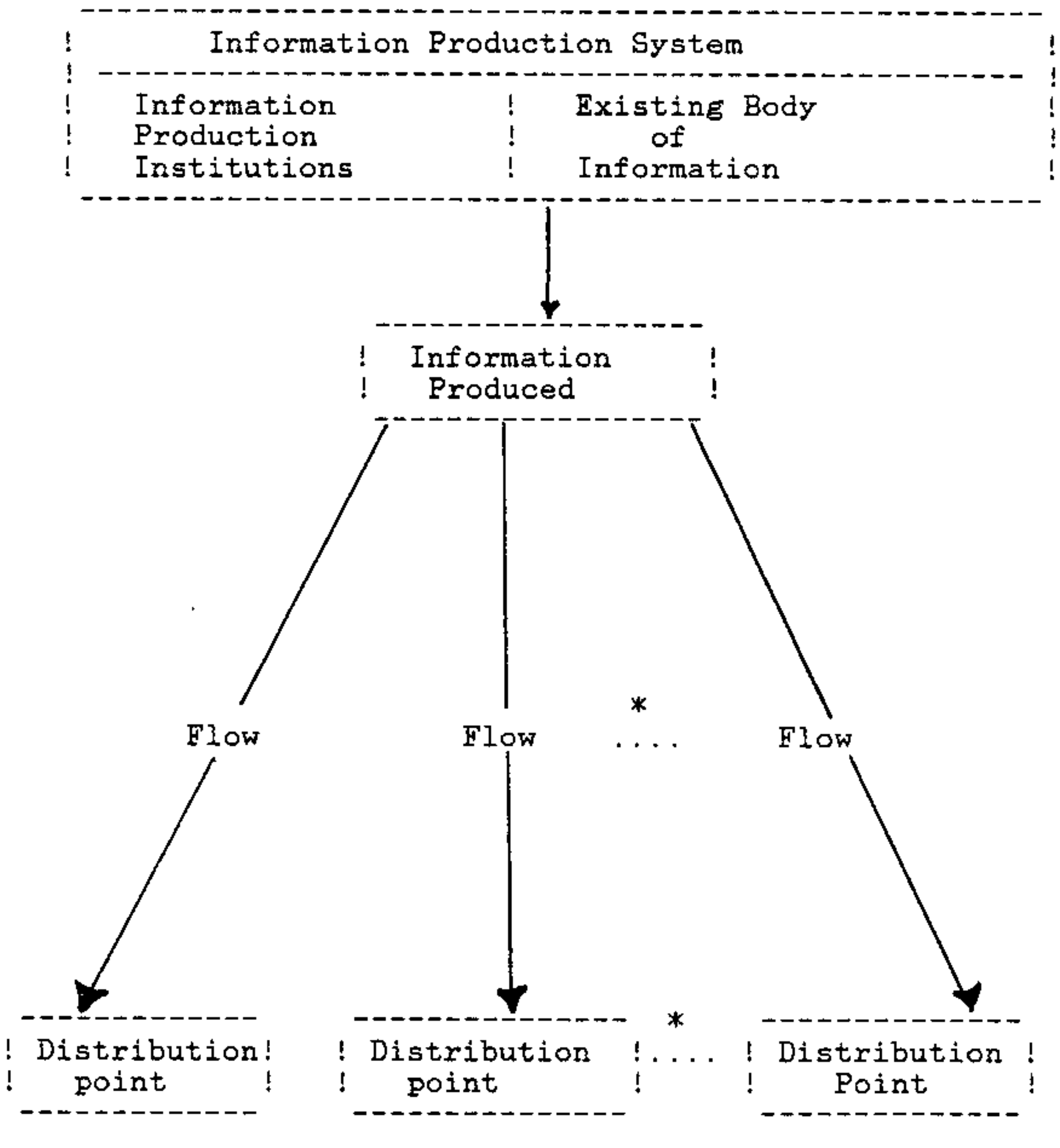
Regarding these two directions, one of the following information utilization conditions is possible:

1) information might be frequently utilized for a long period of time, suggesting a permanent importance of its value;
2) information might be frequently utilized for only a short period of time, suggesting a temporary importance of its value; or
3) information might be less frequently utilized for

long and short periods of time, suggesting a trivial value.

As mentioned, this research will limit its attention to the production, distribution, and flow dimensions. Figure 1 represents these three basic dimensions within a general information production system.

Fig. 1--Dimensions of Information



* The dotted line means that a typical system can have more or less than three distribution points.

The working definition of "explosion" applied in this study is mathematical.

> **Information growth is considered explosive only if the first and second derivatives of the growth curve are positive.**

Applying this operational definition of information explosion, the amount of information will be measured and plotted against time to draw the pattern of information growth. Curve fitting techniques will be applied to determine the growth function.

2.3 Measurement of Information: Previous Research

Contrary to the voluminous literature debating a definition of information, there is little literature about quantitative measurements for information. Two major efforts are Machlup's work, as presented in (30, 31, 32), and Price's work, as presented in (39, 40). Each work has a completely different approach. Machlup's approach is essentially economic while Price's is basically statistical.

Machlup (32) made the first attempt to measure the production and distribution of information based on the national accounts of the USA (4, p. 517). Machlup grouped thirty industries into five major classes of information production and distribution: education, research and development, media of communications, information machines, and information services. Bell (4) criticizes this classification scheme as being too broad and including non-homogeneous entities in a given class (4, p. 517).

Machlup's main objective was to compute the portion of Gross National Product (GNP) produced by these thirty industries as well as the portion of the labour force they engaged. These two metrics were used to characterize the information growth in the USA from 1900 to 1958.

This early work (32) has been praised for laying "the foundations for a theory of growth of knowledge" (44, p. 841). It was also replicated (e.g., 8, 33, 37) in different time frames to compute the growth rate of knowledge industries and the added values as a percentage of GNP. Despite all this attention, Bell (4) protests that "if one wanted to measure the actual economic magnitudes of the information economy, the difficulty is that there is no comprehension conceptual scheme that can divide the sector logically into neatly distinct units" (4, p. 517).

The other major work in the measurement of information growth is Price's study. Price (39) introduces a growth model applied to a class of information called "scientific information." Bell (4) provides his own interpretations to restricting Price's model to only scientific information by pointing out that "given this huge explosion in news, statistical data, and information, it is almost impossible to provide any set of measurements to chart its growth. Yet there is one area - the growth of scientific information - where some reconstruction of historical trends has been carried out" (4, p. 526).

Price (39) emphasizes that, with impressive consistency and regularity, the mode of growth of scientific information from 1665 to 1958 was exponential. He explains his findings thus: "the law of exponential growth follows from the simple condition that at any time the rate of growth is proportional to the size of the population or to total magnitude already achieved - the bigger a thing is, the faster it grows" (39, p. 5). He notes that the order of magnitudes of information growth vary from one area to another even the same pattern of exponential growth was maintained. According to Price, the order of magnitude is measured by the time required for doubling the amount of information.

Significantly, Price (39) cautions that this normal exponential growth of information describes, in fact, a most abnormal state of events. Things do not grow and grow until they reach infinity. Rather, exponential growth eventually reaches some limit (39, p. 20).

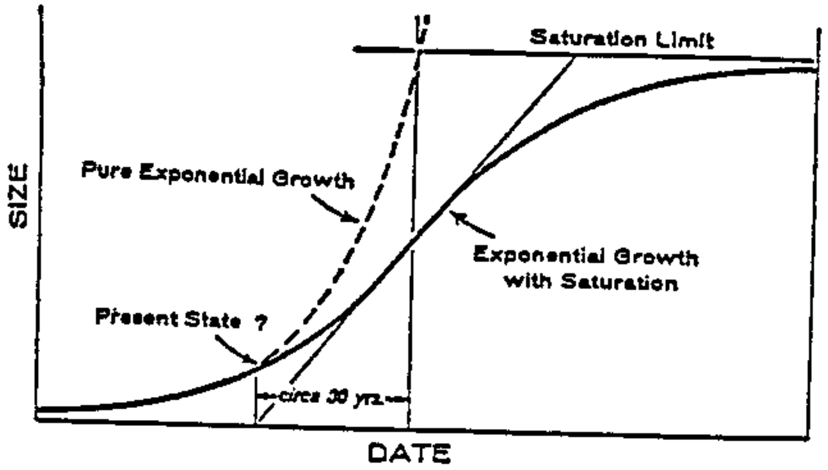
Based on the above conclusion, Price discusses the logistic (S-shaped) curve as a function which governs the general trend of information growth. The logistic function is used as a mathematical model to describe limited population growth such as spread of disease in isolated environment (53, p. 459). The general model of the logistic function is generally expressed as follows:

$$f(t) = \frac{a}{1 + be^{-akt}}$$

where a, b, and k are positive constants.

Certain characteristics govern the behavior of the logistic curve. It is limited by a floor and a ceiling. The floor reflects the base value of growth, usually zero, while the ceiling reflects the ultimate value of the growth beyond which it can not go in its normal behavior. Figure 2 reflects the typical pattern of the logistic curve.

Fig. 2--General Form of the Logistic Curve*



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* Source: Price (39), p. 116

Following the logistic function, the growth starts exponentially and maintains this pace to a point almost halfway between floor and ceiling, where it has an inflection. After the inflection, the pace of growth declines so that the curve moves toward the ceiling in a manner symmetrical with the way in which it moved from the floor to the inflection point.

According to Price's analysis, this normal form of logistic curve behavior is not the most common behavior of the curve. Before they reach a midpoint, logistic curves begin to twist and turn on the way to the ceiling according to one of the following patterns:

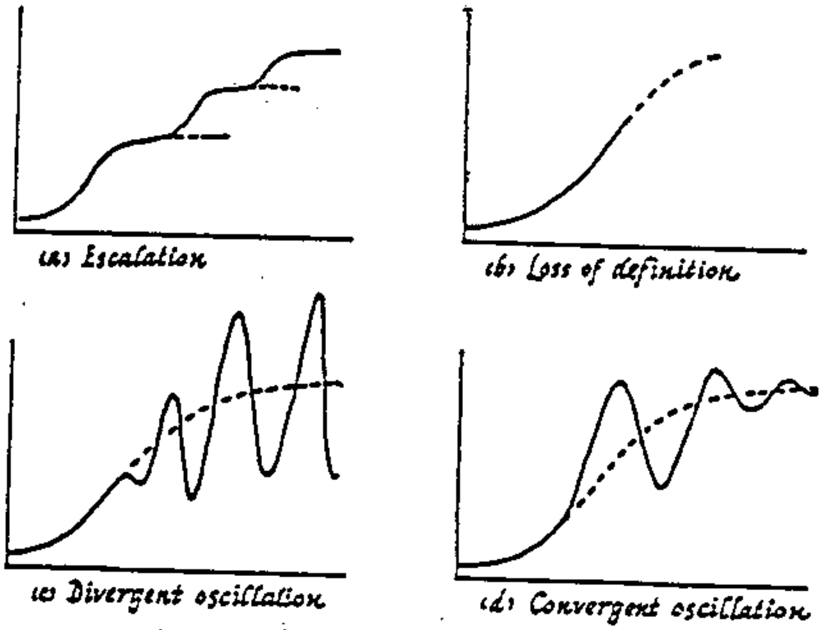
(1) Escalation---the behavior of the curve will change to begin another cycle of S-shaped curve. In other words, new logistic curves are born as the old ones die.

(2) Loss of definition---the behavior of the curve will become so violent as to make impossible further measurement of the variable in the same way or in the same units.

(3) Oscillation (divergent or convergent)---as the curves begin to escalate widely, the newly felt construction produces restorative reaction using cybernetic forces (39, p. 24).

A graphical representation of the way in which logistic growth may react to ceiling conditions is presented in Figure 3.

Fig. 3--Logistic Growth Reactions to Ceiling Conditions*



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* Source: Price (39), p. 24.

Price (39) presents empirical evidence to support his hypothesis that the growth of scientific information has been steadly following the logistic curve for three centuries. He concludes that escalated curves are the most common explaining the growth of scientific information.

Observing historical events, one can conclude that once the growth slowed down another major advance was needed to produce another step in the escalation (39, p. 30).

Weiss (47) presents another model of scientific information growth different from the logistic model presented by Price. In his article, Knowledge: a Growth Process, Weiss states that "scientific knowledge grows like an organic tree, not as a compilation of collector's items" (47, p. 209). So, the model of a higher animal growth is introduced as a model of information growth.

Making an analogy between the growth process of a higher animal and the growth process of information, Weiss states that

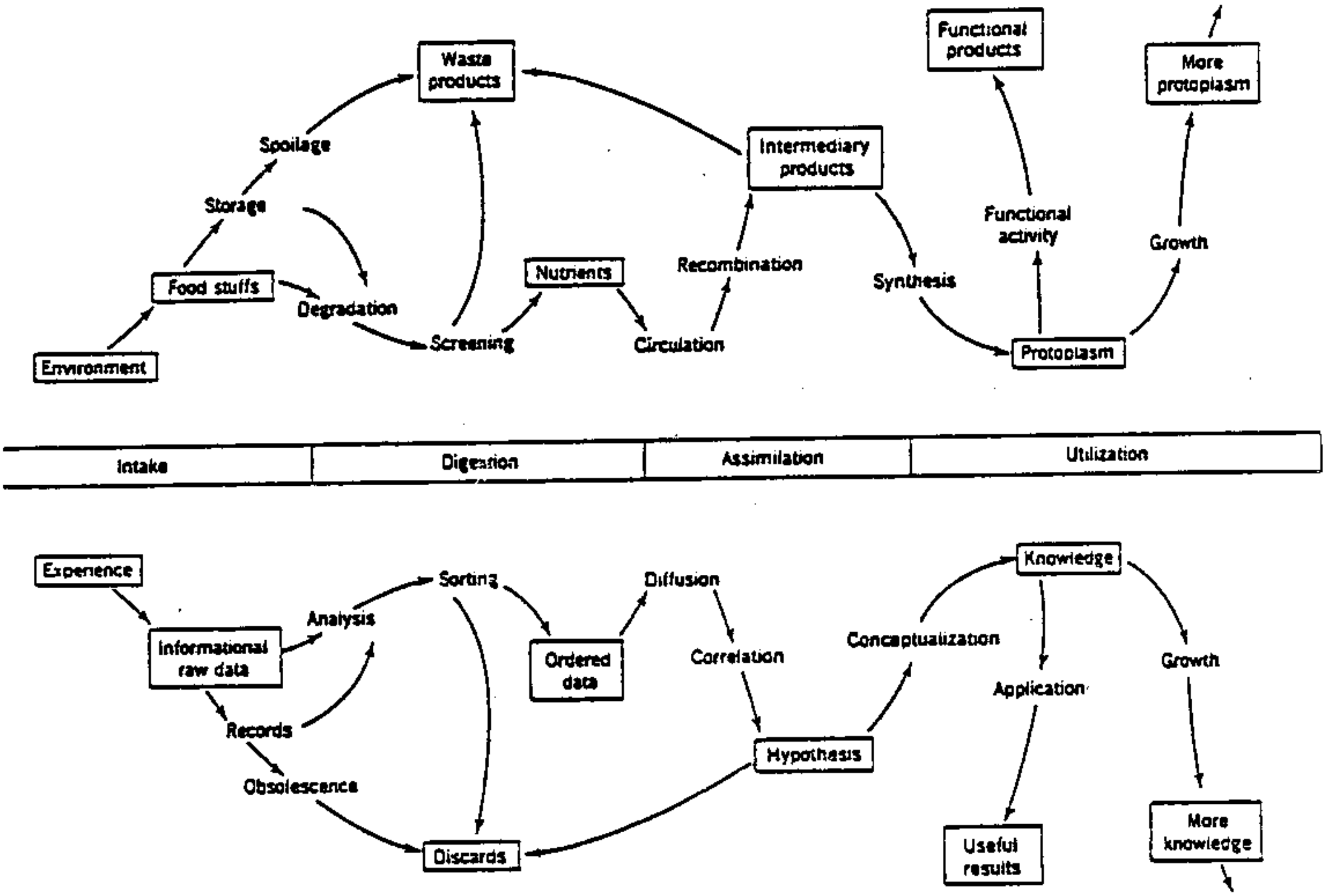
> an organism never adopts foreign matter outright, but reorganizes and assimilates it to fit its own peculiar pattern. Even a leech must first dissolve the hemoglobin of its meal of blood and then compose its own brand from the fragments. Organic growth is by assimilation, not accretion. (47, p. 210).

Weiss continues his analysis to make the analogy between the mentioned process and the process of information growth by stating that the process starts with data either stored or processed. The products of processing the data are then stored according to relevance. As a result of this, an ordered system of identifiable items is created which is similar to the Linnean system of species prior to the theory of evolution. Circulating items of ordered systems leads in critical correlation with other sources which results in emerging hypotheses which upon further testing turn into integral parts of the body of knowledge.

> At this stage, data have become assimilated, have lost their individual identities in merging with that higher entity-the body of organized knowledge. ... A patchwork of unrelated facts has been transformed into a rationally connected thought structure of inner consistency, viable and durable, subject to the tests of survival and the adaptive improvements of evolution-a veritable model of organism. (47, p. 210).

Figure 4 represents the process of information growth (lower half) as compared to the process of higher animals growth (higher half).

Fig. 4--The Process of Information Growth*



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* Source: Weiss (47), p. 211.

There have not been reported studies to test empirically Weiss's model of information growth. It seems that the model lacks practicality because there is no quantitative metrics provided to measure the amount of growth within the model.

Neither the logistic model nor the higher animal model is used in this study. The objective of the study is not to test a specific model of growth. The empirical evidence derived from the study will be used to interpret the theoretical foundation which may exist behind the growth of information. So, the study concentrates on the theory which is suited to measure the amount of information which is discussed in the next chapter.

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CHAPTER III

THE COMMUNICATION THEORY AND THE INFORMATION GROWTH

3.1 An Overview of Basic Concepts of Information Theory

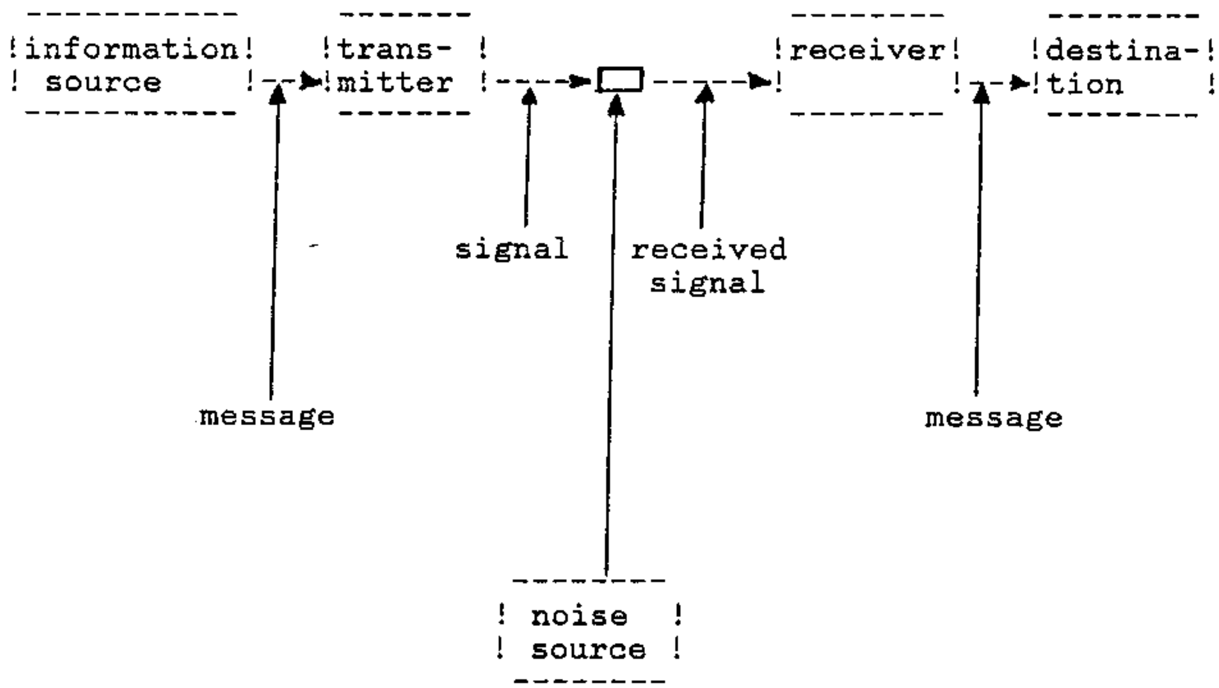
Shannon's theory of communication (introduced in 1948) is a widely accepted model of communication. The model contains five basic elements:

1. information source;
2. transmitter;
3. channel;
4. receiver; and
5. destination.

These five basic elements are represented by Shannon and Weaver (44) in a schematic diagram of a general communication system.

As shown in Figure 5, the model explains the technical aspects of the communication process with which information theory is concerned. The information source provides messages which are to be transmitted to a destination. The model includes a transmitter and a receiver, with the receiver connected to the destination. Transmission and receiver represent the encoding and decoding process. Finally, the model includes the noise source, which interferes with information flow between the transmitter and the receiver.

Fig. 5-- Schematic Diagram of a General Communication System*



* Source: Shannon and Weaver (44), p. 5

Information theory relies heavily on notions drawn from the mathematical science of probability such as finite and discrete probability, conditional probability, and the law of large numbers (28, p. 1). The application of the basic concepts of probability to the generalized communication systems (illustrated in Figure 5) has led to the development of mathematical formulas to compute the amount of information (information content) of a transmitted message, the average amount of information, and the total amount of information transmitted through discrete, continuous, or mixed communication systems.

In all cases, the logarithmic measure is essentially used. Shannon and Weaver (44) state the following reasons behind the convenience of choosing the logarithmic function as a measure of information content:

1. it is practically more useful because of the tendency of many parameters to vary linearly with the logarithm of the number of possibilities;
2. it is nearer to an intuitive feeling as to the proper measure since the tendency to measure entities is by linear comparison with common standards;
3. it is mathematically more suitable (44, pp. 3,4).

The mathematical formulas are presented in detail in Shannon and Weaver (44). The formulas applied in the study are, however, discussed in section 3.3. But the question of applying the information theory formulas in social sciences has been frequently raised. So, before discussing the formulas applied in the study, the question of extending the general model of communication theory to the social science in general and information growth in particular is presented in Section 3.2.

3.2 Information Growth as a Communication Process

Applying the basic structure of communication theory developed by Shannon and Weaver to the social sciences in different contexts requires delineation of those elements which are useful for describing the respective fields. It is also necessary to make the analogy between the process of communication at a given level and Shannon and Weaver's model.

Inspite of the controversy over the propriety of extending information theory to the social sciences, there has been much interest in applying the theory to a wide range of fields such as accounting, economics, and linguistics. The main concern here is to discuss studies whose concerns are with the development of broad conceptual frameworks of the communication process appropriate for the study of respective disciplines in social sciences. Three studies seem appropriate for discussion. They are Bedford and Baladouni (11), Murdock and Liston (37), and King et al.

(29). A brief discussion of each is in order followed by a model of information growth as a communication process in the context of the study.

Bedford and Baladouni (11) examine information theory in accounting. But their model is broad and explores general factors which could be applied to any conceptual framework of communication process. They describe three general factors that they believe are necessary for any communication process: (1) the concept of process, (2) the elements of communication, and (3) the dimensions of communication.

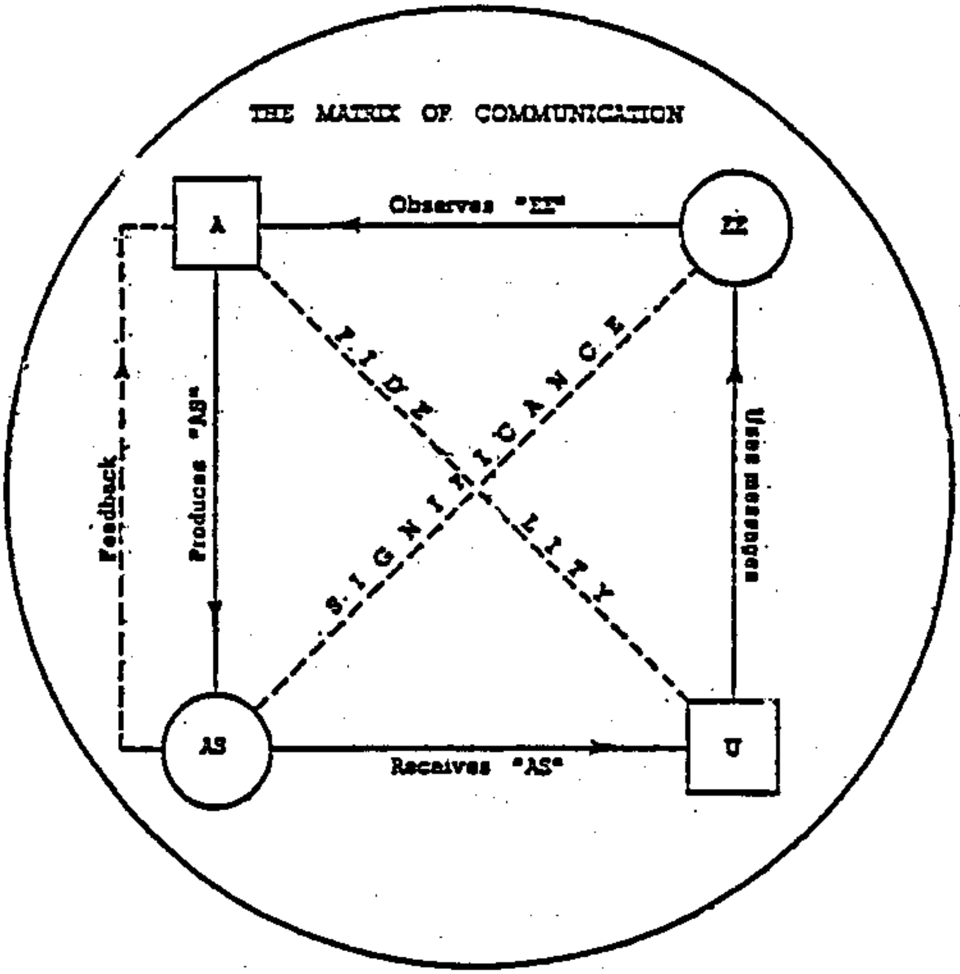
The concept of process, as Bedford and Baladouni see it, is any phenomenon which shows a continuous change of events and relationships in social as well as physical sciences. The elements of communication model as described by Shannon and Weaver are (1) Source; (2) Transmitter; (3) Channel; (4) Receiver; and (5) Destination. But according to Bedford and Baladouni there are no hard and fast rules regarding the number of elements that can be selected. The selection of the elements depends solely upon the usefulness which such elements present in discussing and analyzing the respective field as a communication process on a given level (11, p. 651).

Regarding the dimensions of communication Bedford and Baladouni (11) describe two basic dimensions: (1) observation and (2) production.

> Given a purpose of communicating, the communicator faces two major problems: content and media of communication. In other words, he has to determine what and how to communicate in order to express his purpose adequately. To achieve the what -content- the communicator must select his material from what is available for observation. To achieve the how -media- the communicator has to choose some technical means of producing his message. All this is to say that communication is at once concerned with observational and productional dimensions (p. 652).

Figure 6 represents the general framework of communication process as it is applied to accounting.

Fig. 6--General Framework Of Communication Process*



EE Economic Events of a Business Enterprise.
A Accountant of a Business Enterprise.
AS Accounting Statements of a Business Enterprise.
U Users of Accounting Statements.

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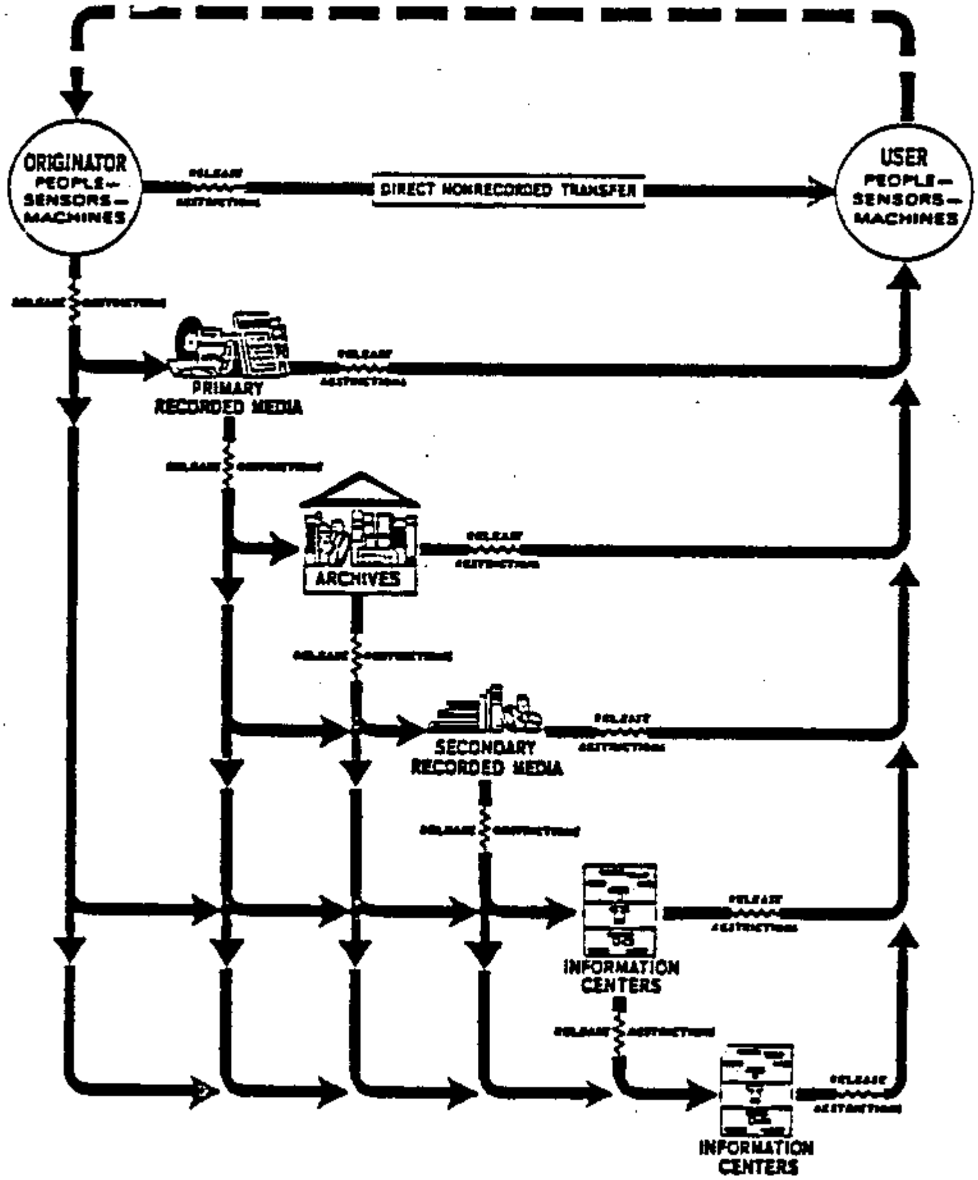
* Source: Bedford and Baladouni (11), p. 653.

According to the model, there are four basic elements of the communication system represented by circles and four relationships among the elements represented by arrows. Bedford and Baladouni point out that the process starts with the accountant (source) observes the economic events of a business enterprise and then produces accounting statements which carry messages of significance and high fidelity to users (destination).

Murdock and Liston (37) present a general model of information transfer which is basically based on the basic structure of Shannon and Weaver model (sender/channel/receiver). Murdock and Liston (37) point out that "Communication between sender and receiver can occur at a number of levels along what is referred to as the "communication continuum" (37, p. 289). Figure 7 presents a graphical representation of the model showing a variety of channels used to transfer information.

Fig. 7--General Model of Information Transfer*



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* Source: Murdock and Liston (37), p. 289.

According to the graphical model presented in Figure 7, the process of transferring information starts with an individual writing himself a note. The note becomes primary recorded medium and his files of notes on a desk top become the archives.

> He [the individual] becomes the user when he wishes to retrieve the note. Sophistication is added when several people prepare reports or write memos and the archives become a central file. Further, complexity is added when the media include reports from outside the organization such as published literature. The archives now comprise a library or its equivalent (37, p. 288).

Along the communication continuum, there are varieties of communication channels: direct, primary recorded, archival, secondary recorded, and information center channels. One extreme on the communication continuum is the direct and nonrecorded channel. This is called face-to-face communication which is characterized by being very direct, very dynamic, and very rapid with no delay time (37, p. 288).

Moving along the communication continuum toward situations involving less directness, less dynamic transfer, and more time delay, other communication channels are used such as phone conversation, television and radio broadcasting which are considered different forms of direct communication channels (37, p. 288).

Murdock and Liston continue to explain the process of information transfer by moving along the communication continuum to the point that the originator might feel that what he has to say should be recorded as a part of the body of knowledge of his discipline. So, non-direct channels such as publications in the forms of letters, newspapers, conference notes, technical reports, handbooks, monographs, texts, patents, and tapes are used. All these forms of communication are called primary recorded media channel (37, p. 288).

The next channel on the continuum is the archival channel where the user is not sensitized to the flow of messages through the current channels. The archival channel is used to store information for subsequent usage when it is needed. The secondary recorded media channel feeds from both the primary recorded media channel and the archival channel. The purpose of this channel is to assist in searching more easily for information of interest stored in the primary and the archival channels. Examples are abstract journals, indexes, and bibliographies. Finally, at the other end of the continuum is the information centers channel whose function is to provide a service to a known group of users upon demand. Murdock and Liston cogently explain the role of information centers in their model of information transfer as follows:

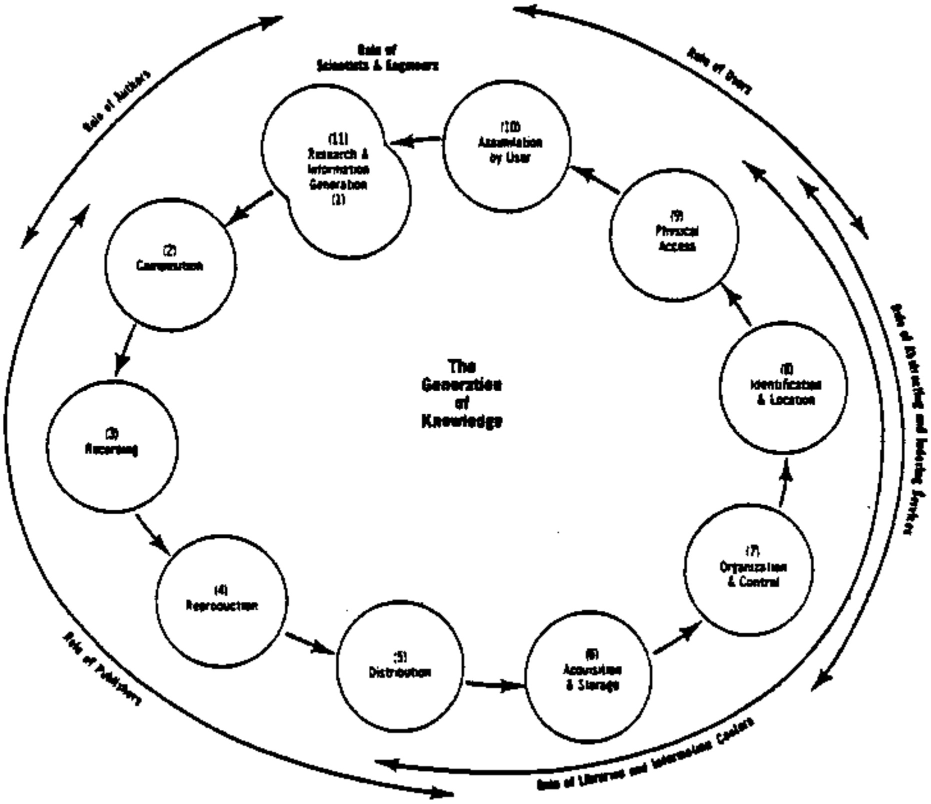
> The information analysis center, in particular, attempts to utilize all information transfer channels to provide technical answers to technical questions posed by users. Thinking in terms of an electrical analogy to the model, information centers act as "switching centers" utilizing combination of series and parallel arrangements (37, p. 290).

There are two observations concerning Murdock and Liston's model. The first is that the entire model is cyclic. This means that users (as a group) are the originators (as a group) of information. It is represented in the model by the dotted line. The second is the role of the term "release restriction" which means loss of some transferred information during the transfer process. Murdock and Liston make the following analogy between the release restriction and the resistance in the electrical channels:

> Regardless of the type of channel utilized in transferring a message, there are certain release restrictions which will impede the "free" transfer of information from originator to user. Returning to our electrical analogy, these release restrictions would be much like resistances or impudences in the circuits concerning the originators to the users. Furthermore, the total resistance to flow would probably vary according to whether the resistance in the channels were applied in series or in parallel or in combination of both (37, p. 29Ø).

Another model of information transfer is introduced by King et al. (29). Although the model is only designed for scientific information transfer based on published documents, some of the functions are applicable to other forms of information transfer as well (29, p. 3ØØ). The model and its functions are depicted in in Figure 8.

Fig. 8--Model of Scientific and Technical Information Transfer *



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* Source: King et al. (29), p. 300.

The diagram represents an information transfer spiral based on published documents. According to King et al. (29), the spiral includes ten functions which were chosen because they appeared to be unique in their representation of the communication process. The beginning of the spiral is generation of information function which is the result of research efforts. The last function is information assimilation which means that the user may gain information to be used in other cycle of generating and transferring information. So, the model is cyclic which means that the process is continuous and regenerative.

King et al. (29) explain how the process of their model takes place by pointing out that the next function after information generation is the composition function which refers to formal writing, editing, and reviewing of manuscripts. Recording function refers to the process of publishing the approved manuscripts in journals, texts, proceedings...etc. Acquisition and storage function refers to the acquisition and storage by libraries and information centers. The next two functions in the spiral (organization & control and identification & location) refer to the roles of libraries and information centers in cataloging, classifying, indexing, and abstracting what is acquired in the previous function. The physical access function includes direct distribution from publishers to users as well as indirect distribution through libraries and information centers.

There are models of scientific communication (22), organizational aspects of information flow (3), patterns of information flow during the innovation process (41), and professional organizations as a means of information transfer (43). They are excluded from discussion because of the specificity of their presentations to some aspect of information growth as related to specific environment.

The above three models are important for the present study because the broadness of their presentation of the communication process supplies common factors which can be included in a general model of information growth for any discipline or society. On the other hand, not one model recognizes the dimensions of information; there is no distinction made between production, flow, and distribution of information. Furthere, each model stresses the generality as it is applied to a respective discipline. This necessitates the adoption of some common factors to construct a general model of information growth independent of information type and of any respective field.

The suggested model depicted in Figure 9 is based on the following features:

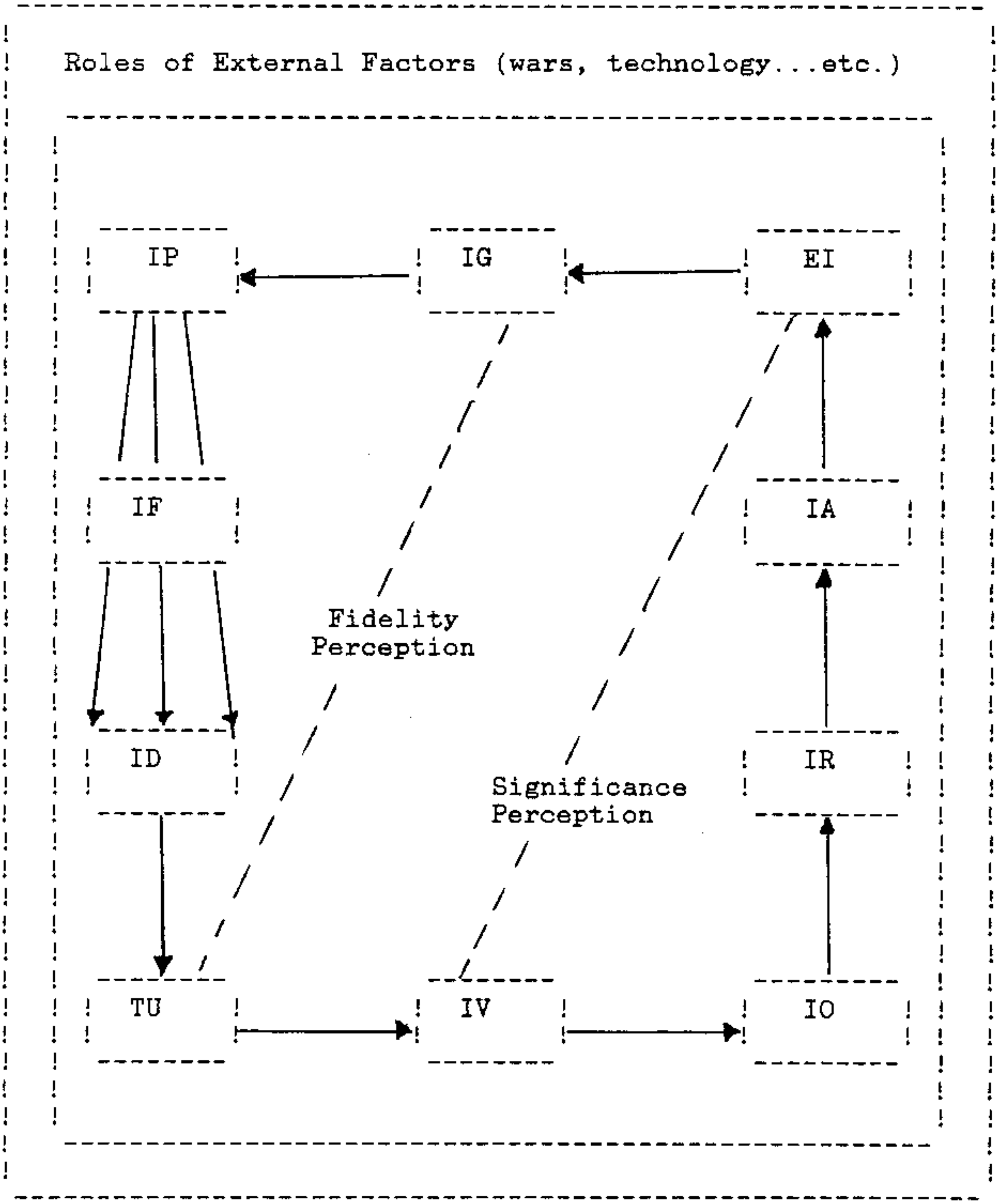
1. the classical communication system which at least includes a sender, message to be transmitted, channel, and receiver used;
2. the dimensionality of information which at least includes production, flow, distribution, value,

organization & storage, retrieval, and assimilation of information is represented. Note that the cited dimensions do not constitute an exhaustive list; rather they are chosen because they appear to represent distinguishable functions within the model,

3. the model is cyclic and regenerative in nature, with each step in the process feeding from the previous one;
4. the model is not only influenced by its components but also by other external factors in all or in part of the whole process of information growth.

Figure 9 presents a model of information growth.

Fig. 9--Information Growth as a Communication Process*



* Legends used in the model are defined on the next page

EI = Existing information in a specific field

IG = Information generation institutions in a specific field

IP = Information produced in a specific field

IF = Information flow in a specific field

ID = Information distributed in a specific field

TS = Target users of information

IV = Information value as perceived by users

IO = Information organization and storage after receipt

IR = Information retrieval after storage for subsequent usage

IA = Information assimilation by users so that the state of knowledge is altered

Fidelity = The degree of understanding a message by intended users compared to what is intended by the information generators

Significance = The degree of relevance perceived in relation tp the existing body of information

Although the model is cyclic, it is convenient to start describing the process of information growth by generation of information. The information production usually begins with observing the **existing body of information** . The **observational function** includes initial steps to select facts, theories, and relationships related to a given level of interest. The existing body of knowledge constitutes a resource supplying the tools, methods, and interpretations to the information producers.

The **production dimension** uses what has been selected to produce new information which reduces the uncertainty about the phenomenon under investigation. Knorr-Cetina (31) describes the process of producing knowledge as making several orders or levels of "selectivity."

> The selection of previous investigations also affect subsequent selections by modalising the conditions of further decision-making. Thus, the products of science are not only decision-impregnated, they are also decision-impregnating, in the sense that they point to new problems and predispose their solutions" (p. 6).

Once the new information is produced, it is transmitted to the target users through appropriate media, such as books, articles, and oral presentations or demonstrations. It should be kept in mind that this process is not only confined to the production and distribution of scientific information but can also be applied to all kinds of information. During that transmission, there are two distinguished functions involved. **Information distribution** refers to the geographic dispersion within a specific region, and **information flow** refers to the frequency of using the distribution channels within a given system.

In order for target users to value the information received, it must be significant and have high fidelity. **Fidelity** is defined as the probability of errors in transmitting information from its source to destination. In the information growth context, fidelity is related to what is understood by intended users and what the information is intended to be as expressed by the information generators. **Significance** refers to the degree of relevance and adequacy which the new information is perceived to have in relation to the existing body of knowledge.

Information value refers to the perceived importance of the information received by its recipient. This importance is usually reflected in the frequency of utilizing this information and the duration of this utilization. **Information organization** refers to the function of cataloging, classifying, indexing, and storage of the information received in such a way as to be more easily available for later use when needed. **Information retrieval** refers to the techniques and methods available to access the stored information for later use. This function is closely related to the previous function. The access methods depend primarily on the way information is organized and stored.

Information assimilation refers to the impact of the information received, valued, stored, and retrieved by users on their state of knowledge regarding a specific topic. If the information received is regarded as of significance and high fidelity, it may be assimilated by users changing their state of knowledge which triggers new conceptualization and new research efforts. So, as a result of information assimilation, a new cycle begins leading to the generation of new information and so the process continues.

Viewing this process of information growth as a dynamic one, on-going and ever-changing phenomenon of events and relationships should prevail. But the factors impacting this process are not limited to its components. There are external factors which play roles in the information growth at different levels.

King et al. (29) include the following factors in their model of information transfer:

1. the role of scientists and engineers in the information generation function;
2. the role of authors in the generation and the composition of information;
3. the role of publishers in composing, recording, reproducing, and distributing information;
4. the role of libraries and information centers in distributing, storing, controlling, identifying and locating, and accessing information;

5. the role of users in accessing and assimilating information (29, p. 300).

Generally these factors are expected to play roles affecting partially or totally the process of information growth. But these factors vary from a specific environment to another leaving room for investigators to delineate factors which are believed to be of significance for specific investigation.

The proposed model is suitable for describing the process of information growth in society. External factors which might impact the information growth at that level are technological, social, and economic situations. Some of these forces such as wars and economic depressions constitute crisis-inducing situations which escalate the efforts of research institutions to begin the cycle of generating more information to meet these crises.

Other factors such as technology might have varying effects on all or some of the components of the information growth process. Technological factors play important roles in the flow, distribution, collection, storage, and retrieval of information. It is obvious that the technological advancements in computer and communications are the major forces driving the whole process of information growth in modern societies.

Detailed discussions of these external forces whether they trigger the cycle generating new information or impact the whole process of information growth are beyond the scope of the study. The main concern of the study is to delineate metrics to only measure three dimensions of information (production, flow, distribution) and to use these measures to test if there has been an information explosion in these dimensions. A discussion of Shannon and Weaver's metrics applied in the study as well as justification for using these metrics is provided in the next section.

3.3 Entropy as a Basic Measure of the Amount of Information

According to Shannon and Weaver, the amount of information in a specific event is essentially the base 2 logarithm of the number of probabilities (40, P. 7). Mathematically, the information content in a particular event is:

$$H = - \log P_i$$

where

H = the amount of information associated with event (i) measured in bits.

P_i = the probability that event i will occur in a given situation.

The average information content is referred to as "entropy" and formulated as follows:

$$H = -K \sum_{i=1}^{i=n} P_i \, . \log P_i$$

where

H = the average information content of messages transmitted through discrete system

K = a positive constant to determine the units of (H); H is measured in bits when K = 1/Ln. So, a modified Formula is:

$$H = - \sum_{i=1}^{n} P_i \log_2 P_i$$

The term "entropy", which represents a measure of the removal of doubt and ambiguity from the system (13, p. 15), has been adapted and extended by Shannon and Weaver for measurement of information because the above information formula is quite similar (except with negative sign) to the Boltzman formula for entropy in thermodynamics (6, p. 3). Shannon and Weaver (44) comment on the negative sign in the formula by pointing out that "any probability is a number less than or equal to one, and the logarithms of numbers less than one are themselves negative. Thus the minus sign is necessary in order that H be in fact positive" (44, p. 105).

Shannon and Weaver justify their use of entropy as a measure of information by pointing out that it uniquely meets the following natural requirements for the measurement of information:

1. the system generating information should be governed by probabilities especially a special class of Markoff chain called ergodic process;
2. the estimation of the properties of the system generating information should depend on the properties of the whole system and still reflect statistical regularity;
3. the probability of choice of the various symbols at one stage of the process is dependent on the previous choices (44, pp. 101-103).

The concept of entropy originated in physical sciences to measure the degree of randomness. It means the tendency of physical systems to become less organized (i.e., more disordered). So, in thermodynamics and other physical sciences, if the entropy of a specific system is low, it means the system is highly organized while in information theory it means less information transmitted by the system because it is characterized by high degree of probability that specific events occur.

The computation of the total amount of information within a system depends basically on the properties of entropy, the channel type, and the degree of noise in the transmission system. The above mentioned formula of entropy is only applicable to discrete channels where a finite set of elementary symbols is transmitted from one point to another. In case of situations where the transmission is in the form of varying continuous signals such as television or radio, the transmission media is continuous rather than discrete. The entropy of a continuous channel is different from the entropy of a discrete channel. A number of communication systems might utilize a continuous source and thus continuous use of the channel.

To compute the entropy for a continuous channel, the probability density function is used instead of the distribution function which makes the entropy of the continuous channel a relative measure rather than an absolute measure as the entropy of discrete channel. Using the probability density function p(x) associated with the signal x(t), the general formula of entropy for a continuous channel is:

$$H(x) = -\int_{-\infty}^{\infty} p(x) \log p(x)\, dx$$

As stated by Shannon and Weaver (44), even though the entropies of continuous distribution have most of the properties of the discrete case, there are still some differences which should be considered when applying the entropy of continuous channels (44, pp. 55,56). In the study, however, all the channels under investigation are considered discrete which limit the discussion to the discrete case. But before delineating the metrics applied in the study, the question of the adequacy of applying the information theory in social sciences is addressed.

There are two divergent views concerning the relevance of applying the information theory in social sciences. The first rejects the extension of the theory outside its technical aspects in electrical engineering. The second considers the theory very valuable in measuring the amount of information in social communication systems as well as physical systems. A brief discussion of each view is in order.

Bandyobadhyay (3) questions the applicability of information theory into open and real-life systems pointing out that the information theory concepts have been used losely in social sciences (3, p. 3). Hopkins (26) and others (e.g., 7, 36, 52) have demonstrated the limited practicality of information theory in social sciences. The proponents of this view base their position on the following:

1. the theory and its mathematical formulas are based on the assumptions that the communication system is closed and it is stationary which are not met in social systems (3, p. 3);
2. the theory ignores questions having to do with what specific information is transmitted in order to describe how much information is transmitted (20, p. 41);
3. the theory neglects questions having to do with the beliefs, intentions, reliability, and other features of the informant and informee (21, p. 56);
4. the amount of information computed is independent from its value which is very important to decision makers (51, p. 222).

These are the main constraints supporting the idea of limiting the applicability of information theory in social sciences. Nevertheless, there are proponents (e.g., 27, 32, 33, 34, 39, 49) who consider information theory very valuable for measuring and analyzing the amount of information in social systems as well as technical systems.

As stated by Shannon and Weaver (44), the word "information" must not be confused with the word "meaning." "In fact two messages, one of which is heavily loaded with meaning and the other of which is pure nonsense, can be exactly equivalent, from the present view, as regards information" (44, p. 99). This means that the theory is designed to provide an objective measure to quantify the amount of information independent from any value assigned to it as perceived by the recipient. For example, the value of the message "it is raining today" might be greater to a farmer than to a student but the amount of information of the message is the same.

In the social systems, there are situations where an objective measure of the amount of information separate from its value, importance, and informant and informee beliefs is critically needed. For such situations, the information theory and its mathematical formulas can play an important role. Examples of applying the information theory in social sciences are Lev (32, 33, 34) and Abdel-Khalik (1) in accounting, Attneave (5) in psychology, Soest (46) in sociology, Schwarts (42) in linguistics, Theil (50, 51) in economics, and Shaw (45) in library science.

The objective of the study is to measure the amount of information separate from its perceived value or importance to test if there has been an information explosion. So, the application of information theory is appropriate within the context of the study.

But applying the basic concepts of information theory in social systems will lead to different interpretations in different contexts. In the present context, for example, the effect of an "error" in producing or transmitting information in social systems can be viewed as noise in the system. Examples in the area of information growth would be reporting conflicted findings in scientific papers. One important difference between noise in social systems and in technical systems is that the noise in social systems may not be treated as purely disruptive as the noise in technical systems which prevents correct transmission of signals.

Knor-Cetina (31) argues that for the optimum amount of information in the whole system, it might be best to have some errors in the transmission of information between the subsystems. He explains this conclusion by drawing the following example:

> As a simple example, consider the leak in the communicative network of the Nixon administration with regard to the bombing of Cambodia (kept secret by the administration). While the leak was without doubt disruptive for some core members of the administration, it may well have benefited the more global system of American democracy. The implication is that we have to take into account different levels of organization in order to distinguish between the disruptive and integrative (or organising) effects of noise (p. 29).

Viewing information growth as a product of a communications system necessitates extension of this view to regard society as a collection of communication subsystems. Examples of information growth subsystems are the various discipline communities. Each discipline has its own information generating institutions to select from the existing body of information. There is a complete cycle of generating, confirming, and distributing the new information. The amount of information in the whole system is simply the addition of the amount of information generated by the subsystems assuming that redundancy and noise are at the optimal level.

Generally, there are different versions of writing the total amount of information within a system. One applies in a variety of situations in which no information is available about the probability distribution. The mathematical formula is:

$$H = \log_2 N$$

where

N = the number of possible messages in the system (31, p.29).

H = the total amount of information generated.

Within the context of the study, the above formula is used with the information production metrics used in the study. Information flow is related to the capacity of a specific channel used to transmit certain information. According to Shannon and Weaver's information theory, the capacity (C) of a discrete channel is defined as

$$C = \lim_{T \to \infty} \frac{\log N(T)}{T}$$

where

N(T) = the number of allowed signals in a duration (T).

C = the channel capacity

The relationship between (H) and (C) is expressed by Shannon and Weaver (44) stating that number of bits transmitted per second (C) needs only to be equal to the average entropy of the source (H) which yields an average rate of transmition (H/C) = 1. Hancock (24) points out that in the case of perfect match, the entropy of the source (H) is equal to the channel capacity (C) (p. 161).

Within the context of the study and in the absence of any information about the flow of messages through the selected channels, noiseless flow is assumed which means the most efficient flow of information through the channels. The channel capacity (C) is replaced by $H = \log_2 N$ metric to be used with the information flow metrics used in the study.

In the next chapter, the research variables as well as the stated hypotheses for production, flow, and distribution of information are presented. The data collection and analysis procedure and the basic assumptions are also discussed.

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CHAPTER IV

RESEARCH METHODOLOGY

4.1 Research Variables

The independent variable of this study is time. The time span covers the period from the take-off phase of the American Industrial Revolution (1860) to 1984. The scope of the study is limited to the USA to keep it within a manageable level.

There are several reasons to choose the 1860 as the beginning time of the study:

(1) the end of the American Civil War confirmed the dominance of the industrializing North over the agrarian South;

(2) the later half of the nineteenth century witnessed heavy foreign investments by European powers which accelerated the scientific and economic development of the US;

(3) new forms of communication (e.g., the telephone, motion pictures, automobiles, aircraft, radio, paperback books, and television) have appeared since 1860;

(4) the second half of the nineteenth century saw a

basic change in the education system in favor of universal public education and the growth of the state (land grant) universities.

Because some of the dependent variables did not exist in 1860, their measurement period is from the time which public records started to keep systematic data about them to 1984. The study also recognizes that the question of information explosion has been raised especially in the last three decades. So, data analysis is designed to test the hypotheses in a shorter time span (1942-1984) compared with the original time span of the study. The study considers the effects of population impact by testing the hypotheses before and after the adjustment of the data variables by population growth in the USA.

The following are the dependent variables:

a) **Information Production**---operationalized by the yearly growth of

1. copyrights;
2. patents;
3. doctorates; and
4. Library of Congress holdings

b) **Information Distribution**---operationalized by the yearly growth of

1. radio and TV stations;

2. miles of telephone wire;
3. telephones; and
4. post offices.

c) Information Flow---operationalized by the yearly growth of

1. pieces of matter handled in post offices;
2. number of books;
3. number of periodicals;
4. number of newspapers and circulation;
5. average daily phone conversation;
6. number of radio and TV sets.

Behind choosing these metrics is a belief that they are considered relevant parameters for generation, distribution, and flow of information at the global level in society. Despite possible changes in their relative importance caused by new technologies, these parameters constitute the basic forms of communication in the USA since the later half of the nineteenth century. In addition, the required statistics have been systematically collected and recorded by the Department of Commerce.

A list of the study's variables is provided in Table I:

TABLE I

VARIABLE LIST

INDEPENDENT VARIABLE	DEPENDENT VARIABLES
Time	A. <u>Information Production</u>
	1. Total number of copyrights
	2. Patents:
	2.1 Total number of inventions
	2.2 Total number of designs
	3. Total Number of Doctorates
	4. Total number of Library of Congress holdings
	B. <u>Information Distribution</u>
	1. Radio Stations
	1.1 Number of Commercial AM Stations
	1.2 Number of Commercial FM Stations
	1.3 Number of Non-Commercial FM Stations
	2. Television Stations
	2.1 Number of Commercial TV Stations
	2.2 Number of Non-Commercial TV Stations
	3.3 Number of Cable Systems
	3. Number of Telephones
	4. Number of Miles of Telephone Wire
	5. Number of Post Offices

TABLE I

VARIABLE LIST (cont.)

INDEPENDENT VARIABLE	DEPENDENT VARIABLES
	C. <u>Information Flow</u> 1. Material Handled in Post Offices 2. Number of Books Published 3. Number of Periodicals 4. Number of Newspapers and Total Circulation 5. Average Daily Telephone Conversations 6. Number of Radios Produced 7. Number of TV Sets Produced

4.2 Metrics of Information

4.2.1 Production: the yearly growth of copyrights, inventions designs, doctorates, and LC holdings are expressed according to Shannon's $H = \log_2 N$. Although these metrics chosen do not constitute an exhaustive list of information production parameters, they are considered more reliable than other parameters. For new copyrights, inventions, and designs, there is an evaluation process to make sure they are valid and are not redundant. There are laws which specify requirements and conditions to be met before patents on inventions or designs have been issued. As stated in the Historical Statistics of the USA from colonial time to 1970, "the subject matter covered by a patent must be sufficiently new as to be not obvious to one skilled in the art to which it relates (p. 954). The collection of the Library of Congress is chosen because all other library holdings are considered redundant and do not reflect production of new information. Each new copyright, invention, design, doctorate, and LC holding is considered a message holding new information and has equal chance of being produced. So, Shannon's $H = \log_2 N$ is applied. Granted, using the Library of Congress holdings as a production metric has some difficulties such as including the foreign language section in the total collection of the Library. Nevertheless, the growth of the total collection is still a major indicator in its overall sense of information production. It is, however, considered a special category.

4.2.2 <u>Distribution</u>: the yearly growth of telephones, miles of telephone wire, radio and TV stations, and post offices. These variables are chosen because they constitute the major distribution media in society. Each variable constitutes a distribution system which contains different channels to disperse information. The growth of the distribution channels will be the reflection of the changes in the number of these channels within each system.

4.2.3 <u>Flow</u> : the average daily telephone conversations, pieces of matter handled in post offices, the number of periodicals, newspapers, radio and TV sets all transformed by Shannon's metric of the capacity (C) of a discrete channel which is defined as

$$C = \lim_{T \to} \frac{\log N(T)}{T}$$

where

N(T) = the number of allowed signals in a duration (T).

C = the channel capacity.

In a noiseless channel, the capacity (C) is equal to the amount of information (H) which means the most efficient flow of information through the channel. In the absence of any information about the flow of messages through the selected channels, noiseless flow is assumed and ($H = \log_2 N$) metric is applied.

4.3 Hypotheses

To investigate information explosion, a set of hypotheses for the stated variables is tested. The test applies to each individual point on each individual curve and is conducted in two steps:

1. computation of first and second derivatives of each point on each individual curve to determine the behavior of the function at each point;
2. frequencies from the result of computing these derivatives at the points on each individual curve are tabulated and used to evaluate the general growth behavior of each variable. Any point whose first and second derivatives are positive is considered explosive.

There is no defined measure to easily identify that one entire curve as explosive. However, in this dissertation, a curve is interpreted as being explosive if the change in information at more than fifty percent of the points are considered to be significantly explosive. The following hypotheses are stated in the null form.

A. Investigating the Information Production Explosion

The following null hypotheses are tested at each of the points on the fitted curves.

HA1 : At a specified point between 1870 and 1984, the change in the amount of information generated, as reflected by increase in copyrights, is not explosive.

HA2 : At a specified point between 1860 and 1984, the change in the amount of information generated, as reflected by increase in inventions, is not explosive.

HA3 : At a specified point between 1860 and 1984, the change in the amount of information generated, as reflected by increase in designs, is not explosive.

HA4 : At a specified point between 1872 and 1984, the change in the amount of information generated, as reflected by increase in doctorates, is not explosive.

HA5 : At a specified point between 1900 and 1984, the change in the amount of information generated, as reflected by increase in LC holdings, is not explosive.

B. Investigating the Information Distribution Explosion

The following null hypotheses are tested at each of the points on the fitted curves:

HB1 : At a specified point between 1921 and 1984, the change in the amount of information distributed, as reflected by increase in number of commercial AM radio stations, is not explosive.

HB2 : At a specified point between 1941 and 1984, the change in the amount of information distributed, as reflected by increase in number of commercial FM radio stations, is not explosive.

HB3 : At a specified point between 1940 and 1984, the change in the amount of information distributed, as reflected by increase in number of non commercial FM radio stations, is not explosive.

HB4 : At a specified point between 1941 and 1984, the change in the amount of information distributed, as reflected by increase in number of commercial TV stations, is not explosive.

HB5 : At a specified point between 1953 and 1984, the change in the amount of information distributed, as reflected by increase in number of non commercial TV stations, is not explosive.

HB6 : At a specified point between 1952 and 1984, the change in the amount of information distributed, as reflected by increase in number of cable TV systems, is not explosive.

HB7 : At a specified point between 1876 and 1984, the change in the amount of information distributed, as reflected by increase in the number of telephones, is not explosive.

HB8 : At a specified point between 1894 and 1984, the change in the amount of information distributed, as reflected by increase in miles of telephone wire, is not explosive.

HB9 : At a specified point between 1860 and 1984, the change in the amount of information distributed, as reflected by increase in the number of post offices, is not explosive.

C. Investigating the Information Flow Explosion

The following null hypotheses are tested at each of the points on the fitted curves:

HC1 : At a specified point between 1886 and 1984, the change in the amount of information flow, as reflected by increase in the number of pieces of matter handled in post offices, is not explosive.

HC2 : At a specified point between 1880 and 1985, the change in the amount of information flow, as reflected by increase in the number of books published, is not explosive.

HC3 : At a specified point between 1919 and 1984, the change in the amount of information flow, as reflected by increase in the number of periodicals, is not explosive.

HC4 : At a specified point between 1920 and 1984, the change in the amount of information flow, as reflected by increase in the number of newspapers, is not explosive.

HC5 : At a specified point between 1920 and 1984, the change in the amount of information flow, as reflected by increase in the number of total newspaper circulation, is not explosive.

HC6 : At a specified point between 1895 and 1984, the change in the amount of information flow, as reflected by increase in the average telephone conversation, is not explosive.

HC7 : At a specified point between 1922 and 1984, the change in the amount of information flow, as reflected by increase in the number of radio sets, is not explosive.

HC8 : At a specified point between 1946 and 1985, the change in the amount of information flow, as reflected by increase in the number of TV sets, is not explosive.

4.4 Data Collection and Analysis Procedure

The procedure designed to test the hypotheses of the study is arbitrarily classified into three steps. The first describes the process taken to collect, validate, and present the data used in the study. The second discusses the mathematical technique applied to identify the fitted function for each variable as a prerequisite to compute the derivatives. The third describes the process of interpreting the results of computations in order to compute the frequencies of the positive, negative, and undetermined derivatives as a final step before testing the hypotheses.

4.4.1 Data Collection and Presentation:

Data regarding the research variables were collected from government documents and classified into three categories: production, distribution, and flow. Appendixes A, B, and C fully present information production, distribution, and flow data and graphs. In Appendix A, information production data are presented before Shannon's log transformation in numerical units and after the log transformation in number of bits. The original data were adjusted for population growth and then transformed into bits using the same procedure used to transform the original data before adjustment by population.

Since each variable is analyzed separately, an adjustment scale suitable for each variable is chosen to generate scaled data used for analysis. The scales used to adjust the data by population growth were designed to produce a unit of each variable per 1,000,000 population except for Library of Congress holdings which produced a unit per 1000 population. The information production data in bits were used to carry on the computation process to test the hypotheses.

The same process was applied to information distribution variables data using suitable scales. The original data are presented in numerical units except for telephones which are presented in thousands. Data after adjustment by population growth is presented as a unit per 1,000,000 population except for telephones data which is presented as a unit per 10,000 population and miles of wire data which is presented as a unit per 1000 population. Since the log transformation does not apply to information distribution metrics, the original data before and after adjustment are tabulated and plotted against time (see Appendix B). It has been also used to carry on the computation to test the related hypotheses.

Information flow data are presented in the log forms before and after adjustment by population. The original data were collected in units for books, periodicals, newspapers, and in thousands for matter handled in post offices, newspaper circulation, average daily conversation, radio and TV sets. The adjusted data by population growth were (1) a unit per 1,000,000 population for books, periodicals, and newspapers; (2) a unit per 1000 population for newspaper circulation, radio and TV sets; (3) a unit per individual for matter handled in post offices and average daily conversation. The data are presented and plotted against time in Appendix C.

The fitted and the actual data are plotted against time in Appendic D to validate the technique used to carry on the computation process as described in the next section. The information generation and information flow data before the log transformation were used to carry on the computation but not used to test any hypotheses. The results are presented in Appendix E. The population data are used as a correction factor for all variables data. A pure population growth curve is presented in Appendix F along with population data in the USA.

4.4.2 Data Computation Process:

The final objective of data computation process was to compute the number of explosive points on each curve representing a specific variable. Review of the basics of mathematics reveals that the slope of a point on a curve is determined by the slope of the straight line tangent to the curve at that point. So, the slope changes from point to point as the curve changes steepness according to its specified function. To compute the first and second derivatives of a point on a curve, an approximation of the function of that curve must be defined either analytically or by a discrete set of data (Pachner, 1984, p. 2.1). So, the first step in the computation process is the approximation of a function suitable for each data set in order to be able to go through the given points and compute the prescribed derivatives.

There are many interpolation techniques to approximate a function $y(x)$ given by a discrete set of data such as Lagrange, Newton, Hermite, and cubic-spline interpolations. Unlike the interpolation techniques, least-squares method can be used to approximate a function not by going through the given set of all points on a specific curve but to reduce the total sum of squares of the deviation at all the points to a minimum. Pachner (5) states that the least-squares technique approximation can be applied successfully in problems where the data are the result of observations which have a degree of error (p. 2.15). Smith and Williams (10) support using least-squares technique, which is called "regression" or "curve fitting" in time-series analysis to fit the function Y = f(x) where Y represents the dependent variable over specified time intervals (x). The most commonly used forms to represent time series functions are the polynomial forms which can be expressed as:

$$Y = B_0 + B_1 x + B_2 x^2 + B_3 x^3 + \ldots\ldots\ldots\ldots B_n x^n$$

where n refers to the degree of the function.

The least-squares method was applied to fit the function of each data set. Generally, any observations made over a period of time are subject to secular, seasonal, cyclical, and erratic influences (1, p. 145). So, it was expected that all or some of these influences might affect the observations under investigation. Preliminary review of the plotted data, revealed that the graphs have cycles which indicate changes in the trends of the data over time. So, a special case of regression, cycle regression, was used to obtain the fitted function for each data set.

Shah (6) defines cycle regression analysis as "an algorithm that allows the estimation of sinusoidal or harmonic components in time series data" (p.7). The cycle regression algorithm, developed by Simmons and Williams (8, 9), Simmons and Simmons (7), and Mehta and Simmons (4), has different steps to determine the period (length of the cycle), amplitude (height of the peak), and the phase (distance from the zero value of the sine wave to time equal zero). The general strategy of the algorithm is to test for the significance of the extracted harmonic using an F-test. If the extracted harmonic is significant, then the process is repeated to extract an additional one; otherwise no more harmonics are extracted and the previously significant harmonics are obtained.

The cycle regression algorithm has been validated by being successfully using it to estimate the harmonics from time series data (e.g., 8, 9, 4). Shah (6) points out that the results obtained by using cycle regression algorithm were better than the periodogram technique given the same sets of parameters (p. 44). He also states that the cycle regression algorithm overcomes many of the the limitations of other techniques such as Fourier analysis and periodogram method which makes the cycle regression algorithm an accurate technique to handle time series data without a priori knowledge of the sinusoidal periods (4, p. 45).

In relation to the objective of the study, cycle regression algorithm was only used to extract the fitted function of each data set. The algorithm was then extended to obtain the cycle regression equation and compute the first and the second derivatives at each point on the fitted curve in terms of sines and cosines. Since the derivatives are computed for the fitted function, an error term should be considered where the actual dependent value of each variable at any point may differ from the corresponding fitted value. A common technique to deal with the error term is to use a confidence interval, generally in the form (1 - α)%, to obtain bound of error when using the fitted value instead of the actual value.

The concept of simultaneous confidence intervals was applied to determine if the value of any computed derivative at each point is statistically significant. The level of alpha chosen was .05. This means that for each derivative of a point on each curve, lower and upper bounds were computed in order to conclude that with ninety five percent confidence, the value of the derivative falls between the computed lower and upper bounds. Bowerman, O'Connell, and Dickey (2) explain what simultaneous confidence intervals concept means:

> We say that a sample in the population of all possible samples is simultaneously successful for all the linear combinations of regression parameters in a set of linear combinations if all the 100(1 - α)% confidence intervals for the linear combinations in the set computed using the sample contain their respective linear combinations (p. 392).

The simultaneous confidence interval procedure will allow for the construction of (100 - α)% confidence intervals for the first and second derivatives at each time value on a population curve such that the overall confidence level for all the confidence intervals taken simulatanesouly is still (1 - α)%. The Scheffe simultaneous confidence formula is*

$$[\lambda' b-\sqrt{qF^{(q,n-k)}_{[\alpha]}}\, s\sqrt{\lambda'(XX)^{-1}\lambda},\lambda' b+\sqrt{qF^{(q,n-k)}_{[\alpha]}}\, s\sqrt{\lambda'(XX)^{-1}\lambda}\,]$$

where

1. $F(q,n-k)_{[\alpha]}$ = the point on the scale of the F-distribution with q and (n-k) degrees of freedom so that the area under the curve to the right of that point is α.
2. b = a column vector containing the least squares estimates b_0, b_1, b_2,.... ,b_p.
3. s = the standard error.
4. n = the number of observed values of the dependent variable.
5. k = the number of parameters in the regression model.
6. q = the number of the regression parameters B_0,B_1,..B_p that are involved nontrivially in at least one of the linear combinations for which simultaneous intervals are being computed.

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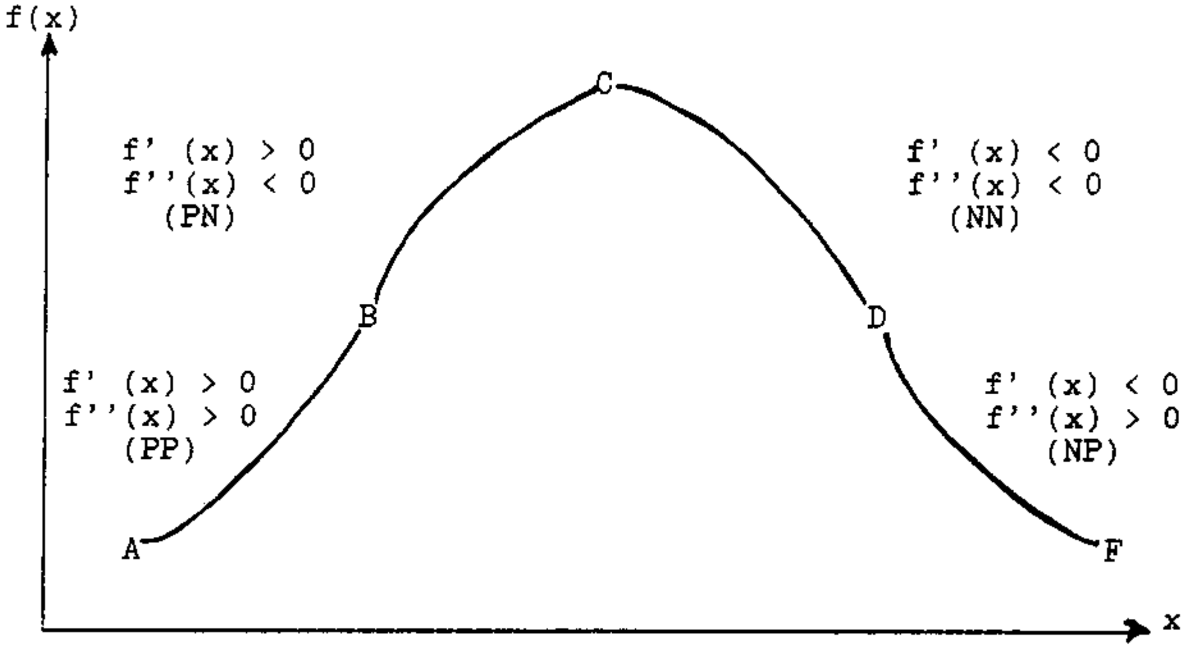
* The formula and the interpretations of its components have been adapted from Bowerman, O'Connell, and Dicky (2).

The cycle regression algorithm was modified and extended to compute Scheffe confidence intervals for the first and second derivatives and to compute the frequencies of each class of significant and insignificant derivatives.

4.4.3 Results Interpretation and Frequency Computations

There are several combinations of positive, zero, or negative first and second derivatives each of which describes a specific behavior of a function at a point. In general, as shown in Figure 10, the function f(x) changes its behavior as it moves from left to right. Starting from point A, the function increases at increasing rate until it reaches the inflection point (B); then the rate of increase decreases until it reaches a maximum point (C). Between C and D, the function decreases rapidly where the magnitude of the decreasing rate is getting larger. After the inflection point (D), the magnitude of the rate gets smaller until it reaches a minimum point (F) and the function continues.

Fig. 10--General Form of Function Behavior



Expressing these different behaviors in terms of derivatives, both derivatives are positive at any point from A to B, while the first is positive and the second is negative at any point from B to C. Both derivatives are negative from C to D, while the first is negative and the second is positive at any point from D to F. The second derivative at any inflection point is zero.

In relation to the study, A confidence interval is computed for each derivative. If the lower and upper bounds of a derivative are positive, it is considered positive. On the other hand, the derivative is negative if both bounds are negative. If the lower bound is negative and the upper bound is positive, it can not be statistically concluded that the derivative is positive or negative. In other wards, the confidence interval will determine whether the derivative is significant positive or negative.

Based on the above rules, nine possibilities (3^2) were expected:

PP = first derivative is positive and the second is positive.
PN = first derivative is positive and the second is negative.
PU = first derivative is positive and the second is undetermined
NP = first derivative is negative and the second is positive.
NN = first derivative is negative and the second is negative.
NU = first derivative is negative and the second is undetermined.
UP = first derivative is undetermined and the second is positive.
UN = first derivative is undetermined and the second is negative.
UU = first derivative is undetermined and the second is undetermined.

Expressing the derivatives of a function in terms of growth behaviors, there are two types of growth behavior: (1) increase and (2) decrease. Increasing function is where the first derivative is positive while decreasing function is where the same derivative is negative. Within the increasing function, the highest increase is where the second derivative is also positive followed by relatively less increase where the second derivative is either undetermined or negative.

Although the analyses are focused on the explosive increase (PP), total count of all the frequencies of each possibilities was done to facilitate general understanding of the whole behavior of the associated variable. But the last three categories (UP, UN, UU) were combined in one category in the frequency tables presented in the next chapter for simplicity. Once the first derivative is not statistically significant at a specific point, that point is excluded from analysis. It is called Not Significant (NS) in the frequency tables. The process was repeated for each production, distribution, and flow variable at four different levels to produce the frequency tables presented in the next chapter.

4.5 Basic Assumptions

The study is based on the following assumptions:

1. the indicators selected to reflect the amount of information generated, distributed, and flow represent the relevant indicators;
2. all pieces of information have equal chances to be generated, distributed, and flow through the communication systems;
3. noise and redundancy in information production,

distribution, and flow systems do not affect the measurement of amount of information at the gross level. So, they are ignored in computing the amount of information.

4.6 Limitations of the Study

The limitations of the study center around five factors:

1. the scope of the study is geographically limited to the USA;
2. the time span of the study covers a period from 1860 to the present;
3. the variables taken as indicators of amount of information production, distribution, and flow are not exhaustive;
4. the assumption that no information is available about the probability distribution of information growth somehow does not reflect the real behavior of information growth systems. But because of the complexities and interdependences of the system at social level, it is nearly impossible but to assume an unknown probability distribution. This assumption leads to the use of Shannon's metric $H = \log_2 N$ which assumes equal chance for each message of information to be produced and distributed.
5. There are noise and redundancy in the production and distribution of information in society. These factors

are ignored because of the necessity to study these factors at the very low levels of each subsystem of information growth. The main objective of this study, however, is to provide a gross measure of information growth in order to characterize its behavior.

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CHAPTER V

RESULTS AND ANALYSIS

Following the procedure explained in the previous chapter, the results obtained are classified and tabulated to test the three groups of hypotheses stated in the study. All the results related to a specific variable are included in one table to facilitate testing the related hypothesis.

5.1 Test of the Information Production Hypotheses:

To examine the hypotheses HA1, HA2, HA3, HA4, and HA5, the following tabular results are presented.

TABLE II

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF COPYRIGHTS AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	35	30.4	19	16.5	10	23.3	0	0
PN	36	31.3	27	23.5	17	39.5	0	0
PU	44	38.3	21	18.3	16	37.2	0	0
NP	0	0	0	0	0	0	0	0
NN	0	0	0	0	0	0	0	0
NU	0	0	0	0	0	0	0	0
NS	0	0	48	41.7	0	0	43	100
TOTAL	115	100	115	100	43	100	43	100

* Data are available since 1870.

TABLE III

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF INVENTIONS AT ALPHA = .05

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	20	16.0	2	1.6	0	0	0	0
PN	41	32.8	1	.8	0	0	0	0
PU	22	17.6	19	15.2	3	7.0	5	11.6
NP	5	4.0	0	0	0	0	0	0
NN	5	4.0	0	0	0	0	0	0
NU	5	4.0	15	12.0	2	4.7	4	9.3
NS	27	21.6	88	68.4	38	88.3	34	79.1
TOTAL	125	100	115	100	43	100	43	100

TABLE IV

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF DESIGNS AT ALPHA = .05

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	19	15.2	13	10.4	1	2.3	2	4.7
PN	14	11.2	8	6.4	1	2.3	1	2.3
PU	23	18.4	17	13.6	8	18.6	6	14.0
NP	5	4.0	6	4.8	1	2.3	3	7.0
NN	5	4.0	8	6.4	2	4.7	5	11.6
NU	7	5.6	17	13.6	5	11.6	6	14.0
NS	52	41.6	56	44.0	24	58.1	20	46.6
TOTAL	125	100	125	100	43	100	43	100

TABLE V

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF DOCTORATES AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	51	45.5	37	33.0	12	28.6	5	11.9
PN	45	40.2	38	33.9	9	21.4	3	7.1
PU	9	8.0	7	6.3	4	9.5	14	33.3
NP	0	0	0	0	0	0	2	4.8
NN	0	0	0	0	0	0	0	0
NU	0	0	0	0	3	7.1	3	7.1
NS	7	6.3	30	25.7	14	33.3	18	35.7
TOTAL	112	100	112	100	42	100	42	100

* Data are available from 1872.

TABLE VI

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF L.C. HOLDINGS AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	34	40.0	21	24.7	14	32.6	11	25.6
PN	39	45.9	22	25.9	12	27.9	6	14.0
PU	12	14.1	25	29.4	8	18.6	8	18.6
NP	0	0	0	0	0	0	0	0
NN	0	0	0	0	0	0	0	0
NU	0	0	0	0	0	0	0	0
NS	0	0	17	20.0	9	20.9	18	41.9
TOTAL	85	100	85	100	43	100	43	100

* Data are available from 1900.

The results in Table II show that only 30.4% of the points at the curve have had explosive increases. Recalling that the criterion chosen for the curve to be explosive is to have more than fifty percent explosive points, the study concludes that there has not been an explosive increase in the amount of information generated as indicated by the growth of copyrights issued. As expected, the results show that the impact of population growth makes the degree of explosiveness relatively less. The percentage of explosiveness as well as the total percentage of increase (explosive and unexplosive) has gone down from 30.4 to 16.5 percent and from 100 to 58.3 percent respectively.

Contrary to the common belief that the information explosion is a recent phenomenon, the analysis shows that the degree of explosiveness in the shorter time span was less than in the longer time span of the study. Furthermore, the impact of population growth was to cause the computations of all the derivatives to be statistically insignificant, which concludes that there has not been an information explosion in all cases of analysis.

As shown in Table III, the analysis shows that there has not been an information explosion. Only 16.0 percent of the points was explosive increases. Furthermore, 12.0 percent of the points was decreasing in which 4 percent had explosive decreases. The impact of population growth did not contradict the general expectation of making the growth of any phenomenon less explosive. The degree of explosiveness was decreased from 16.0 to 1.6 percent. In the shorter time span, the analysis shows that there has not been any explosive increase at any point which concludes that there has not been an information explosion in the amount of information generated as indicated by the growth of inventions at any level of analysis.

Table IV indicates that the amount of information generated as indicated by the growth of designs was only 15.2 percent explosive. The total percentage of information increase was only 45 percent leaving 56 percent of the points to have information decrease or undetermined growth. The impact of population growth was in the same general trend but the magnitude of the decrease was relatively less compared to the magnitude of decrease in the other production metrics.

Based on the results in Table V, only 45.5 percent of the points was explosive decreasing to 33 percent as a result of the impact of population growth. The shorter time span has had only 28.6 percent explosive increase which has been decreased to 11.9 percent because of the impact of population growth. So, there has not been an information explosion in the amount of information generated as indicated by the growth of doctorates.

Results in Table VI indicate that even all the points have had increase in the amount of information generated as indicated by the growth of the Library of Congress holdings, only 40 percent of the growth was explosive. The patterns detected for the impact of population growth and the shorter time span of the study still hold with similar magnitudes.

5.2: **Test of the Information Distribution Hypotheses**

To examine hypotheses HB1 through HB9, the following nine tables are prepared to present the results required for examining the stated hypotheses. Discussions of the results follow the frequency tables.

TABLE VII

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF AM RADIO STATIONS AT ALPHA = .05 *

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	28	44.4	23	36.5	0	0	0	0
PN	31	49.2	18	28.6	34	81.0	23	54.0
PU	4	6.3	2	3.2	8	19.0	6	14.3
NP	0	0	0	0	0	0	0	0
NN	0	0	0	0	0	0	10	23.8
NU	0	0	0	0	0	0	0	0
NS	0	0	20	31.7	0	0	3	7.1
TOTAL	63	100	63	100	42	100	42	100

* Data are available since 1921.

TABLE VIII

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF COMM FM RADIO STATIONS AT ALPHA = .05 *

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP					24	55.8	9	20.9
PN					0	0	19	44.2
PU					14	32.6	3	7.0
NP					0	0	0	0
NN					0	0	0	0
NU					0	0	0	0
NS					5	11.3	12	28.0
TOTAL					43	100	43	100

* Data are available since 1941.

TABLE IX

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF NON COMM FM RADIO STATIONS AT ALPHA = .05 *

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP					32	72.7	31	70.5
PN					8	18.2	8	18.2
PU					4	9.1	5	11.4
NP					0	0	0	0
NN					0	0	0	0
NU					0	0	0	0
NS					0	0	0	0
TOTAL					44	100	44	100

* Data are available since 1940.

TABLE X

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF COMMERCIAL TV STATIONS AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 - 1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP					21	48.8	18	41.9
PN					10	23.3	9	20.9
PU					5	11.6	3	7.0
NP					0	0	0	0
NN					0	0	0	0
NU					0	0	0	0
NS					7	16.4	13	28.0
TOTAL					43	100	43	100

* Data are available since 1941.

TABLE XI

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF NON COMMERCIAL TV STATIONS AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP					15	48.4	14	45.2
PN					14	45.2	10	32.3
PU					2	6.5	7	22.6
NP					0	0	0	0
NN					0	0	0	0
NU					0	0	0	0
NS					0	0	0	0
TOTAL					31	100	31	100

* Data are available since 1953.

TABLE XII

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF CABLE TV SYSTEMS AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP					18	54.5	11	33.3
PN					0	0	12	36.4
PU					14	42.4	10	30.4
NP					0	0	0	0
NN					0	0	0	0
NU					0	0	0	0
NS					1	3.0	0	0
TOTAL					33	100	33	100

* Data are available since 1951.

TABLE XIII

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF TELEPHONES AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	28	64.2	51	48.1	40	100	29	72.5
PN	26	24.5	27	25.5	0	0	0	0
PU	0	0	17	16.0	0	0	11	27.5
NP	0	0	0	0	0	0	0	0
NN	0	0	0	0	0	0	0	0
NU	0	0	0	0	0	0	0	0
NS	12	11.3	11	10.4	0	0	0	0
TOTAL	106	100	106	100	40	100	40	100

* Data are available since 1876.

TABLE XIV

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF MILES OF WIRE AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	52	57.8	55	61.1	40	95.2	32	76.2
PN	18	20.0	21	23.3	0	0	0	0
PU	0	0	8	8.9	0	0	7	16.7
NP	2	3.3	0	0	0	0	0	0
NN	3	4.4	0	0	0	0	0	0
NU	2	3.3	0	0	0	0	0	0
NS	10	11.2	6	6.6	2	4.8	3	7.1
TOTAL	90	100	90	100	42	100	42	100

* Data are available since 1894.

TABLE XV

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF POST OFFICES AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	24	19.2	9	7.2	0	0	0	0
PN	17	13.6	11	8.8	0	0	0	0
PU	1	.8	1	.8	0	0	0	0
NP	0	29.6	49	39.2	13	30.2	16	37.2
NN	0	24.0	37	29.6	9	20.9	8	18.6
NU	0	4.0	6	4.8	14	32.6	16	37.2
NS	11	8.8	12	9.6	7	15.4	3	7.0
TOTAL	125	100	125	100	43	100	43	100

Based on the results in Table VII, the study concludes that there has not been an information explosion as indicated by the growth of commercial AM radio stations. Only 44.4 percent of the points on the curve were explosive increase. The impact of population growth was to decrease the degree of explosiveness to 36.5 percent. As for the shorter time span of the study, the analysis shows that the curve as a whole maintained 100 percent increase but no explosive increase at any point. The impact of population growth was so severe to the point of having 23.8 percent explosive decrease in the shorter time span of the study. So, examining hypothesis HB1 reveals that there has not been an explosion in the amount of information distribution as indicated by the growth of AM radio stations at all levels of the analysis taken.

As shown in Table VIII, there are no results available for the longer time span of the study because the data is available only since 1941. Based on the results available, the study concludes that there has been an information explosion as indicated by the growth of commercial FM radio stations. The percentage of explosive points was 55.8 which means that the criterion of curve explosiveness was met. The impact of population growth was to decrease the degree of explosiveness below the fifty percent line. So, it can be concluded that there has been an explosion in the amount of information distribution as indicated by the absolute growth of commercial FM radio stations but not as indicated by the relative growth.

The results in Table IX indicate that there has been an information explosion measured by the growth of non commercial FM radio stations. The impact of population growth has decreased the degree of explosiveness but it is still above the fifty percent which means that the study rejects the hypothesis in all cases of analysis. So, a conclusion can be drawn that there has been an explosion in the amount of information distribution as indicated by the absolute or relative growth of non commercial FM radio stations.

Regarding the growth of commercial TV stations, Table X shows that the study's conclusion is that there has not been an information explosion. But it should be noticed that the percentage of explosiveness was very close to the fifty percent criterion. Furthermore, taking the time span of the study,the number of observations used, and the level of alpha used into consideration, it can be concluded that one more explosive point would have increased the percentage of explosiveness to more than fifty percent. But the impact of population growth has, however, decreased the percentage to be definitely not explosive. As a result of this discussion and the data presented in Table X, it can be concluded that there has not been an explosion in the amount of information distribution as indicated by the absolute or relative growth of commercial TV stations. The degree of explosiveness was, however, very close to meet the criterion of explosiveness.

Table XI presents results very similar to the results in Table X. Only 48.4 percent of the points were explosive which concludes there has not been an information explosion measured by the growth of non commercial TV stations. The impact of population growth has decreased the percentage to 45.2 but 100 percent increase (explosive and unexplosive) was maintained. In conclusion, examining hypothesis HB5 reveals that there has not been an explosion in the amount of information distribution as indicated by the absolute or relative growth of non commercial TV stations. The percentage of explosive points was, however, very close to meet the criterion of explosiveness for the absolute growth.

Based on the results presented in Table XII, it can be concluded that there has been an information explosion measured by the growth of cable TV systems. The degree of explosiveness has, however, decreased from 54.5 to 33.3 percent as a result of the impact of population growth. So, examining hypothesis HB6 reveals that there has been an explosion in the amount of information distribution as indicated by the absolute growth of cable TV systems but not as indicated by the relative growth.

As shown in Table XIII, examining hypothesis HB7 reveals that there has been an information explosion. The degree of explosiveness was 64.2 percent decreasing to 48.1 percent as a result of the impact of population growth. At .10 alpha, the degree of explosiveness of the relative growth was 50 percent which rejects the hypothesis at that level of alpha. The results of the shorter time span of the study was in total agreement with the common expectations that information explosion is a recent phenomenon. The curve was 100 percent explosive for the absolute growth and 72.5 percent explosive for the relative growth. So, examining hypothesis HB7 reveals that there has been an explosion in the amount of information distribution as indicated by the absolute or relative growth of telephones. The degree of explosiveness was at every individual point on the curve for the shorter time span of the study.

Similar to the results exhibited in Table XIII, Table XIV indicates that the study concludes that there has been an information explosion measured by the growth of miles of telephone wire. In all cases of analysis, the curve has met the criterion of explosiveness at .05 alpha level. The only observation contrary to the general expectation is that the impact of population growth has slightly increased the degree of explosiveness for the absolute growth. It seems that the impact of population growth has resulted in this case in a fitted curve which changed the relative increases of the points so the curve was explosive at points which were not on the curve of the absolute growth. In conclusion, examining hypothesis HB8 reveals that there has been an explosion in the amount of information distribution as indicated by the absolute or relative growth of miles of wire. The degree of explosiveness in the shorter time span of the study was close to 100 percent which exhibited the second highest degree of explosiveness.

As for hypothesis HB9, Table XV indicates that the study concludes that there has not been an information explosion measured by the growth post offices. The degree of explosive decrease (24%) was even higher than the degree of explosive increase (19.2%). The results also show that in the shorter time span of the study, there has not been any increase compared to 20.9 percent explosive decrease in this period which should trigger questions to investigate certain factors behind these results.

5.3: Test of the Information Flow Hypotheses

The hypotheses HC1 through HC8 are designed to examine the information flow explosion. The results needed to examine these hypotheses are presented in the next eight tables followed by analyses of these results in the light of examining the related hypotheses.

TABLE XVI

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES CLASSIFICATION OF MATTER HANDLED IN POST OFFICES AT ALPHA = .05 *

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	50	50.5	38	38.4	15	34.9	0	0
PN	38	38.4	31	31.3	21	38.8	27	62.8
PU	6	6.1	4	4.0	7	16.3	9	20.9
NP	0	0	7	7.0	0	0	0	0
NN	0	0	6	6.0	0	0	0	0
NU	0	0	2	2.0	0	0	0	0
NS	5	5.0	11	11.0	0	0	7	16.3
TOTAL	99	100	99	100	43	100	43	100

* Data are available since 1886.

TABLE XVII

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF BOOKS AT ALPHA = .05 *

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	24	23.5	19	18.8	15	37.5	11	27.5
PN	27	26.5	23	22.5	14	35.0	10	25.0
PU	21	20.6	10	9.8	11	27.5	4	10.0
NP	4	3.9	10	9.8	0	0	0	0
NN	3	2.9	9	8.8	0	0	0	0
NU	3	2.9	6	5.8	0	0	0	0
NS	20	19.7	25	22.5	0	0	24	37.5
TOTAL	102	100	102	100	40	100	40	100

* Data are available since 1880.

TABLE XVIII

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF PERIODICALS AT ALPHA = .05 *

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	00	0	6	9.1	8	41.9	10	23.3
PN	25	37.9	10	15.2	9	20.9	5	11.6
PU	33	50.0	11	16.7	4	9.3	2	4.7
NP	0	0	2	3.0	0	0	12	27.9
NN	0	0	8	12.1	0	0	6	14.0
NU	0	0	12	18.2	0	0	2	4.7
NS	08	0	17	26.2	12	28.0	6	14.0
TOTAL	66	100	66	100	43	100	43	100

* Data are available since 1919.

TABLE XIX

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF NEWSPAPERS AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	0	0	0	0	0	0	0	0
PN	0	0	0	0	0	0	0	0
PU	3	4.6	0	0	6	14.0	0	0
NP	7	10.8	15	26.2	0	0	9	20.9
NN	7	10.8	26	38.5	3	7.0	4	9.3
NU	15	23.1	24	35.4	8	18.6	25	58.1
NS	33	49.9	0	0	26	60.5	5	11.6
TOTAL	65	100	65	100	43	100	43	100

* data are available since 1920.

TABLE XX

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF NEWSPAPER CIRCULATION AT ALPHA = .05 *

Classifications	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	2	3.1	8	12.3	0	0	0	0
PN	33	50.8	10	15.4	25	58.1	15	34.9
PU	17	26.1	5	7.7	6	14.0	0	0
NP	0	0	6	9.2	0	0	0	0
NN	0	0	22	32.2	0	0	20	0
NU	0	0	4	6.2	3	7.0	7	16.3
NS	13	20.0	14	17.0	9	20.9	1	2.3
TOTAL	65	100	65	100	43	100	43	100

* Data are available since 1920.

TABLE XXI

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES CLASSIFICATION OF AVERAGE DAILY PHONE CONVERSATION AT ALPHA = .05 *

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	39	43.3	25	27.8	16	37.2	21	48.8
PN	46	51.1	35	38.9	14	32.6	12	27.9
PU	5	5.6	9	10.0	13	30.2	10	23.3
NP	0	0	0	0	0	0	0	0
NN	0	0	0	0	0	0	0	0
NU	0	0	0	0	0	0	0	0
NS	0	0	21	23.3	0	0	0	0
TOTAL	90	100	90	100	43	100	43	100

* Data are available since 1895.

TABLE XXII

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES CLASSIFICATION OF RADIO SETS AT ALPHA = .05 *

Classifi-cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP	21	33.3	19	30.2	2	4.7	0	0
PN	34	54.0	31	49.2	0	0	0	0
PU	8	12.7	2	3.2	12	27.9	2	4.7
NP	0	0	0	0	0	0	0	0
NN	0	0	0	0	0	0	0	0
NU	0	0	0	0	9	20.9	0	0
NS	0	0	3	17.5	20	48.5	41	95.3
TOTAL	63	100	63	100	43	100	43	100

* Data are available since 1922.

TABLE XXIII

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES

CLASSIFICATION OF TV SETS AT ALPHA = .05 *

Classifi- cations	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	Number	%	Number	%	Number	%	Number	%
PP					0	0	0	0
PN					13	33.3	7	17.9
PU					12	30.8	9	23.1
NP					0	0	0	0
NN					0	0	0	0
NU					0	0	0	0
NS					14	35.9	23	59.0
TOTAL					39	100	39	100

* Data are available since 1946.

From the results reported in Table XVI, the study concludes that there has not been an information explosion. The impact of population growth has, however, decreased the degree of explosiveness to the point of not meeting the criterion of curve explosiveness. Furthermore, contrary to common belief, the criterion of explosiveness has not been met in the shorter time span of the study. So, examining hypothesis HC1 reveals that there has been an explosion in the amount of information as indicated by the absolute growth of matter handled in post offices but not as indicated by the relative growth. As for the shorter time span of the study, the degree of explosiveness was much less.

Based on the information exhibited in Table XVII which is designed to examine HC2, only 23.5 percent of the points were explosive decreasing to 18.8 percent as a result of the impact of population growth. For the shorter time span of the study, the results are in agreement with the common expectation even the criterion of curve explosiveness has not been met. The degrees of explosiveness have increased from 23.5 to 37.5 percent and from 18.8 to 27.5 percent as indicated by the absolute and relative growth of books. Furthermore, the results indicate that the curve has maintained 100 percent increase as indicated by the absolute growth which supports the common assumption that information explosion is a recent phenomenon.

The information reported on Table XVIII strongly support the previous claim about information explosion. The degree of explosiveness has gone up from zero to 41.9 percent for the shorter time span of the study. Despite this fact, the study concludes that there has not been an information explosion at all levels of analysis because the degree of curve explosiveness has not been met. So, examining hypothesis HC3 reveals that there has not been an explosion in the amount of information flow as indicated by the growth of periodicals.

The results reported in Table XIX indicate that the study concludes that there has not been an information explosion measured by the growth of newspapers. Furthermore, the results clearly reveal that the behavior of the function was 100 percent decreasing at all levels of analysis. So, examining hypothesis HC4 reveals that there has not been an explosion in the amount of information flow as indicated by the growth of newspapers in any case of analysis.

Based on the results reported in Table XX, the study concludes that there has not been an information explosion measured by the newspaperes circulation. Although the degree of explosiveness increased from 3.1 to 12.3 percent as a result of the impact of population growth, the total percentage of increase has decreased from 80 to 35.4 percent which comply with the general expectation of the impact of population growth. Additionally, the percentage of explosive decrease has gone up from zero to 32.2 percent which clearly supports the previous conclusion. So, examining hypothesis HC5 reveals that there has not been an explosion in the amount of information flow as indicated by newspaper circulation at all levels of analysis.

Based on the information reported in Table XXI, the criterion of curve explosiveness has not been met. So, examining HC6, reveals that there has not been an information explosion as indicated by the average daily telephone conversation at any level of analysis. But the degrees of explosiveness were relatively close to the fifty percent line and the curves maintained 100 percent increases in the amount of information flow which should be kept in mind even if the conclusion is that there has not been an information explosion.

Based on the information reported in Table XXII, the study concludes that there has not been an information explosion as a result of examining HC7. Contrary to the common belief that information explosion is recent, the results show that degree of explosiveness was much less in the shorter time span of the study. So, examining hypothesis HC7 reveals that there has not been an explosion in the amount of information flow as indicated by the growth of radio sets.

As shown on Table XXIII, examining hypothesis HC8 shows that there has not been an information explosion. Furthermore, the degree of explosiveness was zero in both cases of analysis which concludes that there has not been an explosion in the amount of information flow as indicated by the growth of TV sets.

The previous analyses of results and hypotheses examination are used to reach a general conclusion of the study in the next chapter. The implications as well as suggestions for future research are also discussed.

CHAPTER VI

CONCLUSIONS

6.1 Review

The main problem motivating this research is that there has not been any studies which quantitatively test the common claim that there has been an information explosion. Departing from past efforts (1, 2) which consider information explosion as a proven fact and study its impact on aspects such as educational institutions or manpower force, this study concentrated on the development of quantitative parameters to test if there has been an information explosion and, if so, how it might be described.

The specific task chosen for the study required the development of a taxonomy of information in three dimensional contexts, the selection of the most common production, distribution and flow parameters to be surrogates for the measurement of each dimension, the adoption of Shannon's log transformation to be used in the production and flow dimensions, and the development and application of workable definition of explosiveness.

Three groups of hypotheses were developed to test if there has been an explosion in the generation, distribution, or flow of information in a time span covering a period from

1860 to 1984. Hypotheses testing has also extended to investigate the impact of population growth on the production, distribution, and flow of information. Data related to a shorter time span covering only a period since 1942 to 1984 was used to test if the information explosion is a recent phenomenon. The data was collected from government documents, tabulated, and graphed to get the preliminary assessment of the functions' behaviors. The methodology to carry out the computation process was developed and used to produce the results required to test the stated hypotheses.

6.2 Discussion of Results

It might be useful to summarize the hypotheses examination results presented in the previous chapter to facilitate the discussion.

TABLE XXIV

SUMMARY OF INFORMATION PRODUCTION HYPOTHESES TEST

	No Adjustment 1860 - 1984	Adjustment 1860 -1984	No Adjustment 1942-1984	Adjustment 1942-1984
Copyrights HA1	Not explosive	Not explosive	Not explosive	Not explosive
Inventions HA2	Not explosive	Not explosive	Not explosive	Not explosive
Designs HA3	Not explosive	Not explosive	Not explosive	Not explosive
Doctorates HA4	Not explosive	Not explosive	Not explosive	Not explosive
LC holdings HA5	Not explosive	Not explosive	Not explosive	Not explosive

TABLE XXV

SUMMARY OF INFORMATION DISTRIBUTION HYPOTHESES TEST

	No Adjustment 1860 - 1984	Adjustment 1860- 1984	No Adjustment 1942-1984	Adjustment 1942-1984
AM Radio Stations HB1	Not explosive	Not explosive	Not explosive	Not explosive
FM Radio Stations HB2			Explosive	Not explosive
Non Comm FM Stations HB3			Explosive	Explosive
TV Stations HB4			Explosive at .10 alpha level	Not explosive
Non Comm TV Statio. HB5			Not explosive	Not explosive
Cable TV Systems HB6			Explosive	Not Explosive
Phones HB7	Explosive	Explosive at .10 alpha level	Explosive	Explosive
Miles of Wire HB8	Explosive	Explosive	Explosive	Explosive
Post Offices HB9	Not explosive	Not explosive	Not explosive	Not explosive

TABLE XXVI

SUMMARY OF INFORMATION FLOW HYPOTHESES TEST

	No Adjustment 1860 - 1984	Adjustment 1860- 1984	No Adjustment 1942- 1984	Adjustment 1942 -1984
Matter Handled in P.Offices HC1	Explosive	Not explosive	Not explosive	Not explosive
Books HC2	Not explosive	Not explosive	Not explosive	Not explosive
Period-icals HC3	Not explosive	Not explosive	Not explosive	Not explosive
News-papers HC4	Not explosive	Not explosive	Not explosive	Not explosive
Newspapers Circula-tions--HC5	Not explosive	Not explosive	Not explosive	Not explosive
Avg.Daily Conversa-tions HC6	Not explosive	Not explosive	Not explosive	Explosive at .10 level
Radio Sets HC7	Not explosive	Not explosive	Not explosive	Not explosive
TV Sets HC8			Not explosive	Not explosive

As shown on the summary tables of hypotheses examination, the information distribution is first in rejection rate of hypotheses followed by the information flow group and then the information generation group. For the first group, the study shows that there has been an explosion in the distribution of information as measured by most of the parameters used in the study. There were only two variables have been explosive in the information flow group. So, a conclusion can be reached that there has not been an explosion in information flow in general as indicated by failing to meet the criterion of explosiveness in most of the hypotheses. There was no hypothesis meeting the criterion of explosiveness in the information generation group which concludes that there has not been an explosion at any degree in the production of information.

The above results are based on the formal hypotheses examination based on the criterion applied in the study. Because there is no mathematical criterion for curve explosiveness, an arbitrary criterion was developed by classifying the curves into two groups: (1) explosive if more than fifty percent of the points on the curve was explosive; (2) unexplosive if less than fifty percent was explosive. This criterion was necessary to be able to examine the stated hypotheses but it does not really reflect the degrees of explosiveness of the phenomena under investigation.

Consequently, in addition to the previous analyses, it is very reasonable to assume a continuum of possible results under such a dichotomy which was developed to test the hypotheses. To explain the point further, a curve which has 48 percent explosive points is classified as totally unexplosive curve while curve with 50.1 percent explosive points is considered totally explosive, which does not really reflect the true behavior of both phenomena. As a matter of fact, a curve with 50.1 percent explosive points is closer to a curve with 48 percent explosive points than to a curve with 90 percent explosive points; but it is categorized as explosive curve.

To overcome this problem, ranking of the variables based on the degree of explosiveness is presented to facilitate looking at the results as a continuum of possible results to reflect the relative degree of explosiveness. The higher the percentage of explosive points, the higher the degree of explosiveness. Furthermore, if the rest of the points on a curve were increasing, but not at an explosive rate, it may be concluded that the degree of explosiveness is higher than if the rest of the points were decreasing.

As stated in Chapter IV, there was no single hypothesis to test the information explosion in general and the only case to reach such conclusion is to have all of the hypotheses meeting or not meeting the rule of thumb of curve explosiveness. But ranking the variables based on their relative degree of explosiveness helps to reach a conclusion as regard to which dimension of information was more explosive than the others. The following tables represent the ranking of the groups of variables based on two types of increases: (A) refers to the percentage of explosive points (PP); and (B) refers to the percentage of increasing points but not at an explosive rate (PU + PN).

TABLE XXVII

RANKING OF INFORMATION DISTRIBUTION VARIABLES

	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	A	B	A	B	A	B	A	B
Telephones	64.2	24.5	48.1	41.5	100.0	0.0	72.5	27.5
Miles of Wire	57.8	20.0	61.1	29.1	95.2	0.0	76.2	16.7
Non Comm. FM Stations					72.7	27.3	70.5	29.5
Comm. FM Stations					55.8	32.6	20.9	51.2
Cable TV Systems					54.5	42.4	33.3	66.8
Comm. TV Stations					48.8	34.9	41.9	27.9
Non Comm. TV Stations					48.4	51.6	45.2	54.8
AM Radio Stations	44.4	55.6	36.5	31.8	0.0	100.0	0.0	68.3
P. Offices	19.2	14.4	7.2	9.6	0.0	0.0	0.0	0.0

TABLE XXVIII

RANKING OF INFORMATION FLOW VARIABLES

	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No Adjustment 1942-1984		Adjustment 1942-1984	
	A	B	A	B	A	B	A	B
Matter Handles in Post Offices	50.5	44.6	38.4	35.3	34.9	65.1	0.0	83.7
Avg.Daily Conversa-tions	43.3	56.9	27.8	48.9	37.2	62.8	48.8*	51.2
Radio Sets	33.3	62.7	30.2	52.4	4.7	27.9	0.0	4.7
Books	23.5	47.1	18.8	32.3	37.5	62.5	27.5	25.0
Newspapers Circula-tions	13.1	66.9	12.3	23.1	0.0	72.1	0.0	34.9
Period-icals	0.0	100.0	9.1	31.9	41.9	30.2	23.3	16.3
Tv Sets					0.0	64.1	0.0	41.0
Newspapers	0.0	4.6	0.0	0.0	0.0	14.0	0.0	0.0

* At .10 alpha level = 51.1 percent

TABLE XXIX

RANKING OF INFORMATION PRODUCTION VARIABLES

	No Adjustment 1860 - 1984		Adjustment 1860 -1984		No adjustment 1942-1984		Adjustment 1942-1984	
	A	B	A	B	A	B	A	B
Doctorates	45.5	48.2	33.0	40.2	28.6	30.9	11.9	40.4
LC Holding	40.0	60.0	24.7	55.3	32.7	46.5	25.6	32.6
Copyrights	30.4	70.6	16.5	41.8	23.3	76.7	0.0	0.0
Inventions	16.0	50.4	1.6	16.0	0.0	7.0	0.0	11.6
Designs	15.2	29.6	10.4	20.0	2.3	20.9	4.7	16.3

The above ranking tables support to the formal hypotheses examination that the highest degree of explosiveness at any level of analysis was in the distribution of information. Furthermore, the percentage of total increase (explosive and unexplosive) was also in the same area which supports the general conclusion that there has been an explosion in the distribution of information as indicated by the growth of most of the variables investigated in the study.

The second highest degree of explosiveness was in the velocity of information. There was only, however, one variable (matter handled in post offices) which passed the criterion of explosiveness. The second highest degree of growth (explosive and unexplosive) was also detected in the same area which showed consistency in the results of data analysis. With only one exception (newspapers), the total growth showed almost 80 to 100 percent increase which reflected a general sense of steady growth even if it failed in most cases to reach the minimum level of being explosive.

The lowest degree of explosiveness was in the information production. But ranking the degree of explosiveness showed that two variables were close to meet the criterion of explosiveness. Furthermore, the total percentage of increase showed that it was above 80 percent in two variables which truly reflected a degree of explosiveness but lower than it was for information flow. So, another general conclusion can be supported by this analysis that even it was an explosion in the velocity of information as reflected by few parameters, that explosion was not the general dominant behavior of the velocity of information. The last general conclusion supported by the analysis is that even if there has not been an explosion in the generation of information, the results reflected a moderate degree of explosiveness.

6.3 Implications of the Study and Future Research

In recent years, the information systems community as well as the other information sciences communities have been accustomed to statements such as "the amount of information is increasing at exponential rate" or "there has been an information explosion which should be brought under control" or "the information explosion is going to become storage and retrieval problems" (1, 2, 3). The main implication of the study is not to treate the phenomenon as metaphors but to quantitavely measure and characterize its growth.

The second implication is to reveal different growth behaviors in generation, distribution, and flow of information which is basically contrary to the findings of Price (5) that the law of exponential growth was universal to the growth of scientific information. The third implication is to set the foundations for more extended research to predict the amount of information for short and long term periods in different contexts which could be useful for information systems planning specially in the areas of storage and retrieval of information at the organizational as well as society levels.

Specifically, the present study could be directly extended to forecast the characteristics of the next cycle in each of the variables investigated. The technique used is primarily designed to identify and characterize the sinusoidal cycles in the data (4, 6), which could be useful in predicting which is most likely to occur based on the extracted behavior of the variable. The long term prediction, however, may basically rely on extracting the general trend of the whole curve and not to concentrate only on the specific characteristics of the next cycle which is expected to occur in the near future.

There is a word of caution, however, to totally rely on such prediction raised by Bell (1) concerning the use of mathematical models to predict the behaviors of social sciences phenomena. Because of the oppennes in social sciences, specific and exact prediction should not be the main objective of such forecasting. "Yet one advantage of this technique remains: by the use of mathematical language, one can often discern identical underlying structures in highly diverse phenomena" (1, p. 183).

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APPENDIX A

INFORMATION PRODUCTION VARIABLES AND GRAPHS

<u>Legends Used</u>

(TP) = Time Period

(CORB) = Copyrights Raw Data Before Adjustment by Population

(INRB) = Inventions Raw Data Before Adjustment by Population

(DERB) = Designs Raw Data Before Adjustment by Population

(DORB) = Doctorate Raw Data Before Adjustment by population

(LCRB) = LC Holdings Raw Data Before Adjustment by population

(CORA) = Copyrights Raw Data After Adjustment by Population

(INRA) = Inventions Raw Data After Adjustment by Population

(DERA) = Designs Raw Data After Adjustment by Population

(DORA) = Doctorate Raw Data After Adjustment by population

(LCRA) = L C Holdings Raw Data After Adjustment by population

(COBB) = Copyrights Data in Bits Before Adjustment by Population

(INBB) = Inventions Data in Bits Before Adjustment by Population

(DEBB) = Designs Data in Bits Before Adjustment by Population

(DOBB) = Doctorate Data in Bits Before Adjustment by population

(LCBB) = L C Holdings Data in Bits Before Adjustment by population

(COBA) = Copyrights Data in Bits After Adjustment by Population

(INBA) = Inventions Data in Bits After Adjustment by Population

(DEBA) = Designs Data in Bits After Adjustment by Population

(DOBA) = Doctorate Data in Bits After Adjustment by population

(LCBA) = L C Holdings Data in Bits After Adjustment by population

INFORMATION PRODUCTION RAW DATA BEFORE ADJUSTMENT BY POPULATION

(TP)	(CORB)	(INRB)	(DERB)	(DORB)	(LCRB)
1860	.	4357	183	.	
1861	.	3020	142		
1862	.	3214	185	.	
1863	.	3773	178	.	
1864	.	4630	138	.	
1865	.	6088	221	.	
1866	.	8863	294	.	
1867	.	12277	325		
1868	.	12528	445		
1869	.	12921	508	.	
1870	5800	12137	737	.	
1871	12888	11659	903		
1872	14184	12180	886	14	
1873	15352	11818	747	28	
1874	18283	12230	888	13	
1875	15927	13291	915	23	
1876	14382	14189	802	31	
1877	15758	12820	889	39	
1878	15798	12345	580	32	
1879	18125	12125	591	38	
1880	20888	12903	514	54	
1881	21075	15500	585	37	
1882	22918	18081	858	48	
1883	25274	21182	1017	50	
1884	28893	19118	1150	68	
1885	28411	23285	789	77	
1886	31241	21787	584	84	
1887	35083	20403	948	77	
1888	38225	19551	832	140	
1889	40985	23374	723	124	
1890	42794	25313	886	149	
1891	48908	22312	835	187	
1892	54735	22847	816	190	
1893	58958	22750	895	218	
1894	62782	19855	927	279	
1895	67572	20858	1109	272	
1896	72470	21822	1441	271	
1897	75000	22087	1820	319	
1898	75545	20377	1798	324	
1899	80988	23278	2137	345	
1900	94798	24844	1754	382	1457102
1901	92351	25548	1729	385	1877941
1902	92878	27119	639	283	1751077
1903	97978	31029	538	337	1877413
1904	103130	30258	553	334	2015883
1905	113374	29775	486	388	2021170
1906	117704	31170	670	382	2121000
1907	123828	35859	589	349	2250741
1908	119742	32735	795	391	2403104
1909	120131	38581	879	451	2618357
1910	109074	35141	838	443	2748380
1911	115198	32858	1004	497	2909294
1912	120931	36188	1341	500	3082883
1913	118485	33917	1677	538	3254773

INFORMATION PRODUCTION RAW DATA BEFORE ADJUSTMENT BY POPULATION

(TP)	(CORB)	(INRB)	(DERB)	(DORB)	(LCRB)
1914	123154	38892	1711	559	3476293
1915	115193	43118	1538	611	3624991
1916	115987	43982	1745	687	3789327
1917	111438	40935	1505	611	3890098
1918	106728	38452	1206	556	3898913
1919	113003	36787	1521	588	4131361
1920	126582	37060	2481	615	4300884
1921	135280	37798	3285	726	4432085
1922	138633	38388	1809	838	4557550
1923	141946	38818	1927	987	4676178
1924	162684	42574	2670	1088	4790888
1925	165848	46432	2818	1253	5676820
1926	177635	44733	2597	1409	5870870
1927	184000	41717	2387	1428	6066317
1928	193914	42357	3182	1447	6297851
1929	181950	45267	2905	1673	6565019
1930	172792	45228	2710	2299	6826323
1931	164642	51758	2835	2478	7088142
1932	151735	53458	2942	2654	7350882
1933	137424	48774	2411	2742	7539453
1934	138047	44420	2919	2830	7770494
1935	142031	40418	3884	2800	7998314
1936	158982	39782	4558	2770	8787946
1937	154424	37683	5138	2950	8461244
1938	166248	38061	5026	2932	7988139
1939	173135	43073	5582	3111	9019388
1940	176997	42238	8145	3280	9435848
1941	180647	41108	8488	3294	9970388
1942	182232	38448	3728	3497	10262897
1943	180795	31054	2228	2901	18150972
1944	169289	28053	2914	2305	22879718
1945	178848	25895	3574	2138	24479999
1946	202144	21803	2778	1986	24675124
1947	230215	20138	2102	2978	23088648
1948	238121	23983	3988	3989	24400061
1949	201180	35131	4450	5048	27560873
1950	210564	43040	4718	6633	28691350
1951	200354	44328	4183	7337	29319603
1952	203705	43918	2958	7883	30748772
1953	218508	40488	2713	8307	31628551
1954	222885	33809	2538	8996	33152852
1955	224732	30432	2713	8840	34201414
1956	224908	48817	2977	8803	35331657
1957	225807	42744	2382	8756	38118639
1958	236935	48330	2374	6942	38809919
1959	241735	52408	2788	9380	38128241
1960	243828	47170	2543	9828	39985221
1961	247014	48381	2487	10575	41783018
1962	254778	55881	2300	11622	41867494
1963	264845	45879	2985	12822	43131479
1964	278987	47378	2818	14480	43528482
1965	293817	82157	3424	16467	53310588
1966	288886	88406	3188	18237	54289210
1967	284408	65652	3185	20817	55457244

INFORMATION PRODUCTION RAW DATA BEFORE ADJUSTMENT BY POPULATION

(TP)	(CORB)	(INRB)	(DERB)	(DORB)	(LCRB)
1968	303451	59102	3352	23089	58483358
1969	301258	67557	3335	26188	59890533
1970	318488	84427	3214	28858	81317142
1971	329898	78218	3158	32107	84645101
1972	344574	74838	2901	28840	71108427
1973	353848	74139	4033	35100	72488928
1974	372832	78275	4303	33800	69332852
1975	401274	71804	4282	34100	70537768
1976	410988	70200	4800	34100	72805809
1977	457702	85300	3900	33300	73563479
1978	331842	86100	3800	32131	74387574
1979	429004	48900	3100	32703	75683694
1980	464743	61800	3900	32615	78945360
1981	471178	65800	4700	32958	78841380
1982	488149	57900	4900	32707	79754413
1983	488256	58900	4600	33088	80788452
1984	502828	87200	4800		81805918

INFORMATION PRODUCTION RAW DATA AFTER ADJUSTMENT BY POPULATION

(TP)	(CORA)	(INRA)	(DERA)	(DORA)	(LCRA)
1860	.	121.181	5.8038		.
1861	.	83.351	4.3894		
1862	.	98.842	5.8750	.	.
1863	.	110.888	5.1725	.	.
1864	.	132.808	3.8870	.	.
1865	.	170.577	6.1803	.	.
1866	.	242.568	8.0484	.	.
1867	.	328.473	8.6954	.	.
1868	.	327 784	11.8453		
1869	.	331.131	12.9574		
1870	140.33	304.147	18 4689		
1871	309.93	284 787	22 0577		
1872	337 48	290.183	21 0617	0.33358	
1873	358.87	270 102	17 3697	0 80457	
1874	368.73	277.702	20.1183	0.29519	.
1875	353.38	284.877	20.3004	0 51028	.
1876	322.77	307.307	17.3843	0.87235	.
1877	334.27	274.071	14.8279	0 82731	.
1878	327.94	258.250	12.2473	0.88428	.
1879	388.33	248 403	12.0107	0 73158	
1880	411.58	256.715	10.2284	1.07437	
1881	408 89	300 728	10.9818	0.71788	
1882	433 88	342 488	16.7435	0 87087	
1883	467.17	381.165	18.7885	0.87421	
1884	485.62	345.221	20.7680	1.18178	.
1885	501.45	410.975	13.5727	1.35803	.
1886	529.21	375.895	10.2523	1.44883	.
1887	592.45	344.548	18 0089	1.3003	
1888	631 88	323.178	13 7530	2.3142	
1889	663 48	377.584	11.7038	2.0073	
1890	678.67	401 437	14.0510	2.3630	
1891	759.90	344 870	12.9737	2.9055	
1892	833.54	344 882	12 4265	2.8834	
1893	880.33	338 704	13.4239	3.2552	
1894	915.25	290.808	13.5774	4 0484	
1895	971.14	288.741	15.8741	3.9092	
1896	1022.38	307 851	20.3287	3.8231	
1897	1038.94	305.884	22.4411	4 4180	.
1898	1027.91	277.281	24 4782	4 4085	.
1899	1082.47	311.207	28.5699	4.6174	
1900	1245.70	323.837	23.0498	5.0197	19 1472
1901	1190.08	328.201	22 2809	4.7038	21 6230
1902	1173.98	342.412	8.0682	3.8995	22.1098
1903	1215 62	384.875	8.8501	4 1811	23 2930
1904	1254.62	388.102	8.7275	4 0833	24.3214
1905	1352.93	355.310	5.7895	4 4033	24 1190
1906	1378.27	364 888	7.2800	4 4848	24 8381
1907	1423 32	412.172	8 7701	4.0115	25 8708
1908	1348 97	369 053	8.5118	4 4081	27.0925
1909	1327 41	403 898	7.5028	4 9834	28 9321
1910	1180 45	380 314	6 8831	4 7944	29 7552
1911	1228 82	348 904	10 6922	5 2979	30 9826
1912	1268 95	379 832	14 0714	5 2466	32 3493
1913	1228.37	348.940	17.2531	5 5350	33 4853

INFORMATION PRODUCTION RAW DATA AFTER ADJUSTMENT BY POPULATION

(TP)	(CORA)	(INRA)	(DERA)	(DORA)	(LCRA)
1914	1242.72	402.543	17.2854	5.8408	35.079
1915	1148.20	429.035	15.3035	6.0798	36.070
1916	1138.83	430.314	17.1078	6.5392	36.854
1917	1078.71	398.273	14.5892	5.9148	37.854
1918	1034.19	372.587	11.8860	5.3878	37.780
1919	1081.37	352.124	14.5550	5.8077	39.535
1920	1188.38	347.981	23.2858	5.7748	40.385
1921	1248.82	348.389	30.0922	8.8812	40.848
1922	1259.18	348.492	14.8140	7.5831	41.395
1923	1329.80	344.788	17.2054	8.6339	41.752
1924	1425.89	373.120	23.4005	9.6231	41.987
1925	1432.19	400.987	24.3437	10.8204	49.023
1926	1513.07	381.031	22.1210	12.0017	50.007
1927	1546.22	350.583	20.0588	17.0000	50.977
1928	1609.24	351.510	26.4086	12.0083	52.265
1929	1329.71	371.850	23.8508	15.3777	53.900
1930	1403.87	367.392	22.0148	18.8758	55.453
1931	1328.60	417.051	23.6503	19.9517	57.100
1932	1215.83	428.348	23.5737	21.2860	58.802
1933	1084.34	388.328	19.1958	21.8312	60.027
1934	1100.06	351.424	23.0834	22.3892	61.475
1935	1115.72	317.488	30.3535	21.9953	62.815
1936	1225.31	310.554	35.5480	21.6237	64.543
1937	1198.94	292.570	38.8758	22.1273	65.848
1938	1280.80	293.228	38.7211	22.5888	61.372
1939	1322.85	329.053	42.7186	23.7062	69.003
1940	1335.83	318.777	48.3774	24.8302	71.214
1941	1351.14	307.472	48.5118	25.385	74.573
1942	1253.80	285.054	27.8869	25.981	78.248
1943	1180.59	229.858	18.4915	21.473	134.352
1944	1284.34	209.507	21.7825	17.214	169.079
1945	1340.69	192.818	28.4188	16.012	183.508
1946	1438.70	154.981	19.7441	13.973	175.019
1947	1597.61	139.757	14.5871	20.866	180.213
1948	1623.18	163.347	27.0484	27.192	166.328
1949	1347.56	235.305	29.8058	33.818	184.801
1950	1388.20	283.344	31.0598	43.687	188.883
1951	1301.00	287.831	27.0325	47.843	190.387
1952	1302.44	278.875	18.8104	49.124	198.591
1953	1374.25	254.538	17.0829	52.745	198.909
1954	1375.32	208.828	15.8640	55.585	204.774
1955	1381.18	184.325	16.4325	53.543	207.156
1956	1337.94	278.507	17.7087	52.983	210.182
1957	1318.97	248.873	13.7967	51.145	210.873
1958	1372.40	277.399	13.6358	51.381	211.981
1959	1394.98	295.823	15.8290	52.851	215.281
1960	1355.34	262.058	14.1278	54.808	218.440
1961	1348.80	284.308	13.5802	57.787	225.590
1962	1371.24	299.738	12.3788	62.551	225.336
1963	1405.01	242.329	15.7294	68.021	228.814
1964	1459.90	247.912	14.0555	75.824	227.788
1965	1517.40	324.842	17.6951	85.101	275.507
1966	1486.60	349.724	16.2988	93.238	277.552
1967	1490.88	332.415	18.0253	104.380	280.798

INFORMATION PRODUCTION RAW DATA AFTER ADJUSTMENT BY POPULATION

(TP)	(CORA)	(INRA)	(DERA)	(DORA)	(LCRA)
1968	1521.82	296.399	16.8104	115.792	293.198
1969	1495.82	335.437	16.5591	130.030	297.371
1970	1551.30	315.818	15.7549	146.402	300.574
1971	1594.27	371.704	15.2611	155.258	312.597
1972	1848.32	357.583	13.8605	138.837	338.734
1973	1872.88	350.705	19.0778	188.036	342.795
1974	1747.92	357.585	20.1735	158.831	325.049
1975	1882.08	333.881	19.8701	156.237	327.321
1976	1888.84	322.810	21.1397	158.710	333.887
1977	2050.81	287.088	17.7434	151.501	334.688
1978	1494.58	287.814	17.5597	144.889	334.928
1979	1910.08	217.720	13.8023	145.806	336.971
1980	2045.52	272.007	17.1655	143.552	338.868
1981	2054.85	288.980	20.4972	143.733	343.834
1982	2022.24	250.108	21.1683	141.283	344.512
1983	2089.24	243.475	19.6834	141.583	345.736
1984	2132.75	285.143	20.7817		347.543

INFORMATION PRODUCTION DATA IN BITS BEFORE ADJUSTMENT BY POPULATION

(TP)	(COBB)	(INBB)	(DEBB)	(DOBB)	(LCBB)
1860		12.0891	7.5197		
1861		11.9803	7.1487		
1862		11.8502	7.6073		
1863		11.8815	7.4584		
1864		12.1708	7.1189		
1865		12.5718	7.7879		
1866		13.1130	8.1987		
1867		13.5837	8.3443		
1868		13.6128	8.7977		
1869		13.8585	8.9830		
1870	12.4512	13.5871	9.5255		
1871	13.0312	13.5082	9.8188		
1872	13.7898	13.5722	9.7879	3.80735	
1873	13.9081	13.5038	9.5450	4.70044	
1874	13.9811	13.5781	9.7912	3.70048	
1875	13.9592	13.6882	9.8378	4.52356	
1876	13.8613	13.7905	9.0475	4.85420	
1877	13.8438	13.8573	9.4481	5.28540	
1878	13.9475	13.5918	9.2048	5.00000	
1879	14.1457	13.9857	8.2070	5.18893	
1880	14.3384	13.8554	9.0058	5.75489	
1881	14.3832	13.9200	9.1421	5.20945	
1882	14.4842	14.1430	9.7448	5.52358	
1883	14.8254	14.2892	9.9801	5.84318	
1884	14.7148	14.2228	10.1874	6.04439	
1885	14.7842	14.5071	9.5888	6.20878	
1886	14.9312	14.4088	8.2143	6.30232	
1887	15.0885	14.3185	9.8887	6.2888	
1888	15.2222	14.2550	9.7004	7.1293	
1889	15.3228	14.5095	9.4975	6.9542	
1890	15.3851	14.8278	9.7912	7.2192	
1891	15.5778	14.4455	9.7058	7.5489	
1892	15.7402	14.4870	9.6724	7.5899	
1893	15.8474	14.4738	9.8122	7.7882	
1894	15.8378	14.2772	9.8504	8.1241	
1895	16.0441	14.3482	10.1137	8.0875	
1896	16.1451	14.4135	10.4829	8.0921	
1897	16.1848	14.4288	10.6818	8.3174	
1898	16.2050	14.3147	10.8130	8.3398	
1899	16.3051	14.5087	11.0814	8.4205	
1900	16.5328	14.5888	10.7784	8.5774	20.4747
1901	16.4948	14.8401	10.7597	8.5118	20.8783
1902	16.5048	14.7270	8.3197	8.1948	20.7398
1903	16.9802	14.9213	8.0881	8.3988	20.8403
1904	16.8541	14.8850	9.1111	8.3837	20.8428
1905	16.7907	14.8611	8.9248	8.5279	20.9488
1906	16.8848	14.8279	8.2781	8.5812	21.0183
1907	16.9180	15.1300	8.2021	8.4471	21.1020
1908	16.8686	14.8885	9.5803	8.6130	21.1865
1909	16.8742	15.1380	9.4073	8.8170	21.3202
1910	16.7348	15.2009	9.3128	8.7917	21.3907
1911	16.8131	15.0039	8.9715	8.8571	21.4722
1912	16.8830	15.1436	10.3891	8.9658	21.5599
1913	16.8888	15.0487	10.7117	9.0715	21.6341

INFORMATION PRODUCTION DATA IN BITS BEFORE ADJUSTMENT BY POPULATION

(TP)	(COBB)	(INBB)	(DEBB)	(DOBB)	(LCBB)
1914	16.9101	15.2830	10.7400	9.1287	21.7291
1915	16.8127	15.3800	10.5869	9.2550	21.7895
1916	16.8234	15.4217	10.7800	9.3815	21.8450
1917	16.7659	15.3210	10.5555	9.2550	21.8916
1918	16.7036	15.2308	10.2360	9.1189	21.8948
1919	16.7880	15.1872	10.5708	9.1948	21.9782
1920	16.9495	15.1778	11.2787	9.2644	22.0382
1921	17.0456	15.2080	11.6728	9.5038	22.0788
1922	17.0809	15.2277	10.6518	9.7074	22.1188
1923	17.1844	15.2309	10.8121	9.8174	22.1569
1924	17.3118	15.3777	11.3828	10.1007	22.1918
1925	17.3385	15.5028	11.4610	10.2912	22.4387
1926	17.4398	15.4491	11.3426	10.4805	22.4951
1927	17.4193	15.3483	11.2210	10.4798	22.5324
1928	17.5851	15.3703	11.6357	10.4988	22.5185
1929	17.3053	15.4082	11.5043	10.8711	22.6464
1930	17.3987	15.4849	11.4041	11.1988	22.7077
1931	17.3280	15.6594	11.5181	11.2738	22.7586
1932	17.2112	15.7061	11.5228	11.3740	22.8085
1933	17.0683	15.5738	11.2354	11.4210	22.8480
1934	17.0852	15.4389	11.5113	11.4686	22.8898
1935	17.1158	15.3028	11.8159	11.4512	22.9309
1936	17.2601	15.2788	12.1538	11.4357	22.9781
1937	17.2385	15.2016	12.3264	11.4767	23.0158
1938	17.3430	15.2180	12.2852	11.5177	22.9254
1939	17.4015	15.3845	12.4481	11.6032	23.1048
1940	17.4324	15.3883	12.5852	11.6838	23.1887
1941	17.4628	15.3272	12.8631	11.7288	23.2492
1942	17.4754	15.2307	11.8642	11.7718	23.2808
1943	17.2848	14.9225	11.1215	11.5023	24.1135
1944	17.3890	14.7758	11.5089	11.1708	24.4324
1945	17.4484	14.6492	11.7830	11.0607	24.5451
1946	17.6250	14.4122	11.4398	10.9410	24.5538
1947	17.8128	14.2977	11.0375	11.5401	24.4606
1948	17.9813	14.5485	11.9542	11.8618	24.5404
1949	17.8162	15.1005	12.1198	12.3019	24.7161
1950	17.6838	15.3934	12.2040	12.6954	24.7741
1951	17.6122	15.4359	12.0234	12.8410	24.8054
1952	17.6381	15.4128	11.5308	12.9075	24.8738
1953	17.7373	15.3045	11.4057	13.0201	24.8148
1954	17.7845	15.0451	11.3083	13.1351	24.9828
1955	17.7778	14.8833	11.4057	13.1098	25.0278
1956	17.7790	15.3147	11.9398	13.1201	25.0745
1957	17.7847	15.3834	11.2058	13.0981	25.1062
1958	17.8863	15.5806	11.2131	13.1284	25.1373
1959	17.8831	15.6775	11.4348	13.1823	25.1843
1960	17.8961	15.5258	11.3123	13.2828	25.2168
1961	17.9142	15.5018	11.2602	13.3884	25.2990
1962	17.9588	15.7652	11.1874	13.5048	25.3183
1963	18.0148	15.4782	11.5338	13.8483	25.3622
1964	18.0898	15.5319	11.3912	13.8228	25.3754
1965	18.1038	15.5398	11.7415	14.0073	25.6678
1966	18.1300	16.0618	11.8394	14.1546	25.6942
1967	18.1874	16.0028	11.9280	14.3315	25.7248

INFORMATION PRODUCTION DATA IN BITS BEFORE ADJUSTMENT BY POPULATION

(TP)	(COBB)	(INBB)	(DEBB)	(DOBB)	(LCBB)
1968	18.2111	15.8509	11.7108	14.4948	25.8010
1969	18.2006	16.0439	11.7035	14.6786	25.8359
1970	18.2717	15.9754	11.6502	14.8862	25.8698
1971	18.3308	16.2570	11.6238	14.9708	25.9480
1972	18.3845	16.1815	11.5023	14.8057	26.0835
1973	18.4320	16.1779	11.8778	15.0892	26.1108
1974	18.5082	16.2188	12.0711	15.0490	26.0470
1975	18.6142	16.1338	12.0641	15.0575	26.0719
1976	18.6487	16.0982	12.1674	15.0575	26.1136
1977	18.7882	15.9848	11.8283	15.0232	26.1325
1978	18.3406	16.0174	11.8293	14.8717	26.1488
1979	18.7108	15.5775	11.5981	14.9871	26.1735
1980	18.8261	15.8153	11.9293	14.9932	26.1973
1981	18.8458	16.0058	12.1984	15.0083	26.2324
1982	18.8368	15.8213	12.2586	14.9973	26.2491
1983	18.8873	15.7861	12.1674	15.0140	26.2678
1984	18.8381	16.0362	12.2588		26.2875

INFORMATION PRODUCTION DATA IN BITS AFTER ADJUSTMENT BY POPULATION

(TP)	(COBA)	(INBA)	(DEBA)	(DOBA)	(LCBA)
1860		7.11042	2.53700		.
1861	.	8.54459	2.13401	.	.
1862	.	8.59758	2.55474		.
1863	.	8.78283	2.37087	.	.
1864	.	7.05317	1.99532	.	
1865	.	7.41388	2.63001	.	
1866	.	7.82225	3.00835	.	
1867	.	8.35983	3.12028	.	
1868		8.35685	3.54187	.	
1869		8.37128	3.89571		
1870	7.1327	8.24863	4.20702		
1871	8.2758	8.15378	4.48321		
1872	8.3988	8.18087	4.39655	-1.5840	
1873	8.4787	8.07736	4.11850	-0.7260	
1874	8.5303	8.11739	4.33042	-1.7603	.
1875	8.4650	8.20397	4.34344	-0.9708	
1876	8.3344	8.26354	4.12054	-0.5727	.
1877	8.3845	8.08841	3.88024	-0.2735	.
1878	8.3573	8.00148	3.81438	-0.5802	.
1879	8.5248	7.94488	3.58818	-0.4508	
1880	8.8350	8.00402	3.35423	0.1035	
1881	8.6756	8.23230	3.45443	-0.4782	
1882	8.7612	8.41884	4.02179	-0.1895	.
1883	8.8878	8.81163	4.23255	-0.1137	.
1884	8.9237	8.47138	4.37815	0.2531	.
1885	9.0700	8.83281	3.78283	0.4428	.
1886	9.0747	8.55342	3.35788	0.5358	
1887	9.2105	8.42955	4.00080	0.37885	
1888	9.3035	8.33818	3.78187	1.21052	
1889	9.3738	8.58058	3.54890	1.00525	
1890	9.4068	8.84903	3.83280	1.74081	.
1891	9.5697	8.43742	3.88752	1.53878	
1892	9.7031	8.42996	3.63535	1.53278	.
1893	9.7818	8.40814	3.74673	1.70274	
1894	9.8443	8.18383	3.78314	2.03084	.
1895	9.9235	8.22757	3.89314	1.96688	
1896	9.9877	8.20809	4.34545	1.93474	.
1897	10.0209	8.25580	4.48807	2.14371	.
1898	10.0055	8.11510	4.83342	2.14030	.
1899	10.0801	8.28173	4.93842	2.20551	.
1900	10.2827	8.33912	4.52881	2.37780	4.25908
1901	10.2189	8.38283	4.47774	2.23377	4.63449
1902	10.1972	8.41858	3.01224	1.85733	4.46880
1903	10.2475	8.59862	2.73338	2.08390	4.54182
1904	10.2830	8.52388	2.75007	2.02284	4.61597
1905	10.4019	8.47294	2.53583	2.13880	4.59210
1906	10.4288	8.51171	2.85998	2.18504	4.63438
1907	10.4750	8.88710	2.75918	2.00414	4.69324
1908	10.3887	8.52788	3.09947	2.14018	4.75882
1909	10.3744	8.85817	2.90742	2.31714	4.85480
1910	10.2051	8.57305	2.78306	2.28134	4.89507
1911	10.2807	8.45082	3.41849	2.40405	4.95339
1912	10.3094	8.56922	3.81488	2.38138	5.01588
1913	10.2837	8.44884	4.10878	2.46858	5.08548

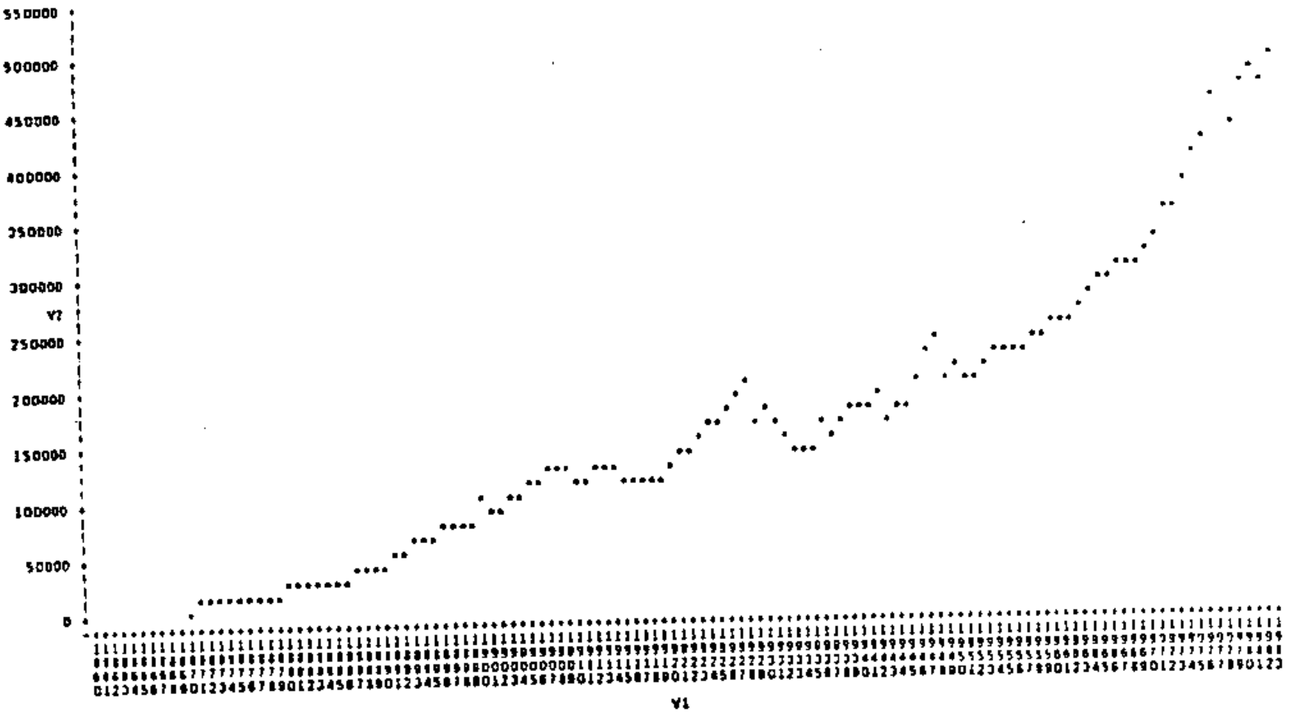
INFORMATION PRODUCTION DATA IN BITS AFTER ADJUSTMENT BY POPULATION

(TP)	(COBA)	(INBA)	(DEBA)	(DOBA)	(LCBA)
1914	10.2793	8.85300	4.10981	2.49589	5.13252
1915	10.1828	8.74495	3.93579	2.60398	5.17771
1916	10.1908	8.74825	4.09859	2.70912	5.20787
1917	10.0752	8.83035	3.86485	2.58433	5.23488
1918	10.0143	8.54147	3.54872	2.42984	5.23958
1919	10.0788	8.45994	3.86745	2.48740	5.30504
1920	10.2148	8.44287	4.54200	2.52973	5.33574
1921	10.2840	8.44447	4.91132	2.74227	5.35722
1922	10.2982	8.44498	3.86928	2.97488	5.37137
1923	10.3771	8.42958	4.10479	3.11002	5.38378
1924	10.4778	8.54353	4.54847	3.28851	5.39188
1925	10.4840	8.64734	4.60548	3.43568	5.61538
1926	10.5633	8.57376	4.46734	3.58517	5.64407
1927	10.5945	8.45353	4.32817	3.58498	5.87179
1928	10.8522	8.45742	4.72283	3.58596	5.70778
1929	10.3789	8.53780	4.57595	3.94278	5.75221
1930	10.4550	8.52118	4.48039	4.22310	5.79321
1931	10.3738	8.70408	4.56378	4.21844	5.83543
1932	10.2477	8.74284	4.59811	4.41048	5.88025
1933	10.0956	8.60113	4.28272	4.44832	5.90755
1934	10.1034	8.45707	4.52841	4.48473	5.84194
1935	10.1238	8.31055	4.92379	4.45912	5.97303
1936	10.2589	8.27870	5.15743	4.43454	6.01219
1937	10.2275	8.19264	5.31744	4.46778	6.04107
1938	10.3228	8.19588	5.27505	4.49752	5.83952
1939	10.3892	8.38217	5.41683	4.57084	6.10848
1940	10.3835	8.31841	5.53535	4.83402	6.15408
1941	10.4000	8.28431	5.80028	4.98582	6.22058
1942	10.4029	8.15412	4.79185	4.89837	6.25258
1943	10.2170	7.84481	4.04385	4.42445	7.00988
1944	10.3039	7.71086	4.44377	4.10554	[illegible]40156
1945	10.3888	7.58959	4.72338	4.00108	7.51970
1946	10.4885	7.27578	4.30335	3.80457	7.45136
1947	10.8417	7.12878	3.88862	4.36920	7.32384
1948	10.8848	7.35180	4.75747	4.78508	7.37787
1949	10.3881	7.[illegible]	4.88752	5.07871	7.52828
1950	10.4389	8.14841	4.95088	5.44847	7.58135
1951	10.3454	8.18808	4.75882	5.57419	7.57279
1952	10.3470	8.12347	4.24180	5.61038	7.61805
1953	10.4244	7.98181	4.09379	5.70723	7.83597
1954	10.4258	7.70816	3.98938	5.79611	7.67788
1955	10.4108	7.52811	4.03848	5.74283	7.89457
1956	10.3851	8.12157	4.14847	5.72880	7.71550
1957	10.3852	7.84380	3.78825	5.87852	7.72082
1958	10.4225	8.11886	3.78833	5.88281	7.72779
1959	10.4146	8.20908	3.96821	5.72387	7.75001
1960	10.4042	8.03373	3.82048	5.77098	7.75818
1961	10.3983	8.04807	3.78448	5.85287	7.81758
1962	10.4213	8.22755	3.82081	5.98886	7.81594
1963	10.4584	7.92082	3.97540	6.08791	7.83803
1964	10.5127	7.95388	3.81308	6.24459	7.83147
1965	10.5874	8.34380	4.14528	6.41110	8.10584
1966	10.5183	8.45007	4.02887	6.54282	8.11882
1967	10.5417	8.37844	4.00228	6.70584	8.13338

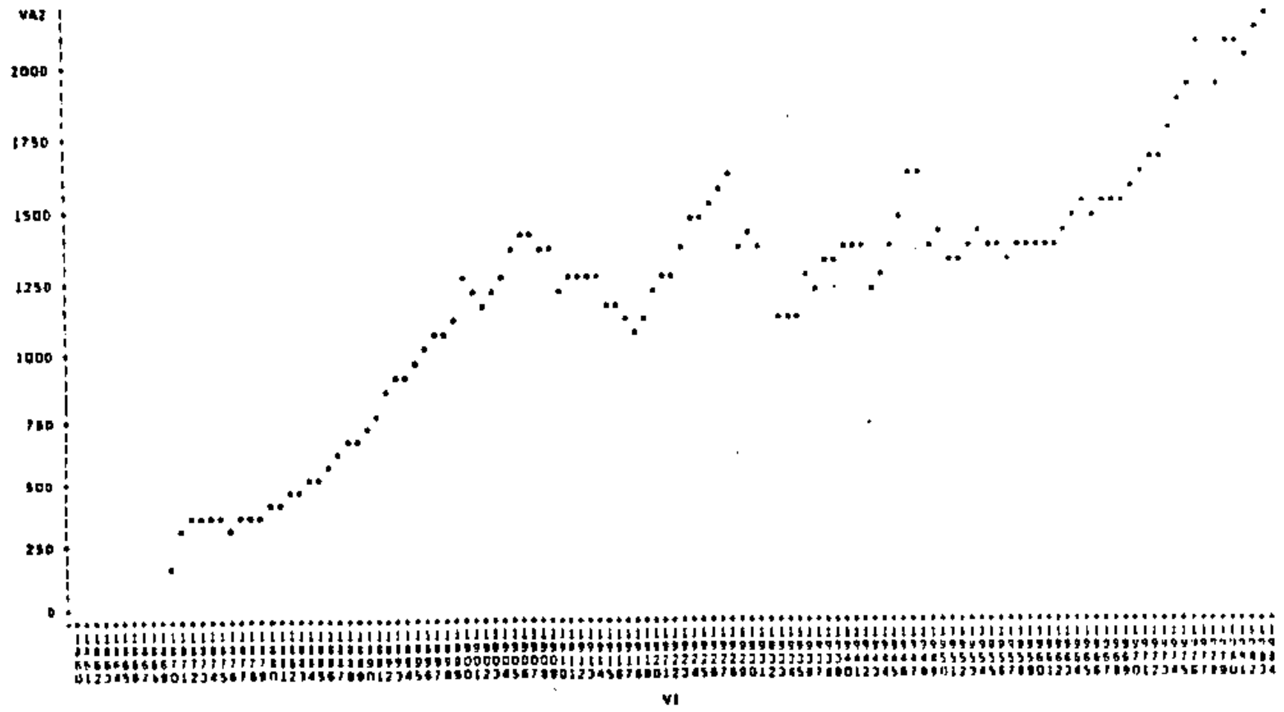
INFORMATION PRODUCTION DATA IN BITS AFTER ADJUSTMENT BY POPULATION

(TP)	(COBA)	(INBA)	(DEBA)	(DOBA)	(LCBA)
1968	10.5718	8.21140	4.07128	8.15540	8.19572
1969	10.5487	8.38890	4.04855	7.02270	8.21612
1970	10.5893	8.30295	3.97773	7.18378	8.23158
1971	10.8387	8.58493	3.93178	7.27851	8.28818
1972	10.8850	8.48205	3.79291	7.09832	8.40828
1973	10.7081	8.45411	4.25381	7.37535	8.42120
1974	10.7714	8.40218	4.33439	7.31228	8.34451
1975	10.8627	8.38224	4.31253	7.30584	8.35458
1976	10.8831	8.33385	4.40188	7.29185	8.38228
1977	11.0082	8.21475	4.14821	7.24318	8.38668
1978	10.5455	8.21730	4.13419	7.17881	[illegible]
1979	10.8994	7.78833	3.78884	7.18582	8.39648
1980	10.9983	8.08750	4.10144	7.18543	8.40373
1981	11.0048	8.18471	4.35735	7.18725	8.42557
1982	10.9817	7.98841	4.40370	7.14244	8.42841
1983	11.0288	7.92783	4.29890	7.14551	8.43353
1984	11.0585	8.15554	4.37794		8.44105

COPYRIGHTS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



COPYRIGHTS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



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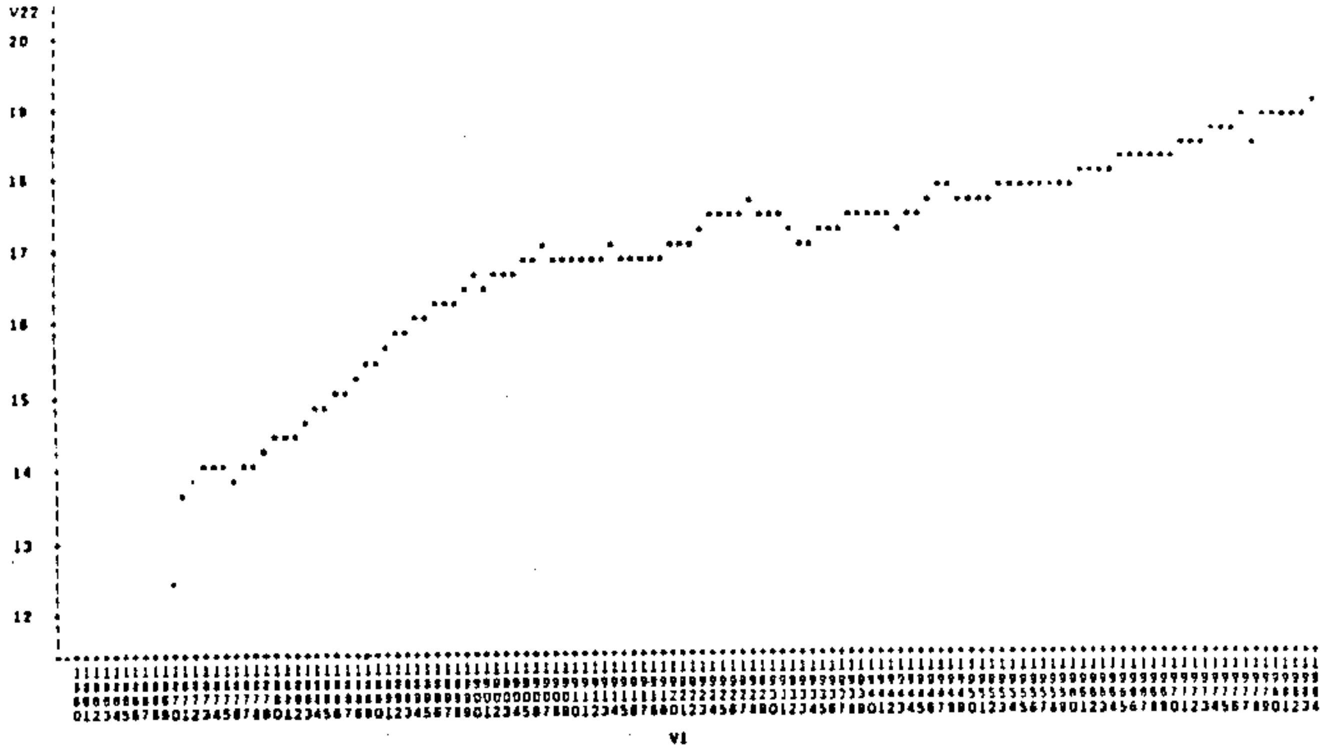
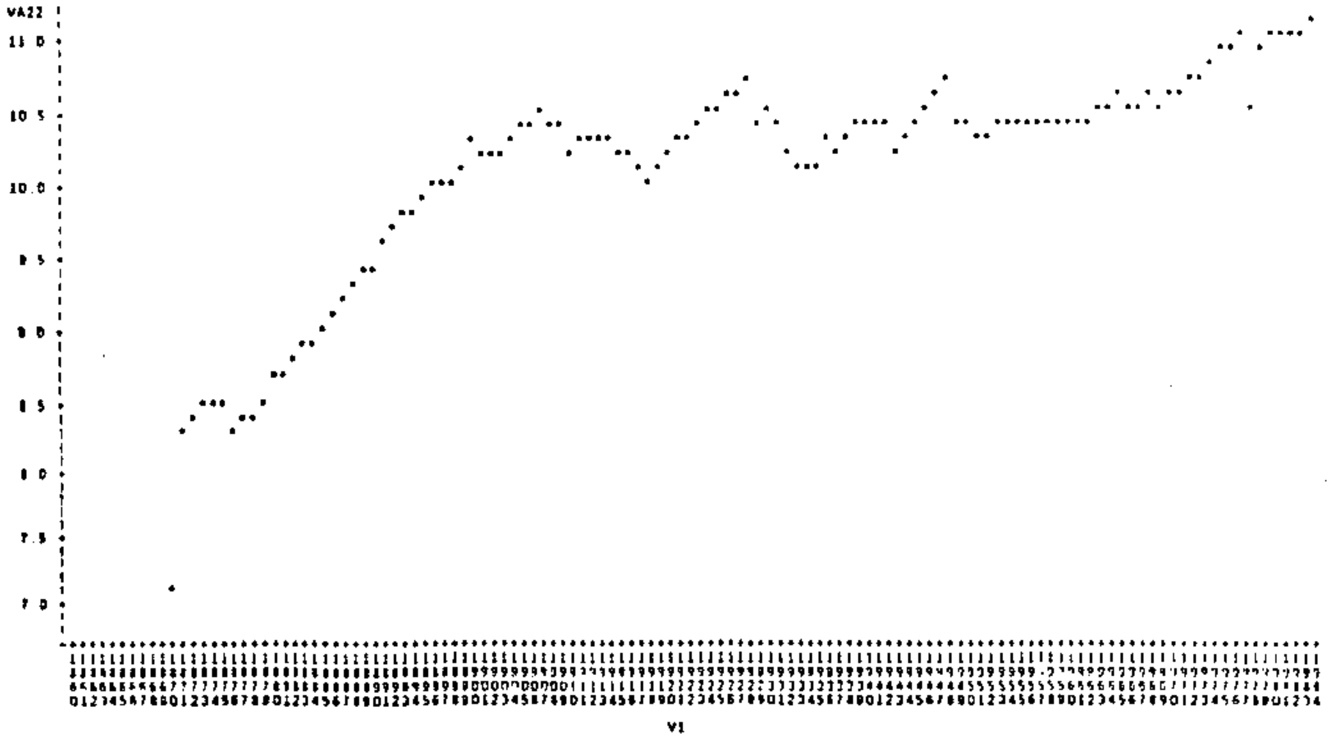
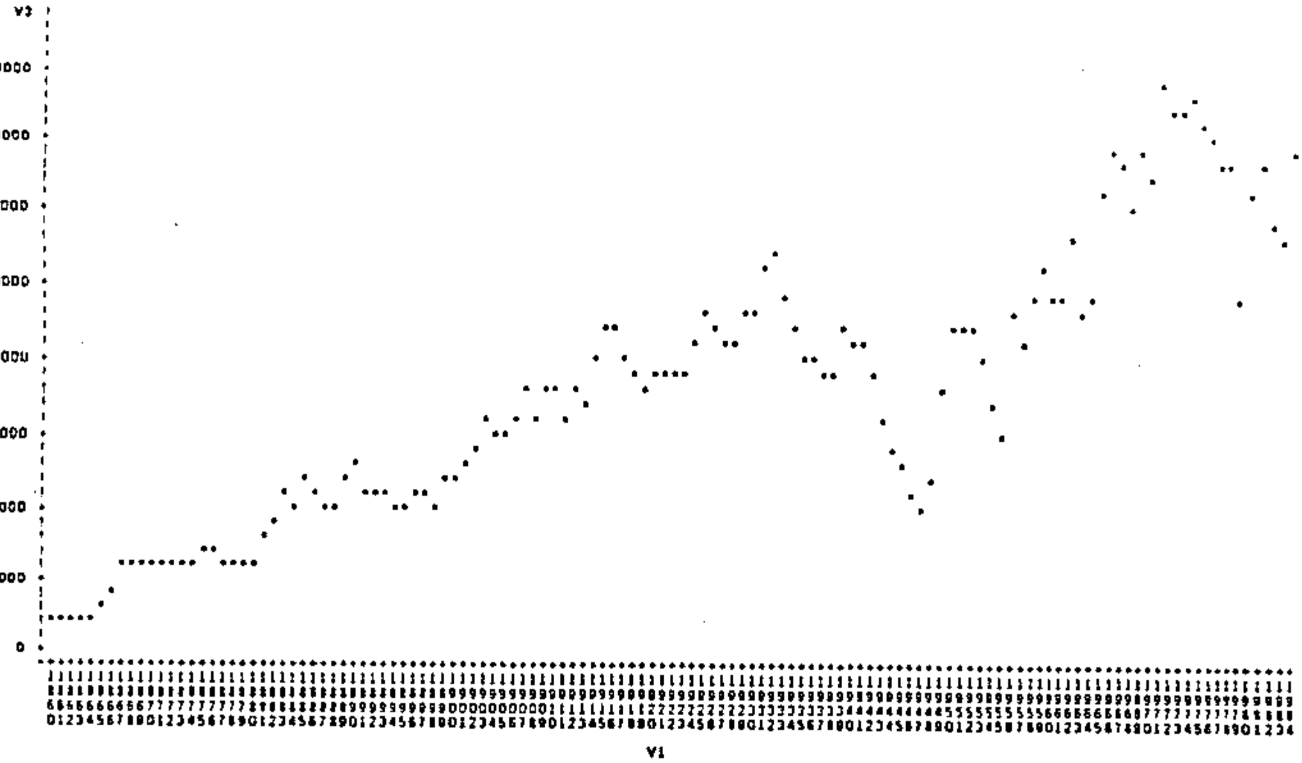
BY POPULATION VS TIME



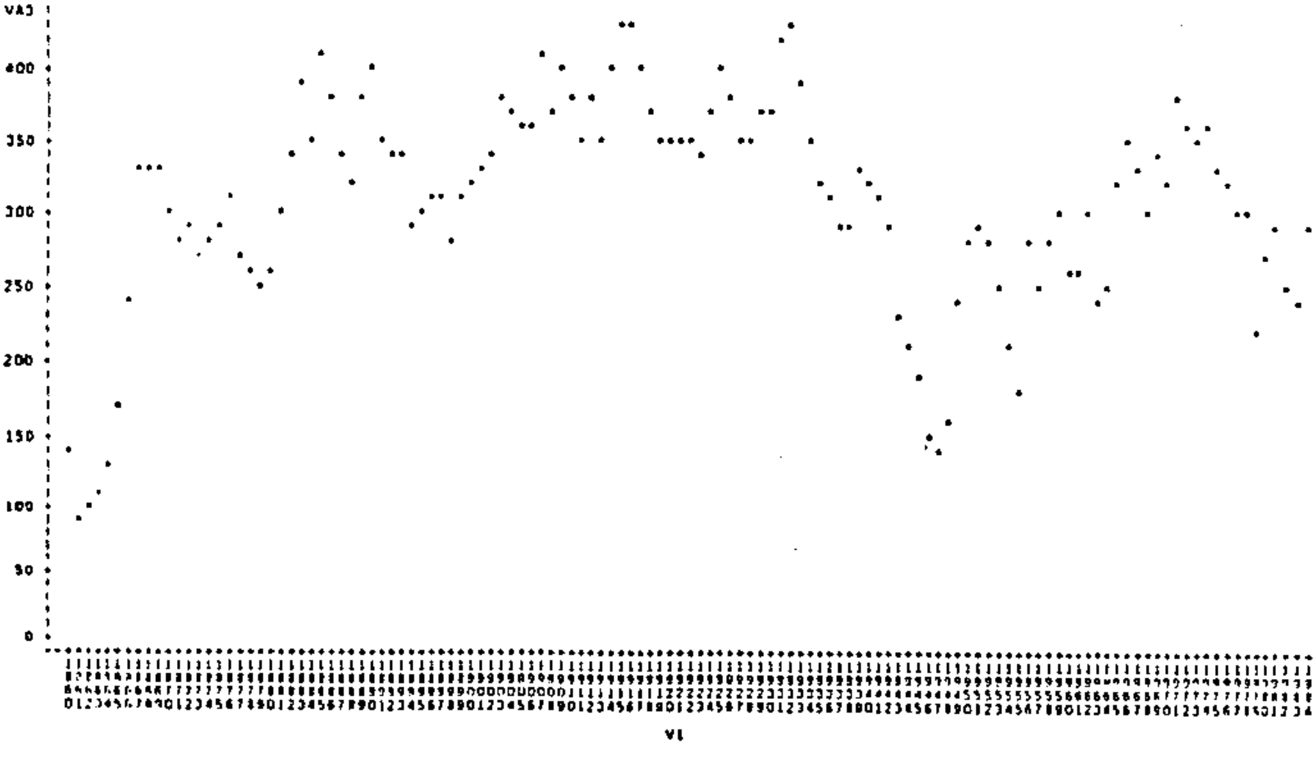
COPYRIGHTS DATA IN BITS AFTER ADJUSTMENT
BY POPULATION VS TIME



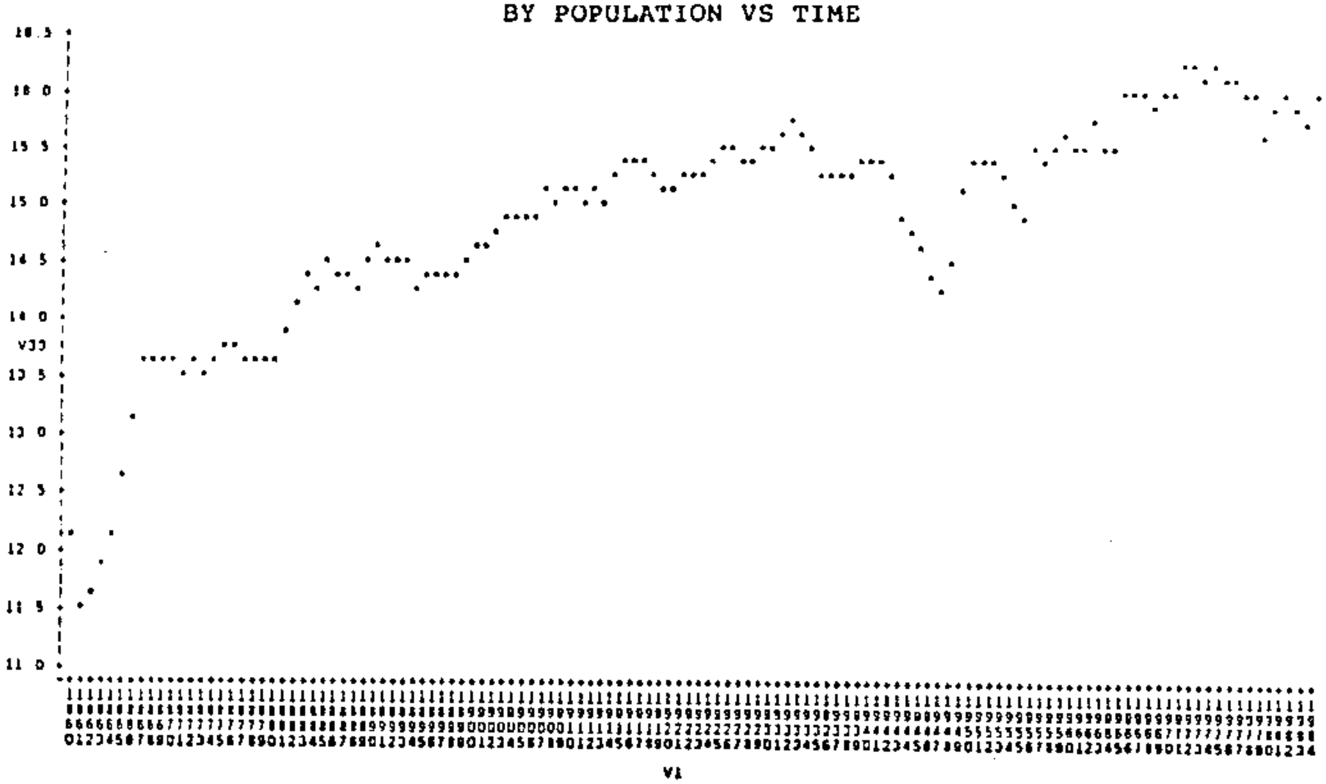
INVENTIONS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



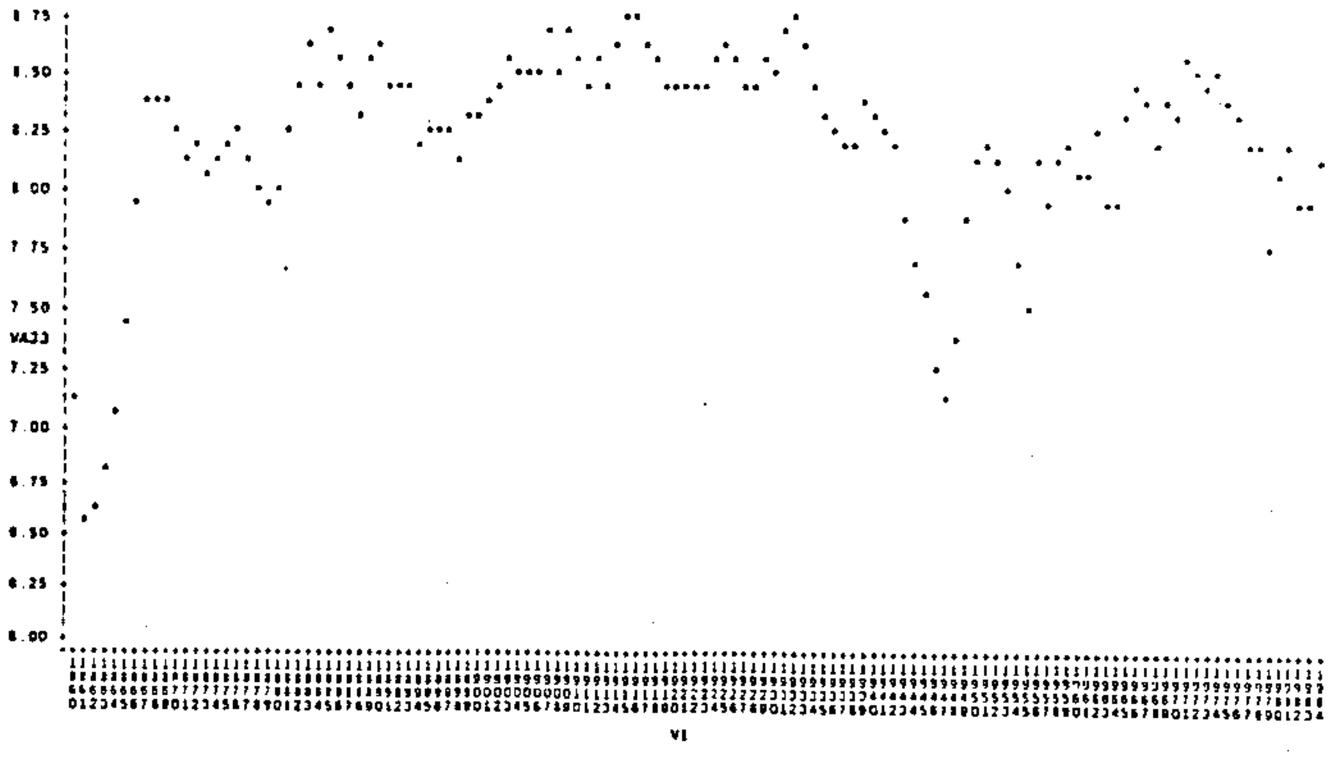
INVENTIONS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



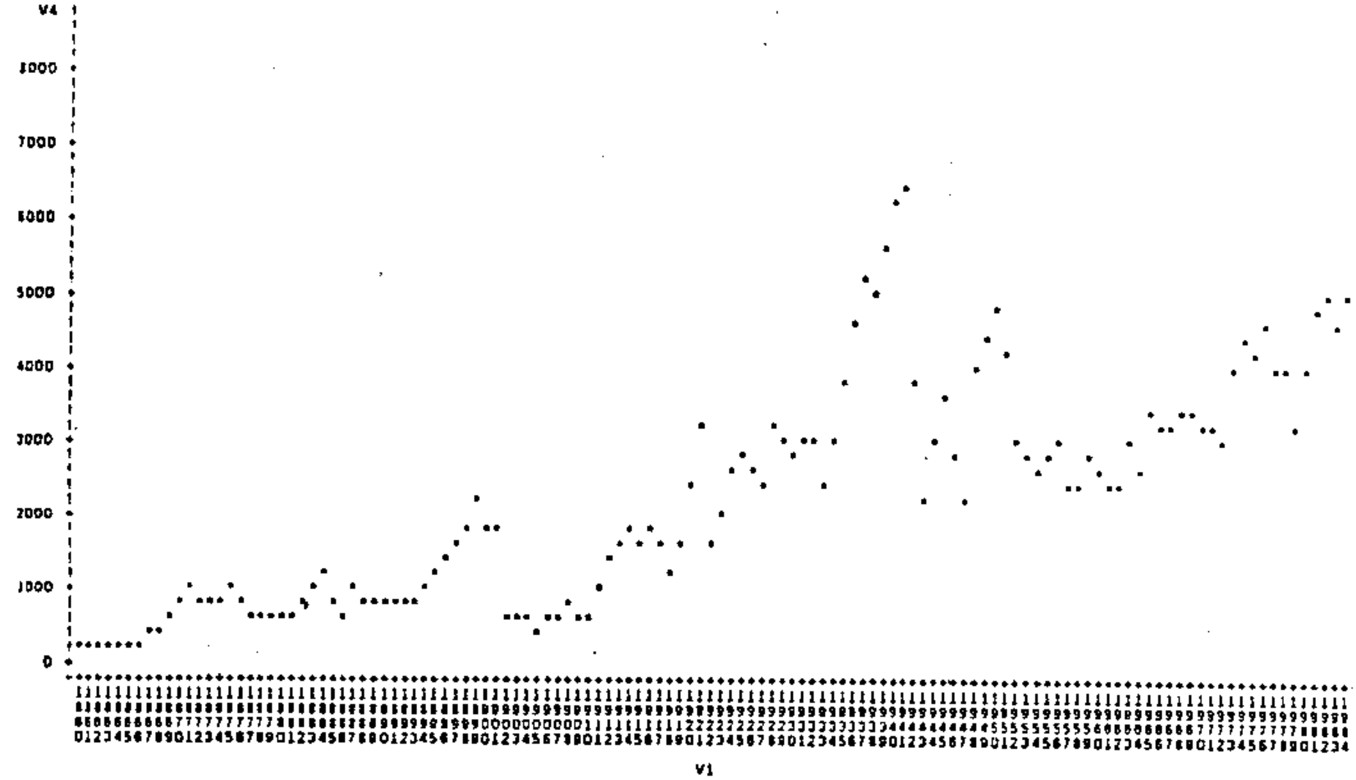
INVENTIONS DATA IN BITS BEFORE ADJUSTMENT
BY POPULATION VS TIME



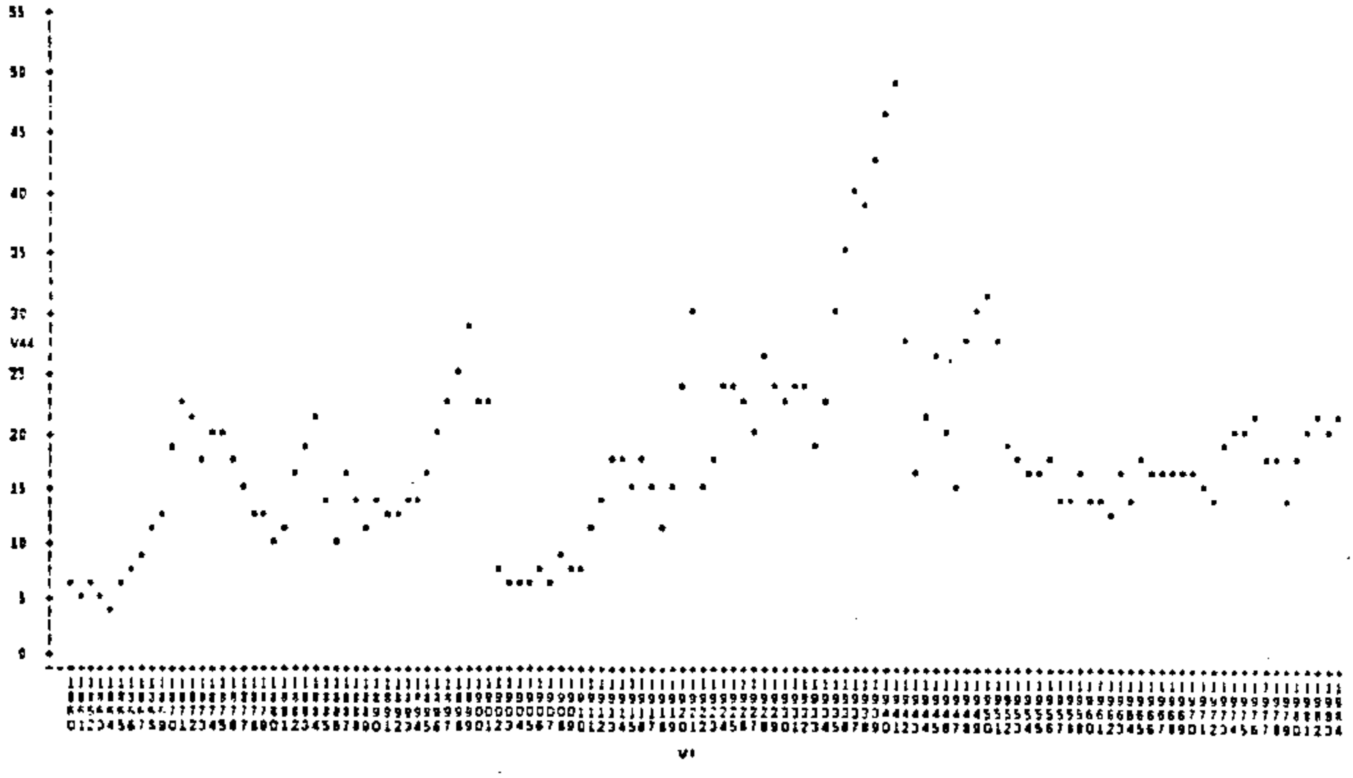
INVENTIONS DATA IN BITS AFTER ADJUSTMENT
BY POPULATION VS TIME



DESIGNS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



DESIGNS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



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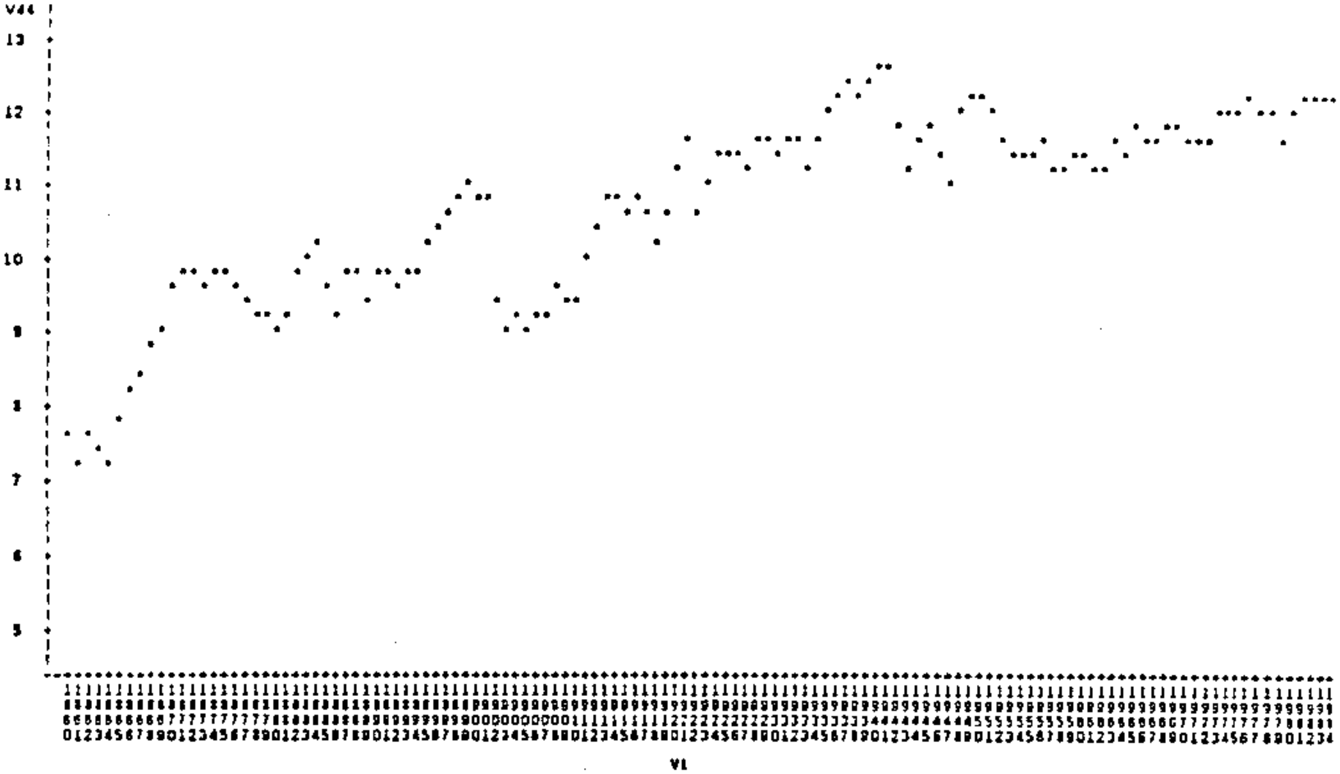
BY POPULATION VS TIME



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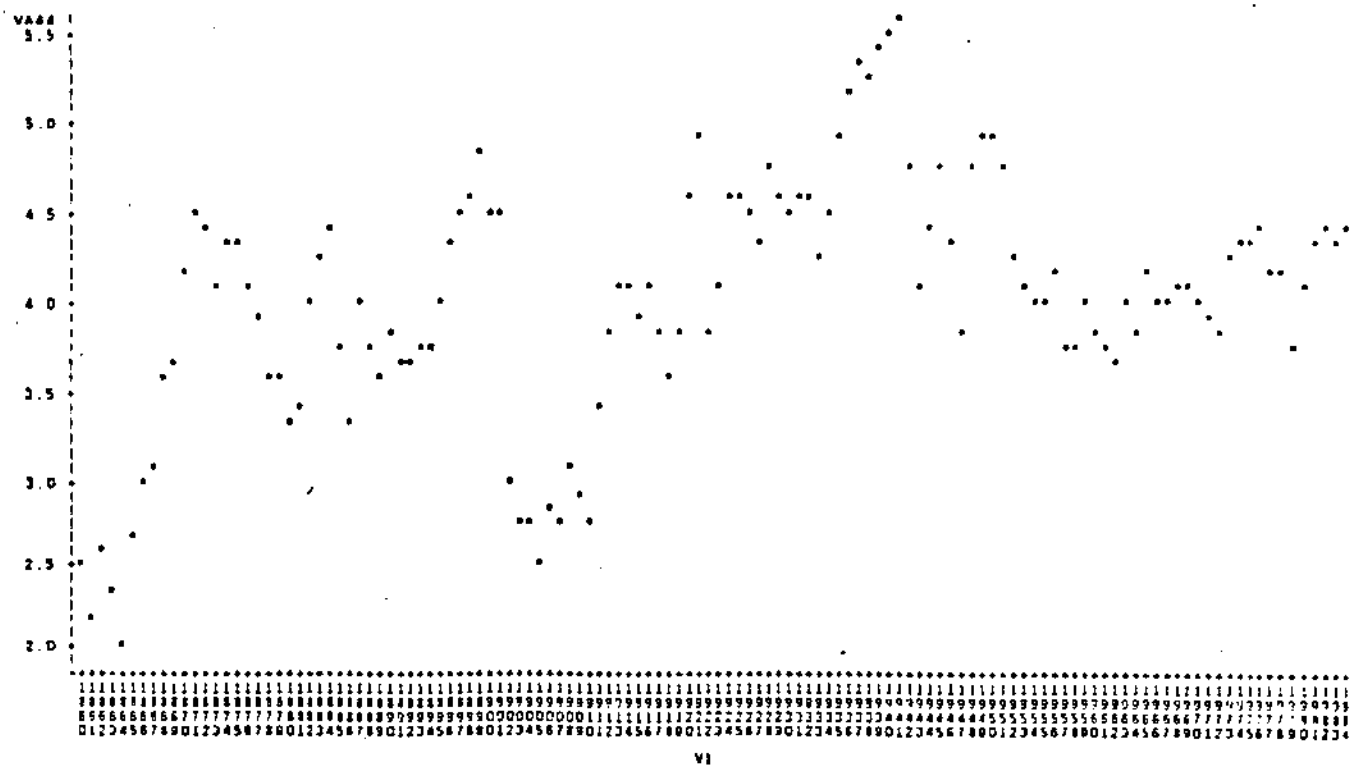
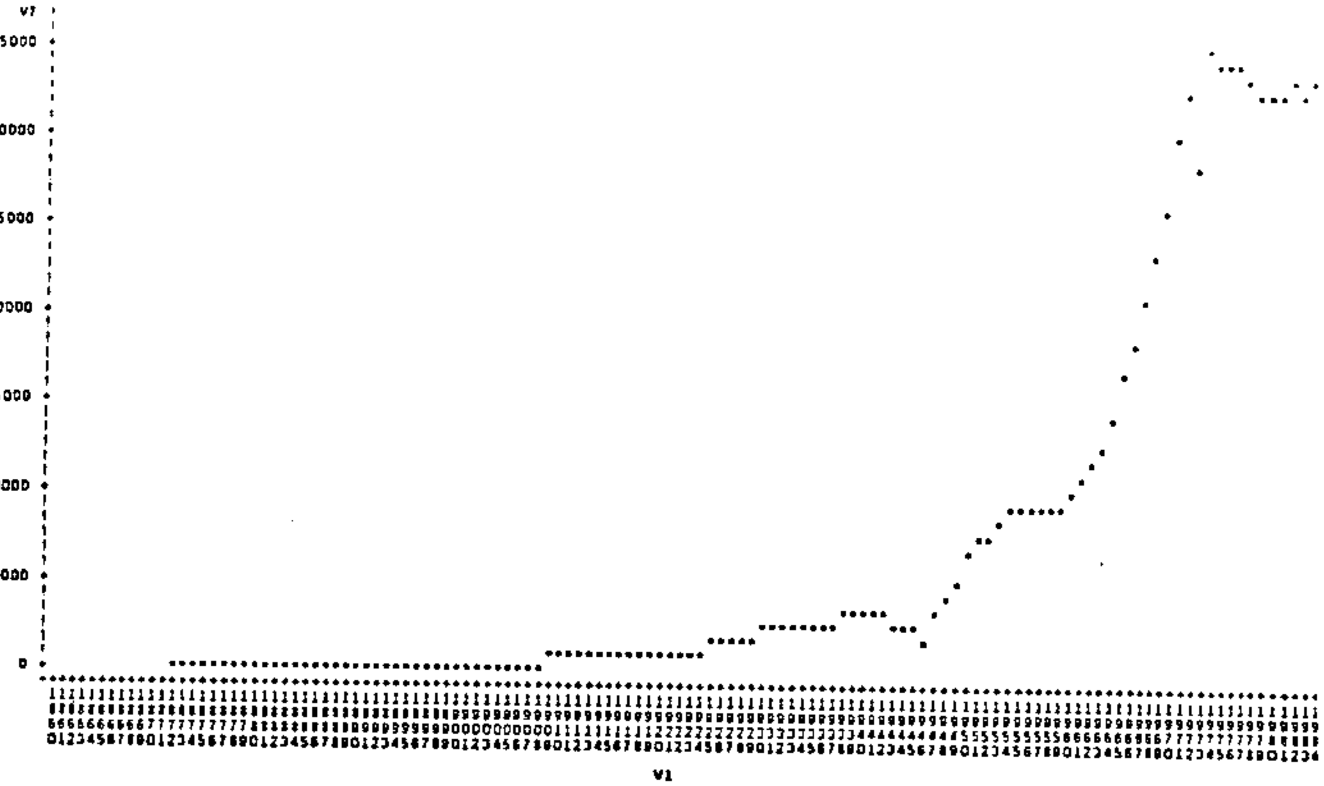
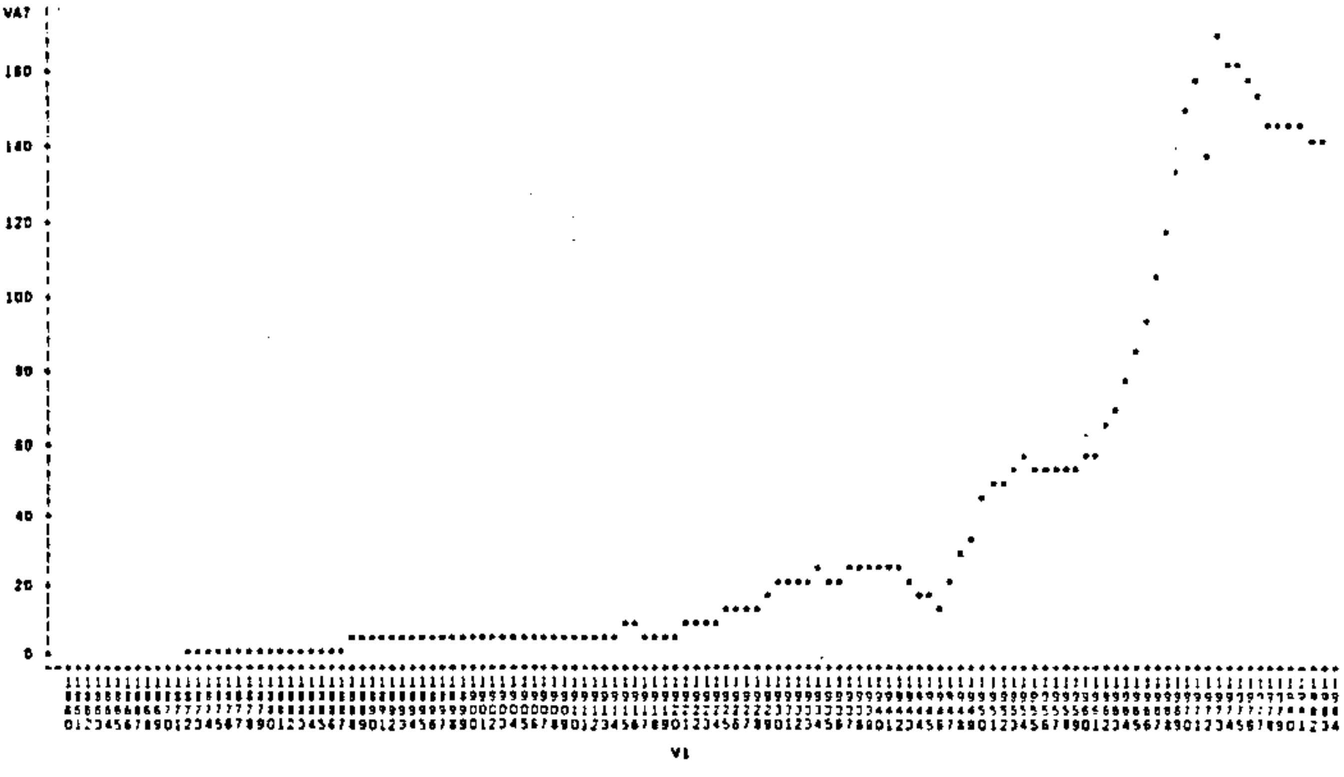
BY POPULATION VS TIME



DOCTORATES DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



DOCTORATES DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



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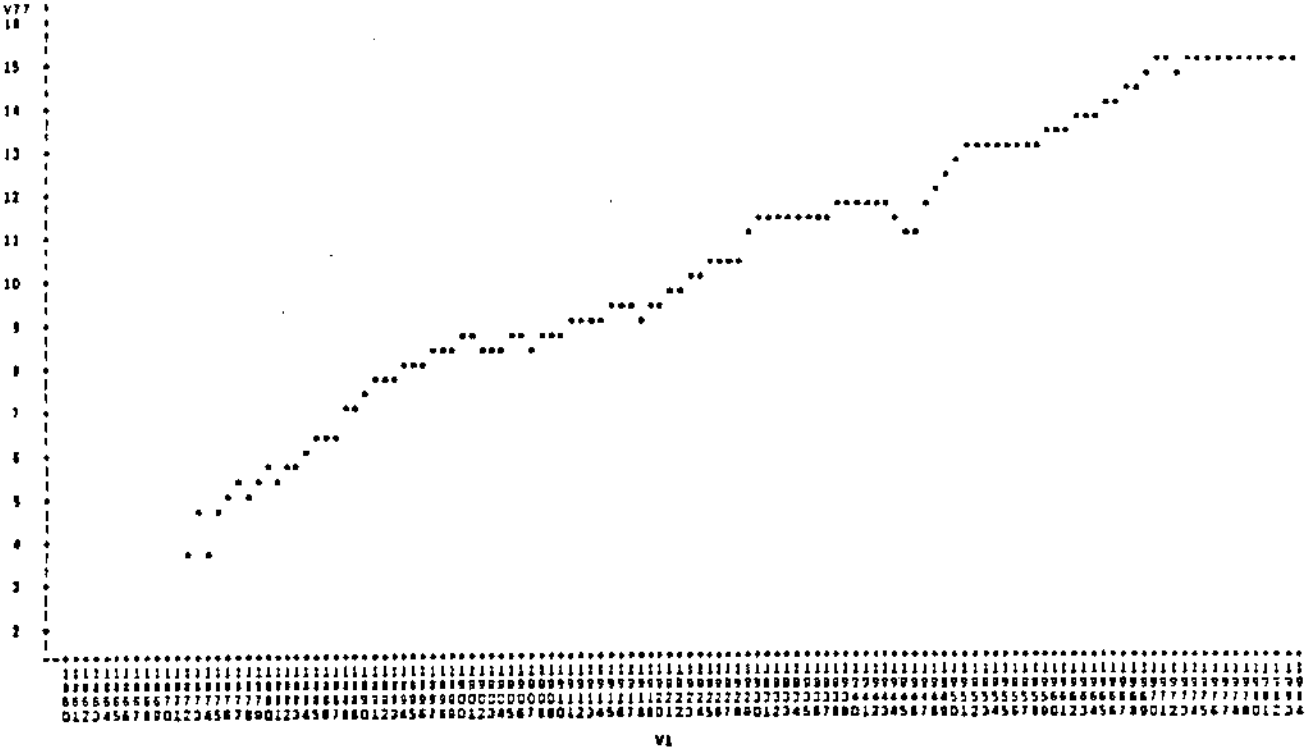
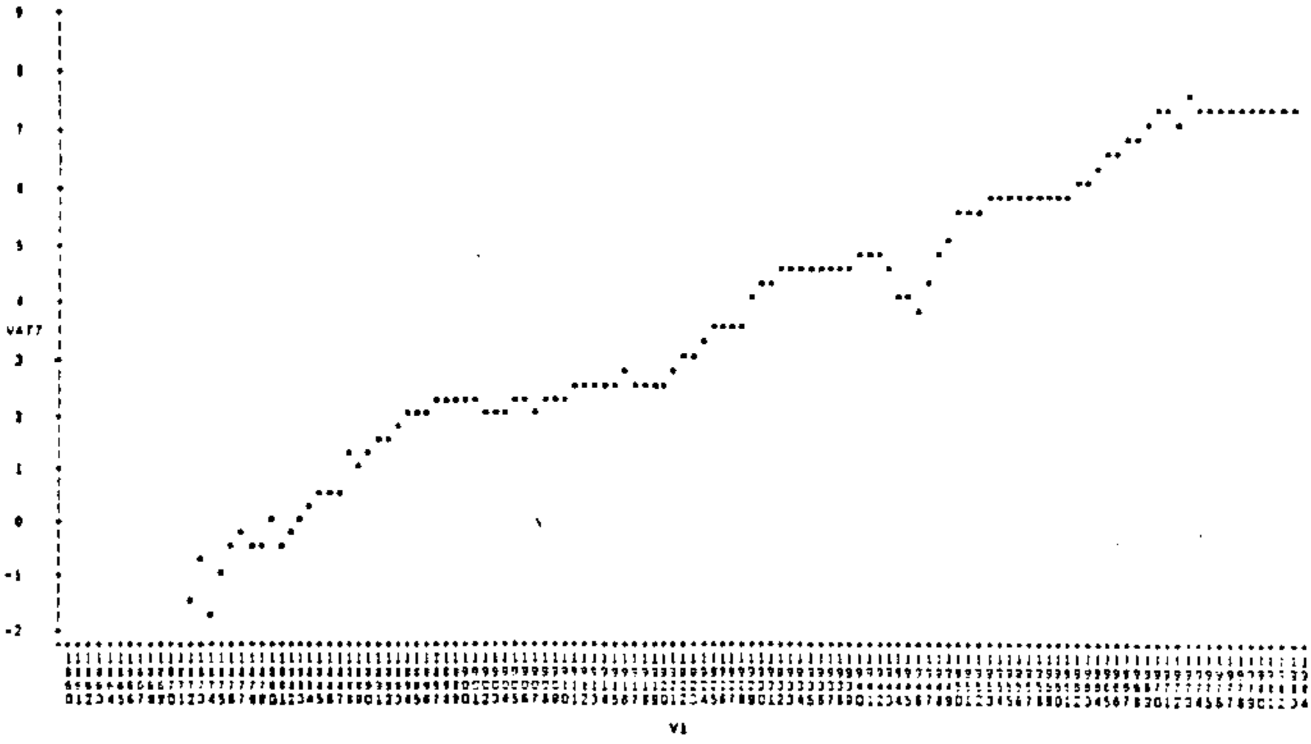
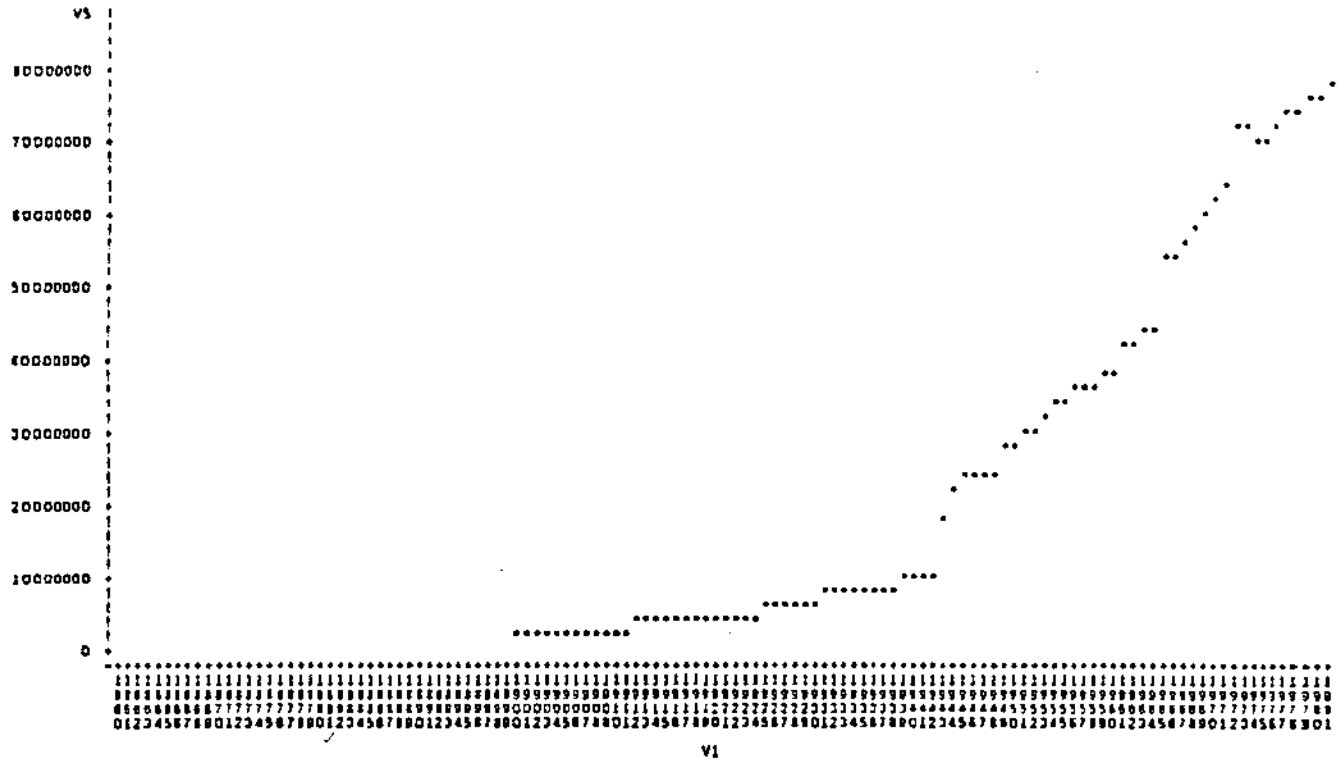
BY POPULATION VS TIME



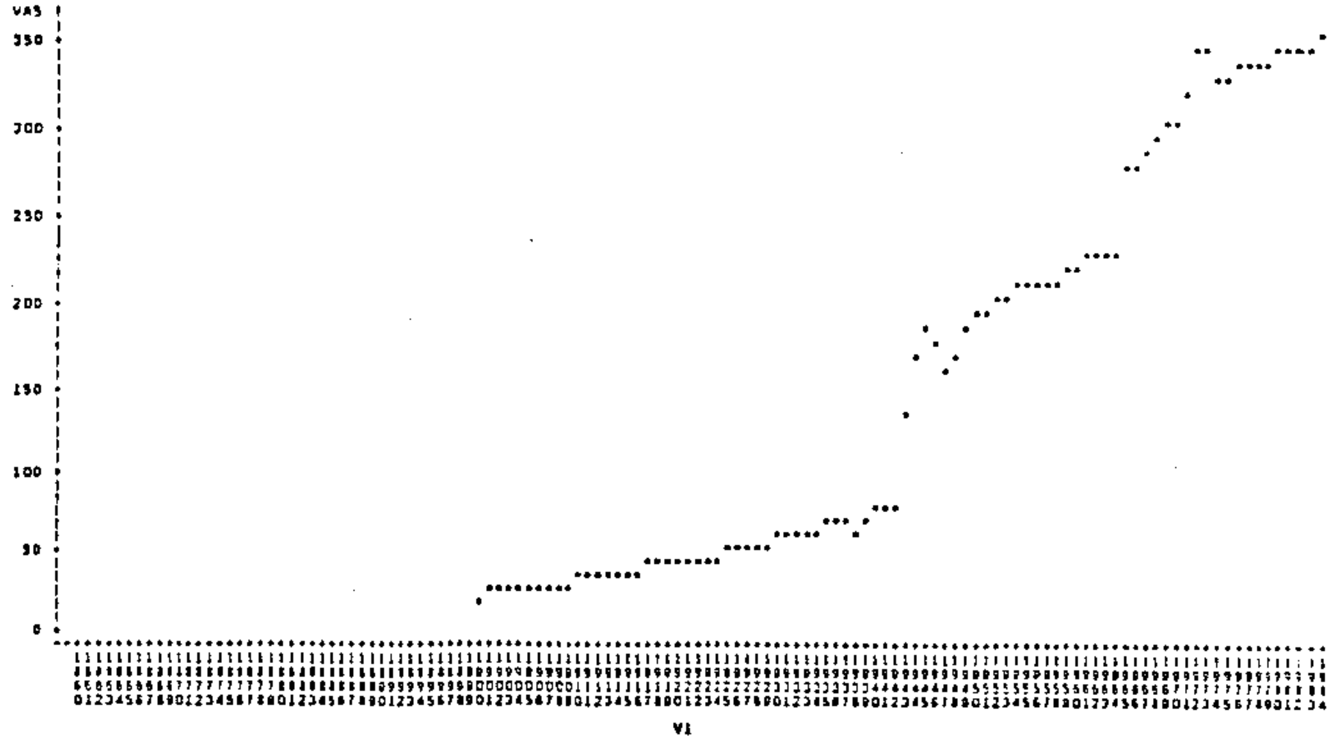
DOCTORATES DATA IN BITS AFTER ADJUSTMENT
BY POPULATION VS TIME



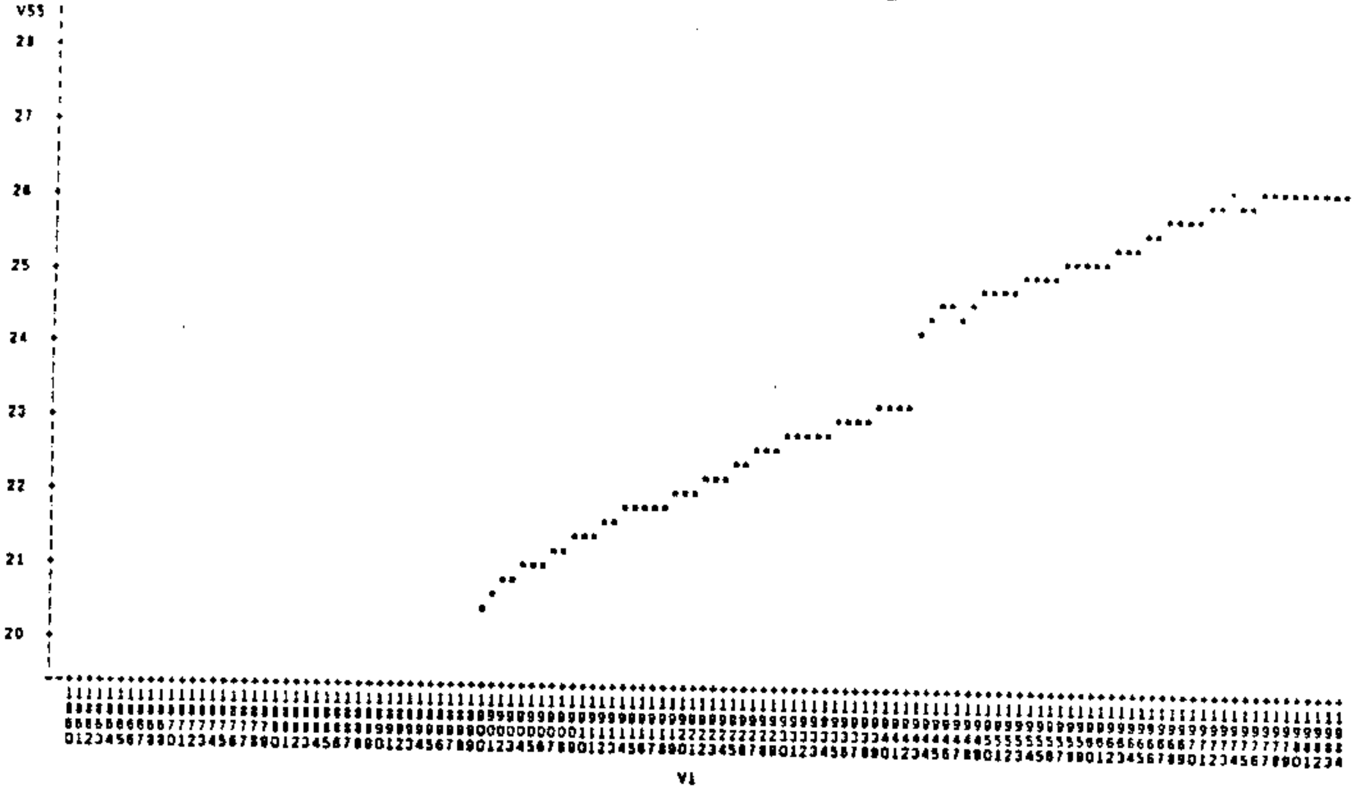
LC HOLDINGS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



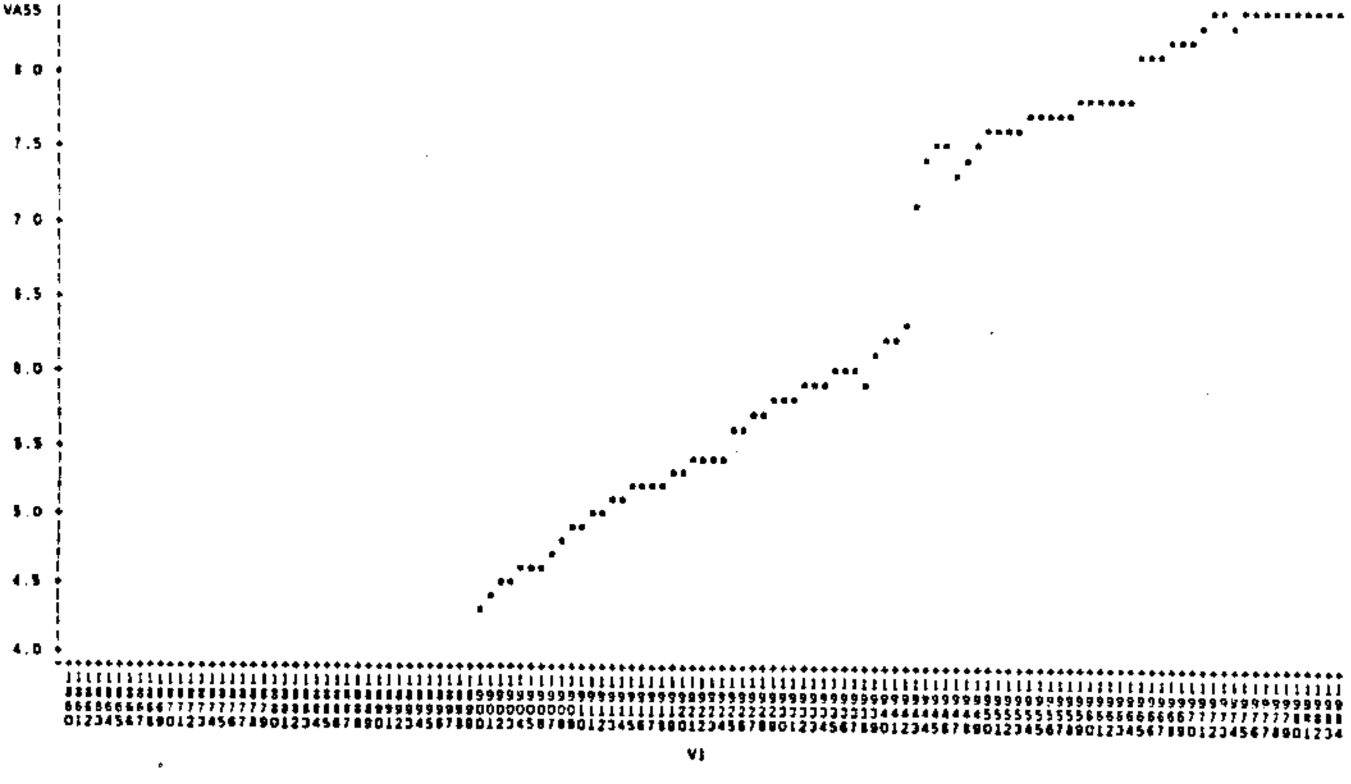
LC HOLDINGS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



LC HOLDINGS DATA IN BITS BEFORE ADJUSTMENT
BY POPULATION VS TIME



LC HOLDINGS DATA IN BITS AFTER ADJUSTMENT
BY POPULATION VS TIME



APPENDIX B

INFORMATION DISTRIBUTION VARIABLES DATA AND GRAPHS

Legends Used:

(TP) = Time Period

(ASRB) = AM Radio Stations Raw Data Before Adjustment by Population

(CFRB) = Commercial FM Radio Stations Raw Data Before Adjustment by Population Growth

(NFRB) = Non-Commercial FM Radio Stations Raw Data Before Adjustment by Population

(CTRB) = Commercial TV Stations Raw Data Before Adjustment by Population

(NTRB) = Non-Commercial TV Stations Raw Data Before Adjustment by Population

(CARB) = Cable TV Systems Raw Data Before Adjustment by Population

(PHRB) = Phones Raw Data Before Adjustment by Population

(MWRB) = Miles of Wires Raw Data Before Adjustment by Population

(PORB) = Post Offices Raw Data Before Adjustment by Population

(ASRA) = AM Radio Stations Raw Data After Adjustment by Population

(CFRA) = Commercial FM Radio Stations Raw Data After Adjustment by Population Growth

(NFRA) = Non-Commercial FM Radio Stations Raw Data After Adjustment by Population

(CTRA) = Commercial TV Stations Raw Data After Adjustment by Population

(NTRA) = Non-Commercial TV Stations Raw Data After Adjustment by Population

(CARA) = Cable TV Systems Raw Data After Adjustment by Population

(PHRA) = Phones Raw Data After Adjustment by Population

(MWRA) = Miles of Wires Raw Data After Adjustment by Population

(PORA) = Post Offices Raw Data After Adjustment by Population

INFORMATION DISTRBUTION DATA BEFORE ADJUSTMENT BY POPULATION

(TP)	(ASRB)	(CFRB)	(NFRB)	(CTRB)	(NTRB)	(CARB)	(PHRB)	(MWRB)	(PORB)
1860									28498
1861									28588
1862									28875
1863									29047
1864									28878
1865									28882
1866									29388
1867									25163
1868									26481
1869									27106
1870									28492
1871									30045
1872									31863
1873									33244
1874									34294
1875									35547
1876							3		36383
1877							9		37745
1878							28		38253
1879							31		40588
1880							54		42989
1881							71		44512
1882							98		46231
1883							124		46820
1884							148		48434
1885							158		51252
1886							187		53814
1887							181		55157
1888							195		57376
1889							212		58998
1890							234		62401
1891							239		64329
1892							281		67119
1893							268		68403
1894							285	577	69805
1895							340	675	70064
1896							404	806	70380
1897							515	951	71022
1898							681	1159	73570
1899							1005	1519	75000
1900							1356	1962	76688
1901							1801	2445	76945
1902							2371	3282	75924
1903							2808	3989	74188
1904							3353	4671	71131
1905							4127	5780	68131
1906							4933	7489	65600
1907							6119	8611	62858
1908							6484	9831	60704
1909							6998	10490	60144
1910							7835	11462	59580
1911							8349	12933	59237
1912							8730	14811	58729
1913							9543	16113	58020

INFORMATION DISTRBUTION DATA BEFORE ADJUSTMENT BY POPULATION

(TP)	(ASRB)	(CFRB)	(NFRB)	(CTRB)	(NTRB)	(CARB)	(PHRB)	(MWRB)	(PORB)
1914							10048	17478	56810
1915							10524	18508	58380
1916							11243	19850	55935
1917							13817	22610	55414
1918							14294	23348	54347
1919							14347	24163	53084
1920							15316	25377	52641
1921	1						18015	27788	52168
1922	30						16875	30617	51950
1923	558						17680	34524	51813
1924	530						18448	39894	51268
1925	571						18523	45474	50957
1926	528						20103	50881	50601
1927	881						19802	58823	50268
1928	877						17341	62193	49944
1929	808						17424	69519	49482
1930	818						16628	76248	49063
1931	812						16869	79238	48733
1932	804						16628	80491	48159
1933	598						16869	80281	47841
1934	593						17424	80118	46506
1935	623						18433	80458	45888
1936	656						19453	81925	45230
1937	704						19453	83391	44677
1938	743						19953	85295	44586
1939	778						20831	87411	44327
1940	847		3				21928	91273	44074
1941	897	49	7	2			23523	97208	43739
1942	825	42	6	10			24819	99708	43358
1943	812	48	7	8			26381	99400	42854
1944	924	52	8	8			26858	100271	42181
1945	955	53	12	9			27867	108813	41792
1946	1215	511	24	30			31811	107343	41751
1947	1795	918	38	88			34987	114850	41780
1948	2034	1020	46	108			38205	126424	41695
1949	2008	737	34	68			40708	135400	41607
1950	2144	691	82	104			43004	144264	41464
1951	2281	649	83	107			45636	152112	41193
1952	2355	629	92	108		70	48056	162120	40919
1953	2458	580	108	198	1	150	50373	173375	40909
1954	2583	553	117	402	8	300	52806	185809	39405
1955	2732	540	124	458	11	400	58243	201235	38318
1956	2888	530	126	498	20	450	60190	220154	37515
1957	3078	530	135	518	28	500	63624	243730	37012
1958	3283	948	147	898	32	525	68845	260464	36308
1959	3377	822	154	586	43	580	70820	282287	35750
1960	3483	741	189	578	47	640	74342	307878	35238
1961	3602	889	188	553	54	700	77432	327318	34855
1962	3745	1012	201	571	59	800	80988	348697	34797
1963	3880	1120	221	581	70	1000	84453	368584	34498
1964	3878	1181	243	582	78	1200	88793	394360	34040
1965	4025	1343	262	589	82	1325	83856	427623	33624
1966	4075	1515	291	613	108	1570	98787	453521	33121
1967	4135	1708	318	628	127	1770	103752	480308	32828

INFORMATION DISTRBUTION DATA BEFORE ADJUSTMENT BY POPULATION

(TP)	(ASRB)	(CFRB)	(NFRB)	(CTRB)	(NTRB)	(CARB)	(PHRB)	(MWRB)	(PORB)
1968	4203	1850	348	655	158	2000	109258	517250	32260
1969	4254	2018	375	680	177	2280	115222	553868	32064
1970	4288	2128	418	691	190	2490	120218	601912	32002
1971	4398	2368	520	796	217	2638	125141	646000	31847
1972	4422	2488	599	774	227	2849	132000	685000	31688
1973	4434	2560	680	785	237	2981	138000	752000	31385
1974	4487	2713	784	758	238	3158	144000	800000	31000
1975	4488	2847	850	758	256	3506	149000	832000	30754
1976	4525	2947	913	764	268	3681	155000	871000	30521
1977	4555	3101	1000	774	285	3832	162000	910000	30521
1978	4577	3208	1053	785	288	3875	169000	952000	30518
1979	4638	3300	1112	807	275	4150	176000	1018000	30499
1980	4688	3390	1158	844	288	4225	180000	1068000	30328
1981	4784	3570	1205	909	296	4375	182000	1113000	30247
1982	4838	3749	1255	975	303	4825	.	1152000	30155
1983	4938	4090	1348	1181	322	5600	.	1181000	29990
1984				.	.	6200	.	.	29850

INFORMATION DISTRBUTION DATA AFTER ADJUSTMENT BY POPULATION

(TP)	(ASRA)	(CFRA)	(NFRA)	(CTRA)	(NTRA)	(CARA)	(PHRA)	(MWRA)	(PORA)
1860									903.81
1861									883.62
1862									870.04
1863									853.67
1864									828.33
1865									809.00
1866									804.34
1867									673.24
1868									692.98
1869									694.12
1870									714.00
1871									733.91
1872									759.15
1873									773.01
1874									778.70
1875									788.65
1876							0.0851		789.10
1877							0.1909		792.20
1878							0.5397		794.06
1879							0.8300		824.83
1880							1.0744		855.30
1881							1.3775		863.81
1882							1.8553		875.24
1883							2.2921		865.43
1884							2.6725		874.58
1885							2.7534		904.59
1886							2.8824		925.37
1887							3.057		931.44
1888							3.223		948.43
1889							3.432		955.08
1890							3.711		989.81
1891							3.713		999.50
1892							3.975		1022.13
1893							3.972		1021.40
1894							4.174	8.451	1022.41
1895							4.886	9.701	1006.98
1896							5.699	11.371	992.59
1897							7.134	13.174	983.83
1898							9.266	15.770	1001.03
1899							13.438	20.308	1002.69
1900							17.819	25.782	1007.73
1901							23.209	31.508	991.58
1902							28.839	41.439	958.64
1903							34.851	118.117	820.21
1904							40.791	58.825	885.34
1905							48.248	88.974	813.02
1906							57.783	87.459	768.15
1907							70.333	98.877	720.21
1908							73.100	110.834	684.37
1909							77.304	115.801	664.57
1910							82.630	124.048	644.81
1911							88.914	137.737	620.85
1912							91.605	153.318	616.25
1913							98.179	165.751	596.91

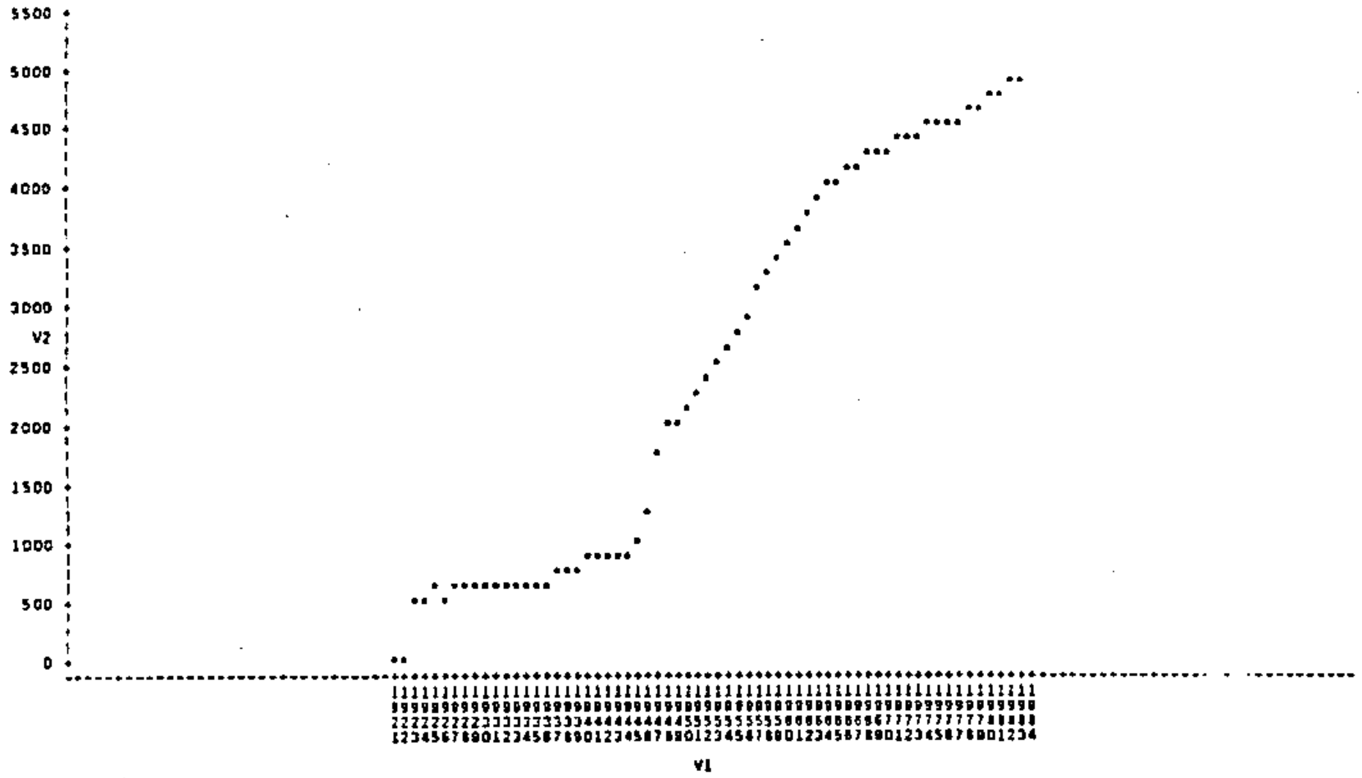
INFORMATION DISTRBUTION DATA AFTER ADJUSTMENT BY POPULATION

(TP)	(ASRA)	(CFRA)	(NFRA)	(CTRA)	(NTRA)	(CARA)	(PHRA)	(MWRA)	(PORA)
1914							101.372	178.35	573 259
1915							104.716	184 14	560 995
1916							110.208	194 81	548 382
1917							133.756	218 88	536 438
1918							138.508	228 25	526 618
1919							137 292	231 22	507 981
1920							143 812	238 28	494 282
1921	0 0092						147 604	255 91	480 811
1922	0 2725						153.270	278 08	471 844
1923	4 9843						157.857	308.25	460 830
1924	4 8450						161 685	348 64	449.308
1925	4.9309						159.957	392 89	440 043
1926	4 4974						171.235	433.23	431 014
1927	5 7227						164 723	477.50	422 403
1928	5 6183						143 809	518 12	414 473
1929	4.9754						143.054	570.78	406 258
1930	5.0203						135 077	619 40	398 562
1931	4 9315						135 931	638 51	392 691
1932	4 8397						133.237	644.98	385 889
1933	4 7611						134.307	638.18	379 307
1934	4 6915						137 848	633 84	367 927
1935	4 8840						144 800	632.03	358 889
1936	5 1210						151 858	639 54	353 084
1937	5 4858						151.033	847 45	348 474
1938	5 7242						153 721	657 13	343 498
1939	5 9435						159.137	887 77	338 833
1940	6 3925		0.02784				185 494	686 85	332 257
1941	8 7091	0 3885	0.05236	0 01488			175 924	727 05	327 143
1942	6 8722	0.3120	0.05944	0.07428			185.134	740 78	322.125
1943	6 7508	0.3553	0 05181	0.05922			195.270	735 75	315 722
1944	6.8007	0.3883	0.05875	0 08721			200.590	748 85	314 889
1945	7.1589	0 3973	0 08988	0 06747			208 898	815 69	313 283
1946	8 6354	3 6318	0.17058	0.21322			224 670	782 92	296.738
1947	12 4588	8.3706	0.28371	0.45802			241 964	797 02	289 798
1948	13.8850	6 9530	0 31357	0 73620			260.429	881 79	284.219
1949	1? 4380	4 9364	0.22773	0 46218			272.666	906 90	278 681
1950	14 1145	4 5490	0 40818	0 69466			283.107	949 73	272 969
1951	14 8117	4 2143	0 53898	0 69481			296 338	987 74	267 487
1952	15 0575	4 0217	0 58824	0 69054		0 4478	307.283	1036 57	261 830
1953	15 4591	3 6478	0 66887	1.24528	0.00829	0 9434	318.811	1090 41	257.288
1954	15 9543	3 4157	0.72267	2.48301	0 03708	1 8530	326.184	1147.68	243 391
1955	18.5475	3.2707	0 75108	2.77408	0.06863	2 4228	340 860	1218 87	232 078
1956	17.2278	3.1528	0 74859	2.95082	0.11898	2.8770	351.061	1308 88	223.171
1957	17.9848	3 0958	0.78855	3.03154	0.15187	2.8208	371.838	1423.66	218.192
1958	18.8847	3.1478	0.84434	3.18397	0.18380	3.0155	382.797	1486 08	208.547
1959	19 0883	3.5121	0 86957	3.19593	0.24780	3.1821	399.887	1583 94	201 883
1960	18.3500	4 1187	0.91667	3.21887	0.28111	3.5558	413.011	1710 42	195.767
1961	19 8831	4 8579	1.01839	3.02188	0.29508	3.8251	423.071	1788 63	191 011
1962	20 1561	5 4487	1.08181	3 07320	0.31755	4.3057	435 780	1885 97	187 282
1963	20 4775	5 9418	1.17241	3 08223	0.37135	5.3050	448.027	1955 41	183 013
1964	20 8058	8.3800	1.27158	3.04553	0 41340	8.2784	464.842	2083 63	178 127
1965	20 8010	8 9408	1.35401	3 04383	0 47545	6 8475	484 010	2184 10	173 767
1966	20 8333	7 7454	1 48773	3.13395	0.55215	8.0268	505 048	2318 81	169.330
1967	20 9387	8 6481	1 61013	3 18962	0 64304	8 9620	525.327	2431.94	165 195

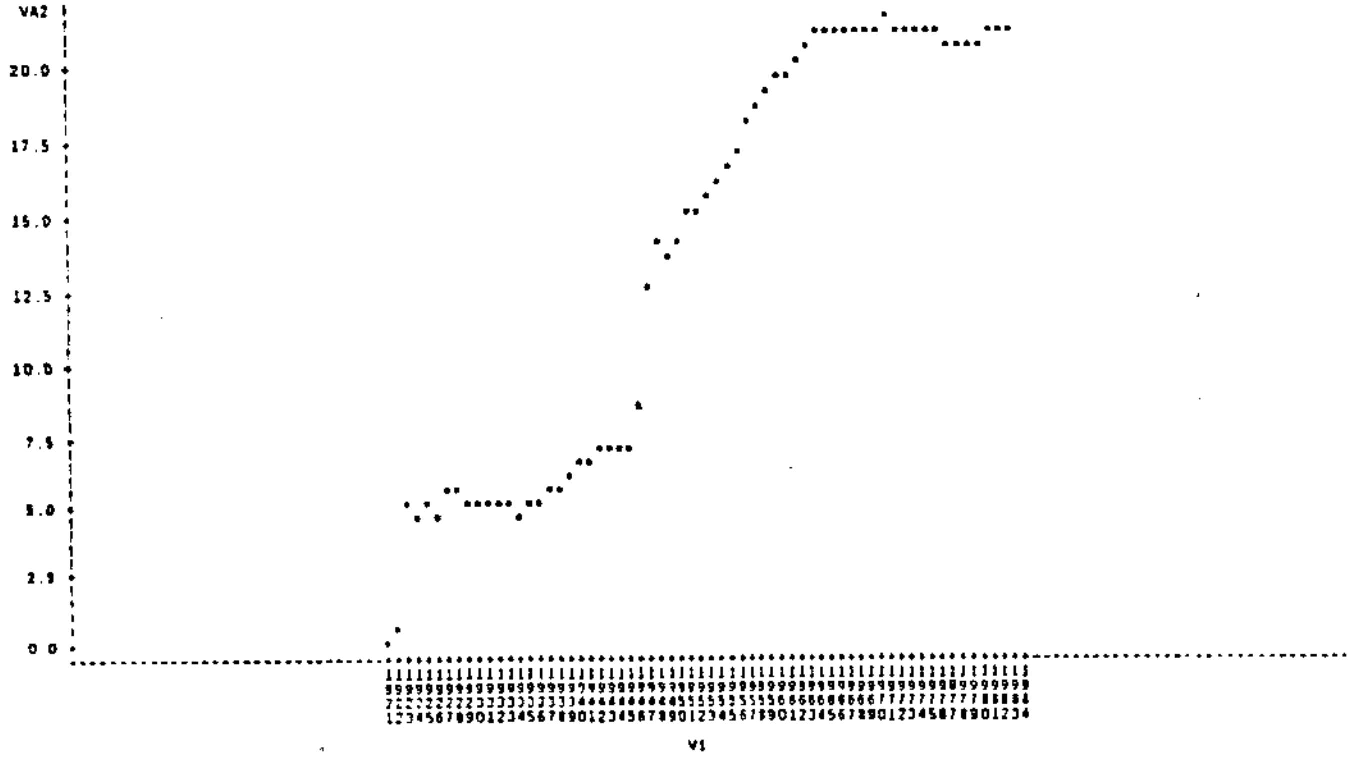
INFORMATION DISTRBUTION DATA AFTER ADJUSTMENT BY POPULATION

(TP)	(ASRA)	(CFRA)	(NFRA)	(CTRA)	(NTRA)	(CARA)	(PHRA)	(MWRA)	(PORA)
1968	21.0782	9.2778	1.74524	3.28485	0.78235	10.0301	547.924	2588.96	161.785
1969	21.1221	10.0189	1.88197	3.37637	0.87815	11.2214	572.105	2750.09	159.208
1970	21.0198	10.4218	2.03922	3.38725	0.93137	12.2059	589.304	2950.55	156.873
1971	21.2573	11.4507	2.51451	3.84813	1.04932	12.7611	605.131	3123.79	154.483
1972	21.1278	11.7917	2.86192	3.69804	1.08457	13.8120	630.874	3320.59	151.390
1973	20.9745	12.1097	3.21665	3.61873	1.12110	14.1485	652.791	3557.24	148.463
1974	20.9423	12.7192	3.58181	3.55837	1.11580	14.8054	675.105	3750.59	145.335
1975	20.8280	13.2111	3.94432	3.52204	1.18794	16.2681	691.415	3860.79	142.710
1976	20.7850	13.5432	4.19577	3.51103	1.23182	16.9184	712.318	4002.76	140.262
1977	20.7234	14.1083	4.54959	3.52138	1.20564	17.4340	737.034	4140.13	138.858
1978	20.8078	14.4349	4.74111	3.53444	1.20888	17.4471	760.919	4331.38	137.407
1979	20.8500	14.8928	4.95102	3.59305	1.22440	18.4773	783.615	4532.50	135.793
1980	20.6382	14.9208	5.08803	3.71478	1.26761	18.5960	792.254	4700.70	133.477
1981	20.7763	15.5691	5.25512	3.88424	1.29089	19.0788	783.720	4853.90	131.888
1982	20.8985	16.1944	5.42117	4.21169	1.30888	20.8423	.	4976.24	130.259
1983	21.1211	17.5011	5.76808	4.96791	1.37783	23.9623	.	5053.49	128.327
1984	.	.	.	.	.	26.3079	.	.	126.660

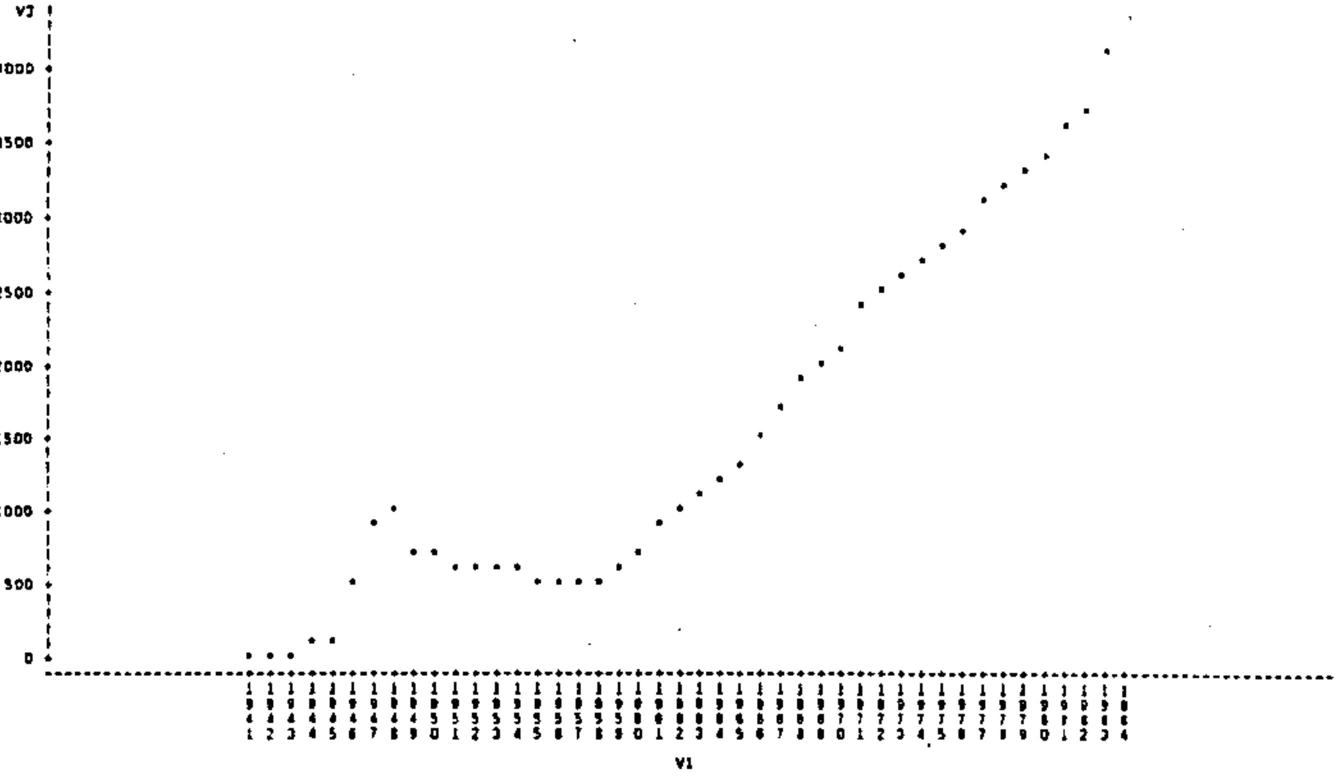
AM RADIO STATIONS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



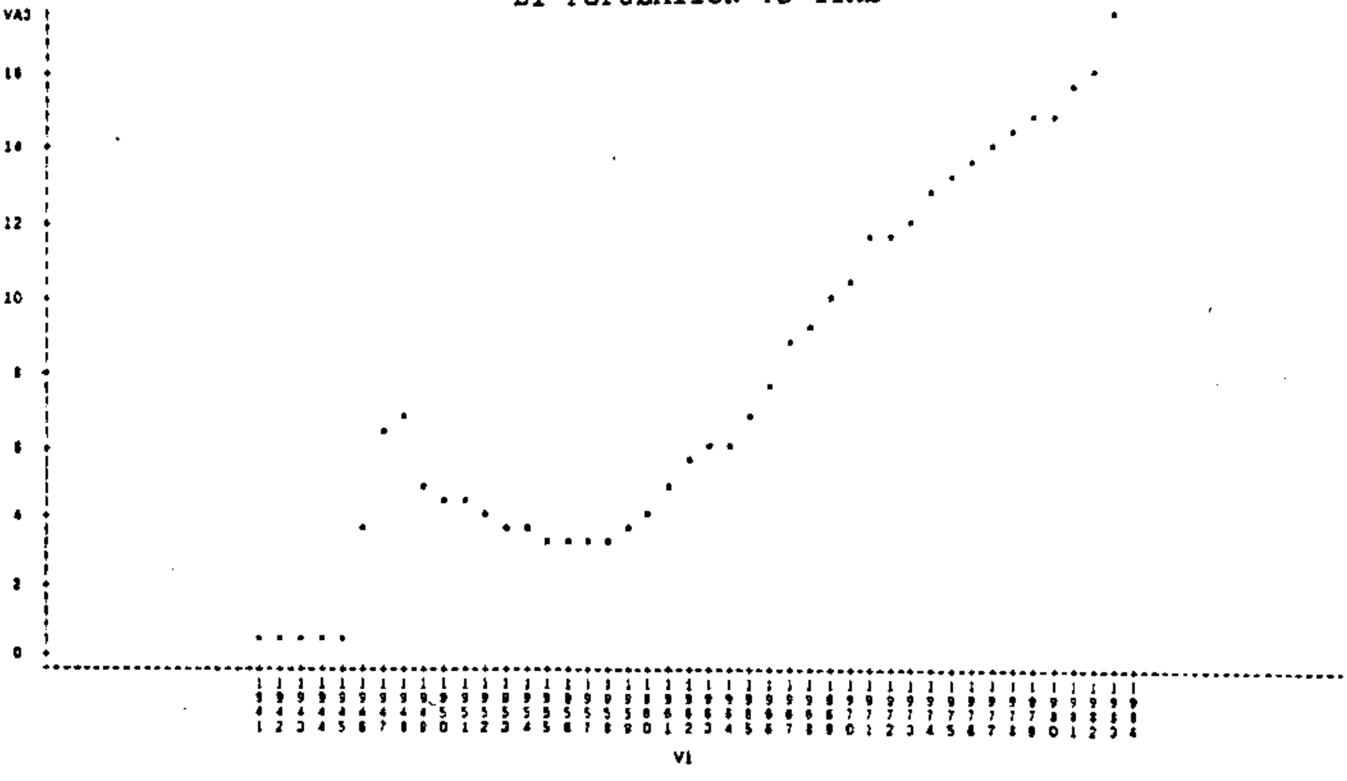
AM RADIO STATIONS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



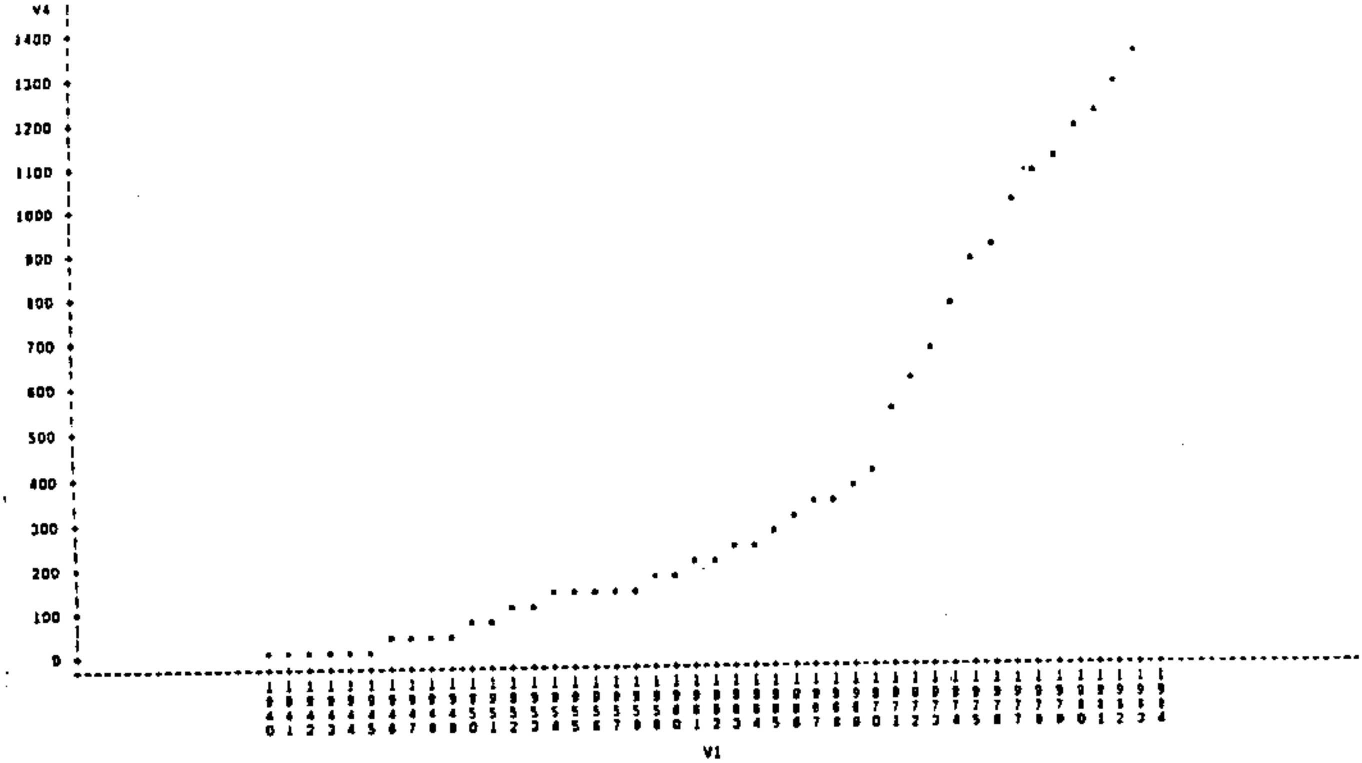
COMMERCIAL FM STATIONS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



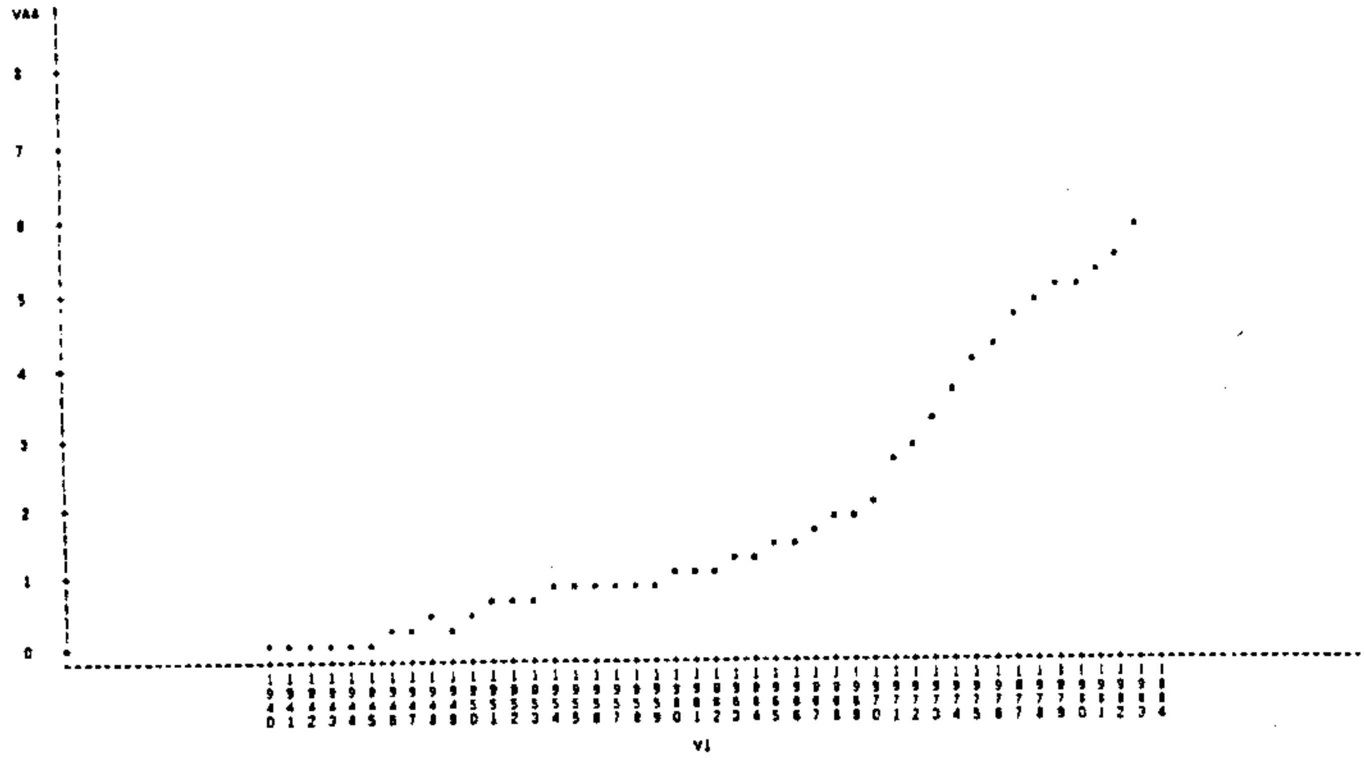
COMMERCIAL FM STATIONS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



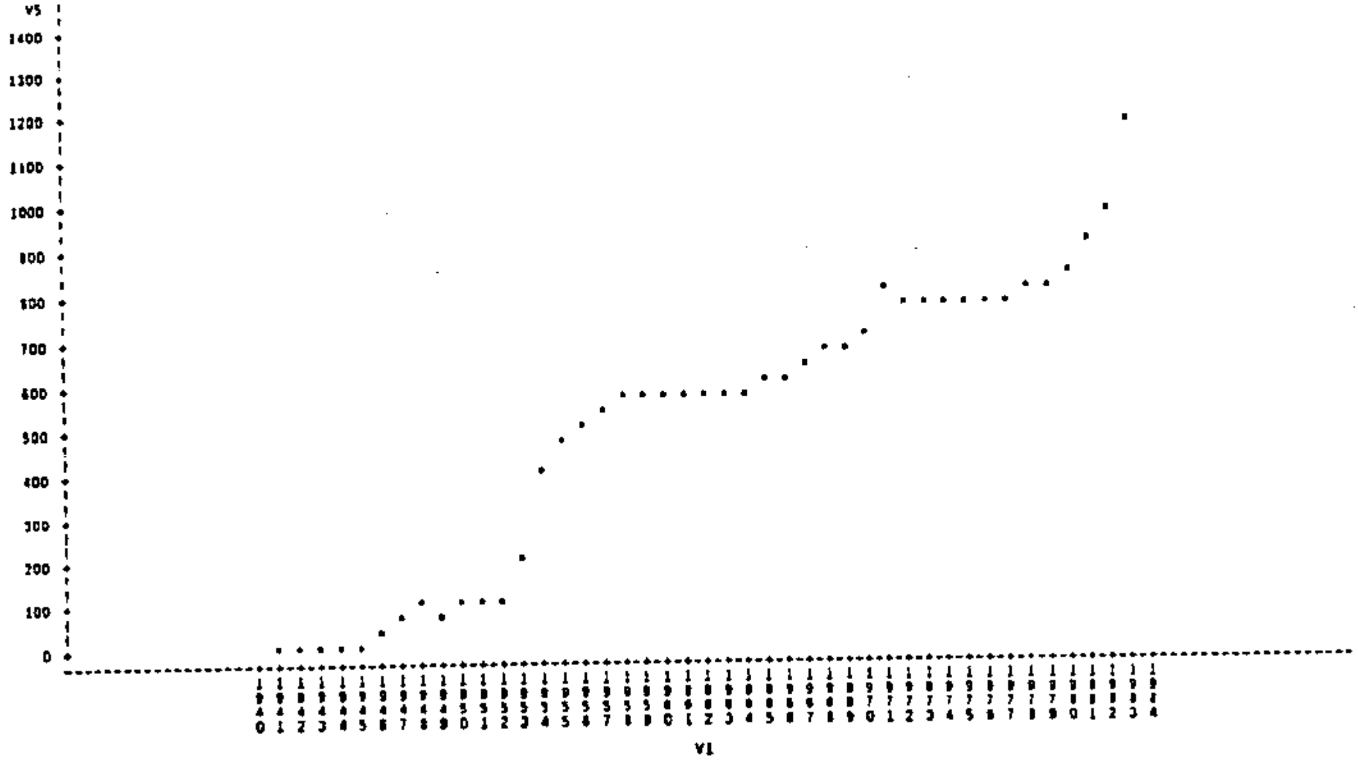
NON-COMMERCIAL FM STATIONS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



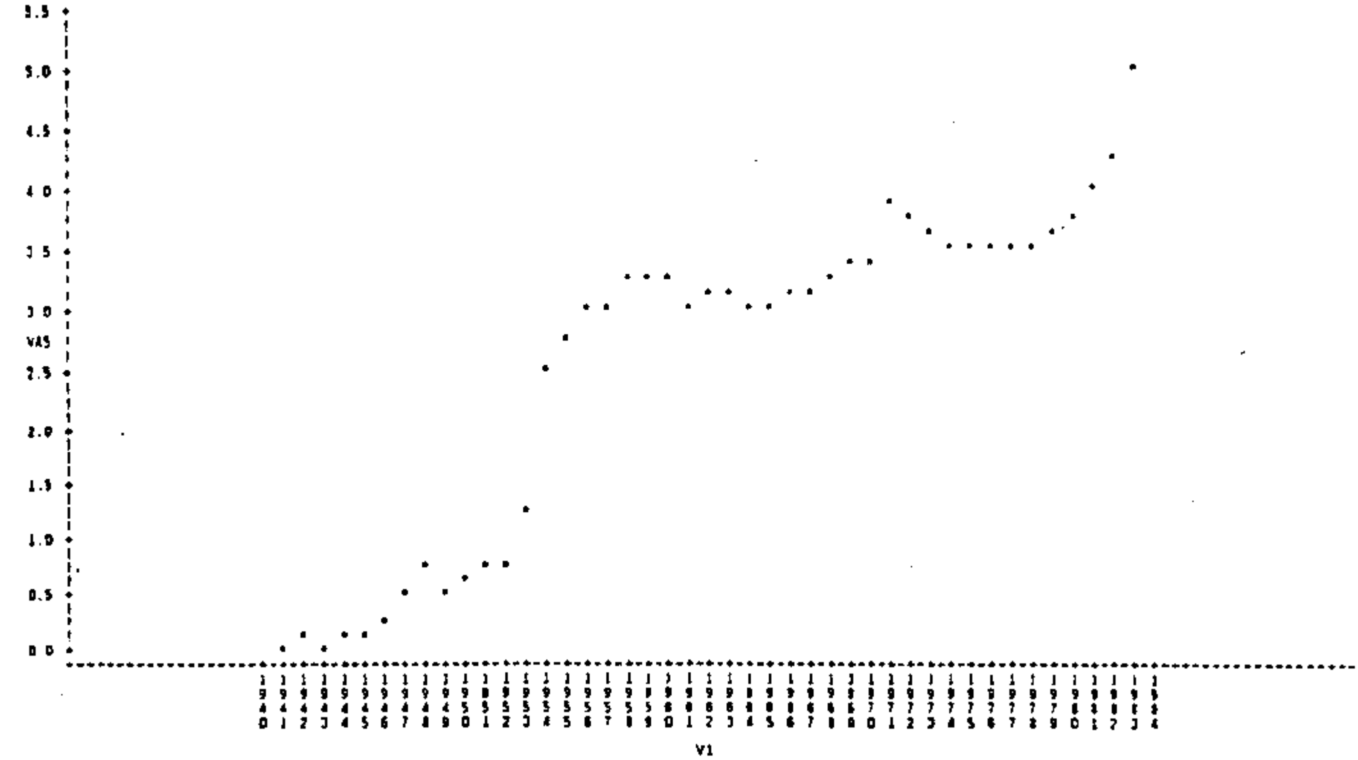
NON-COMMERCIAL FM STATIONS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



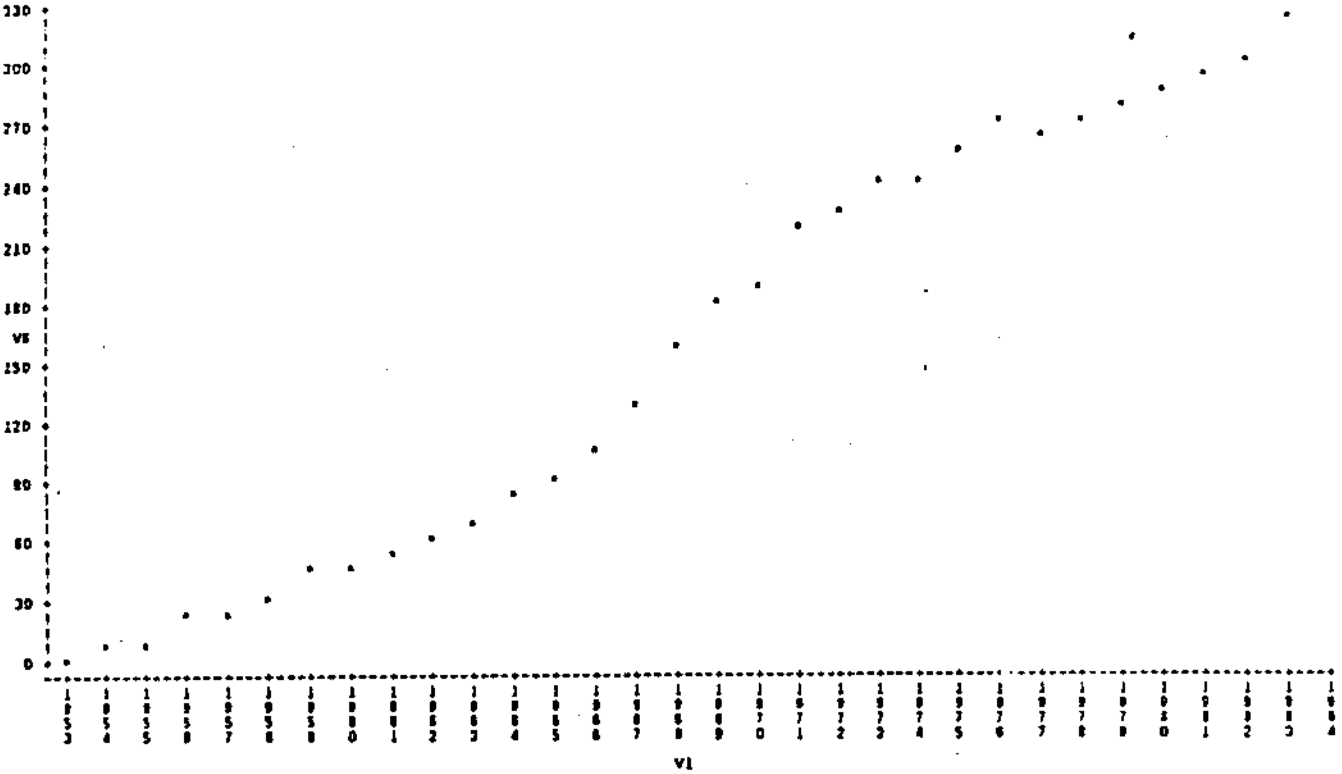
COMMERCIAL TV STATIONS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



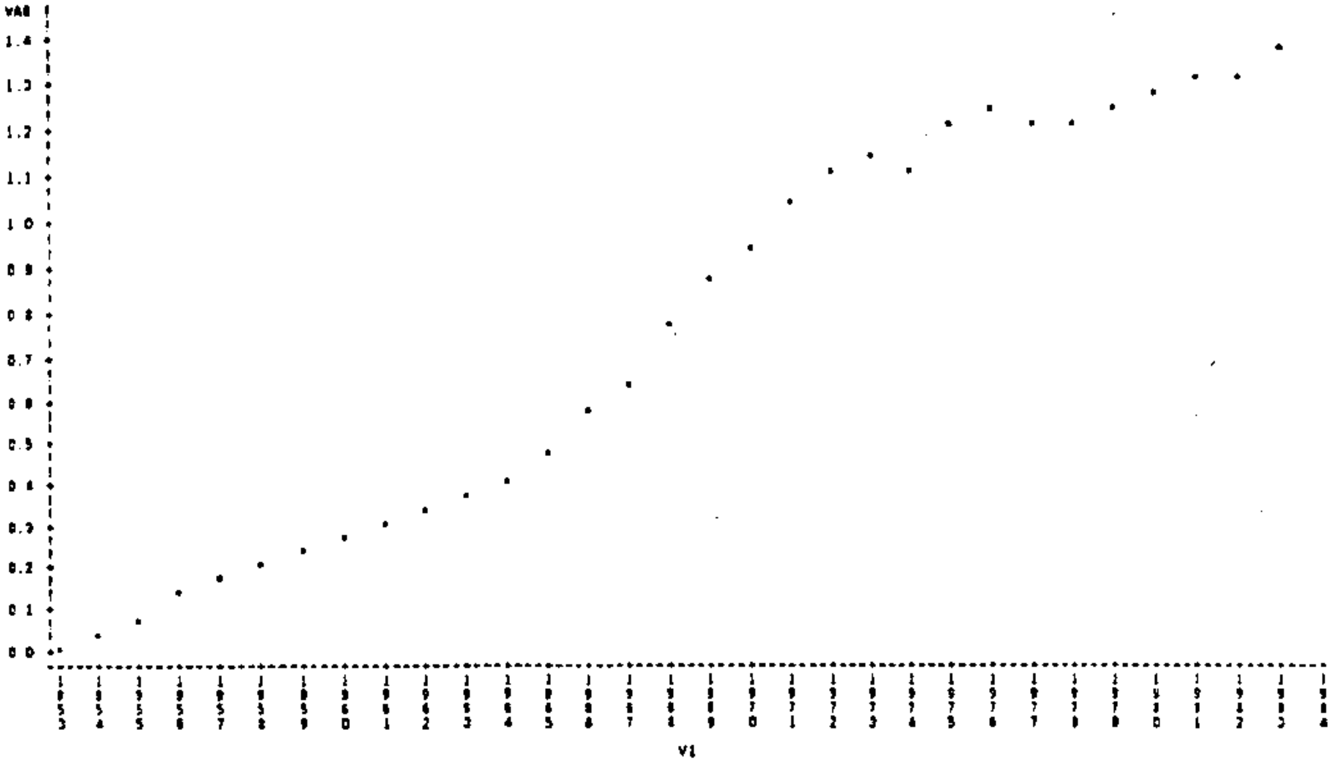
COMMERCIAL TV STATIONS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



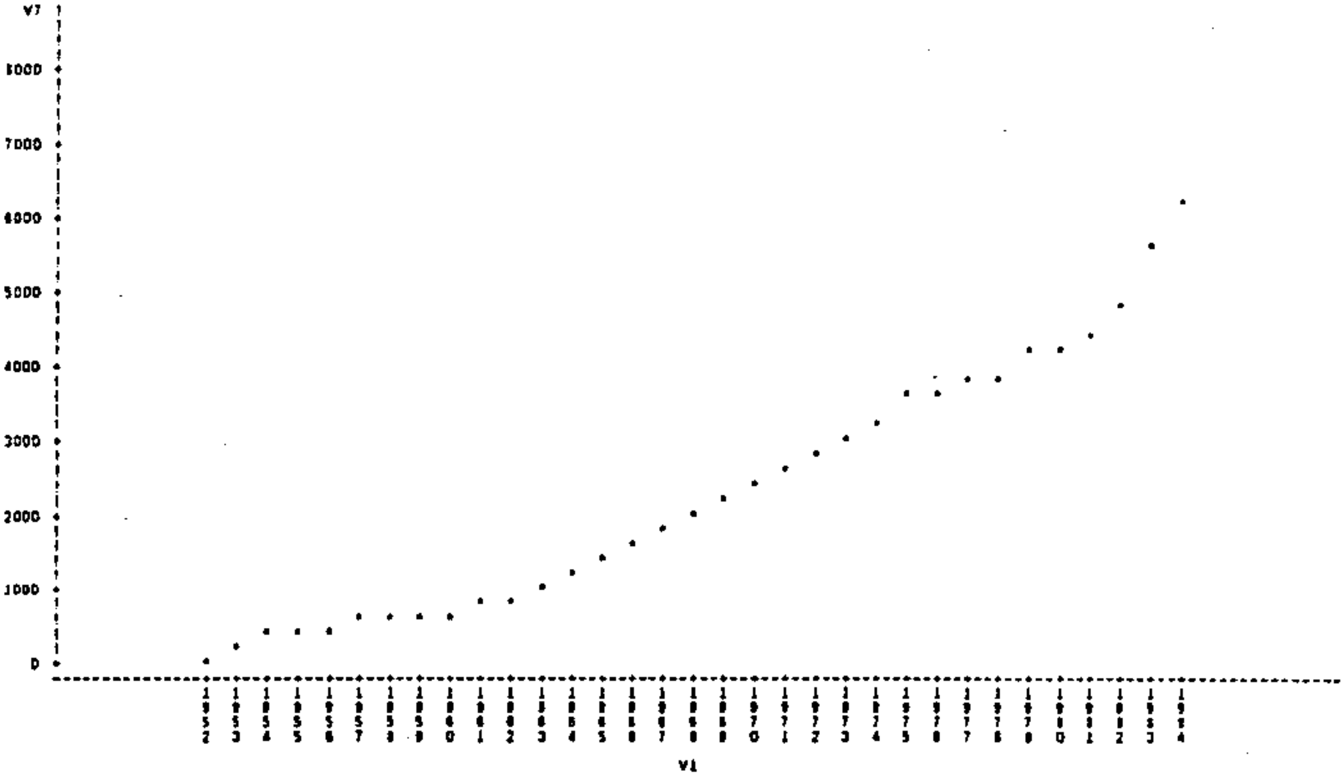
NON-COMMERCIAL TV STATIONS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



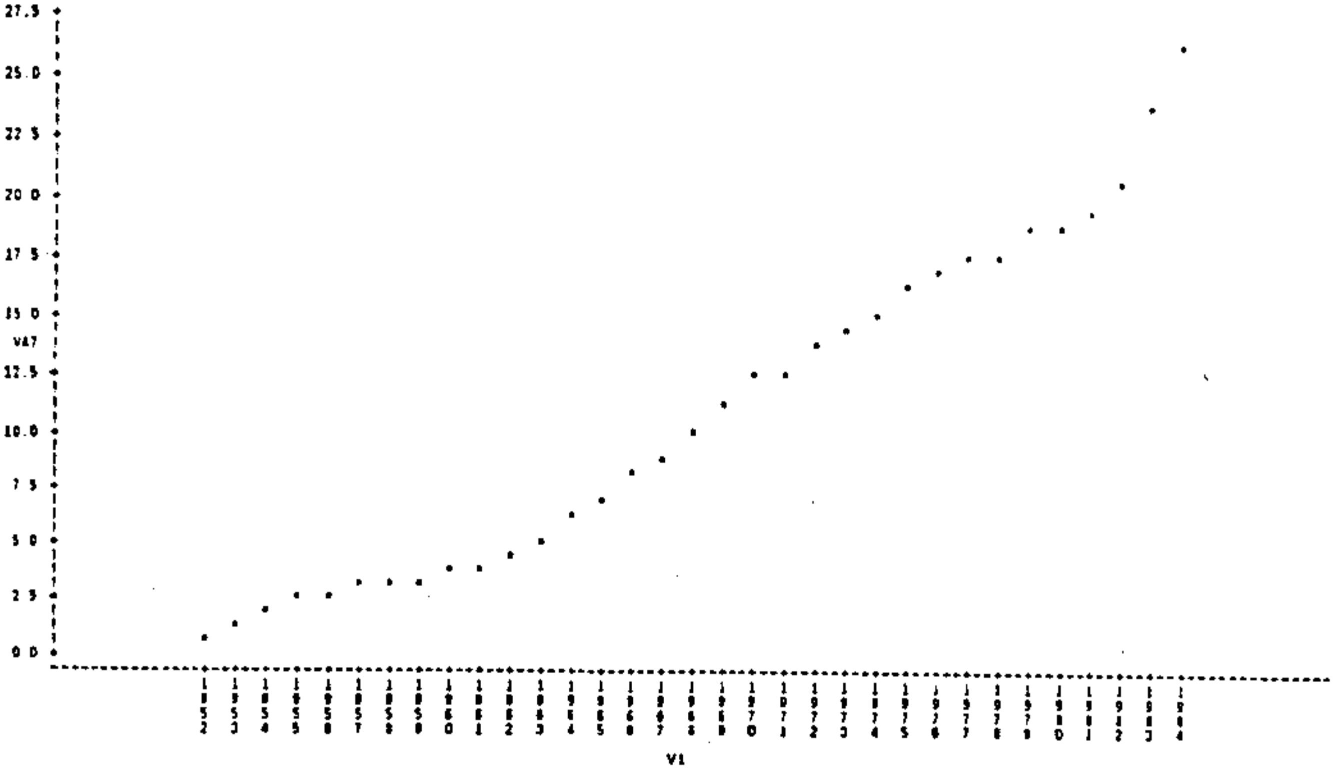
NON-COMMERCIAL TV STATIONS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



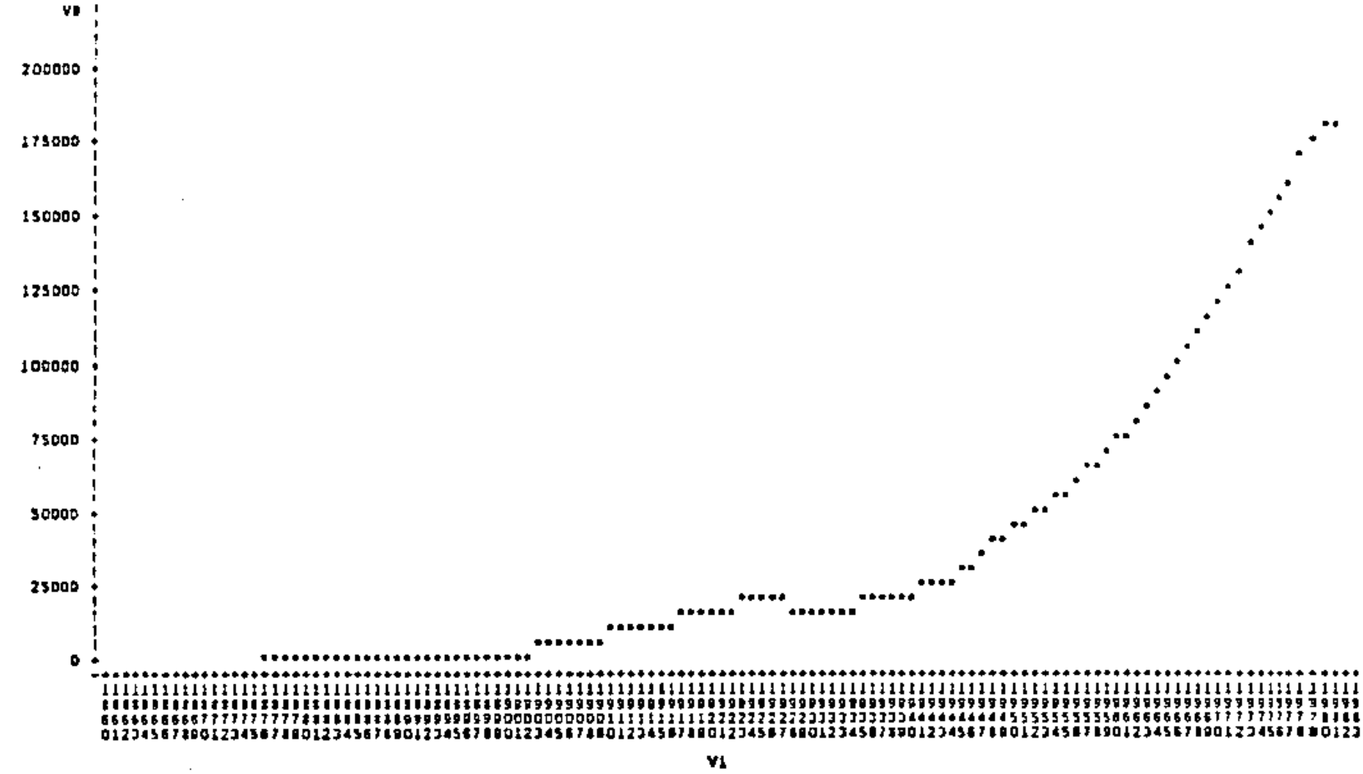
CABLE TV SYSTEMS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



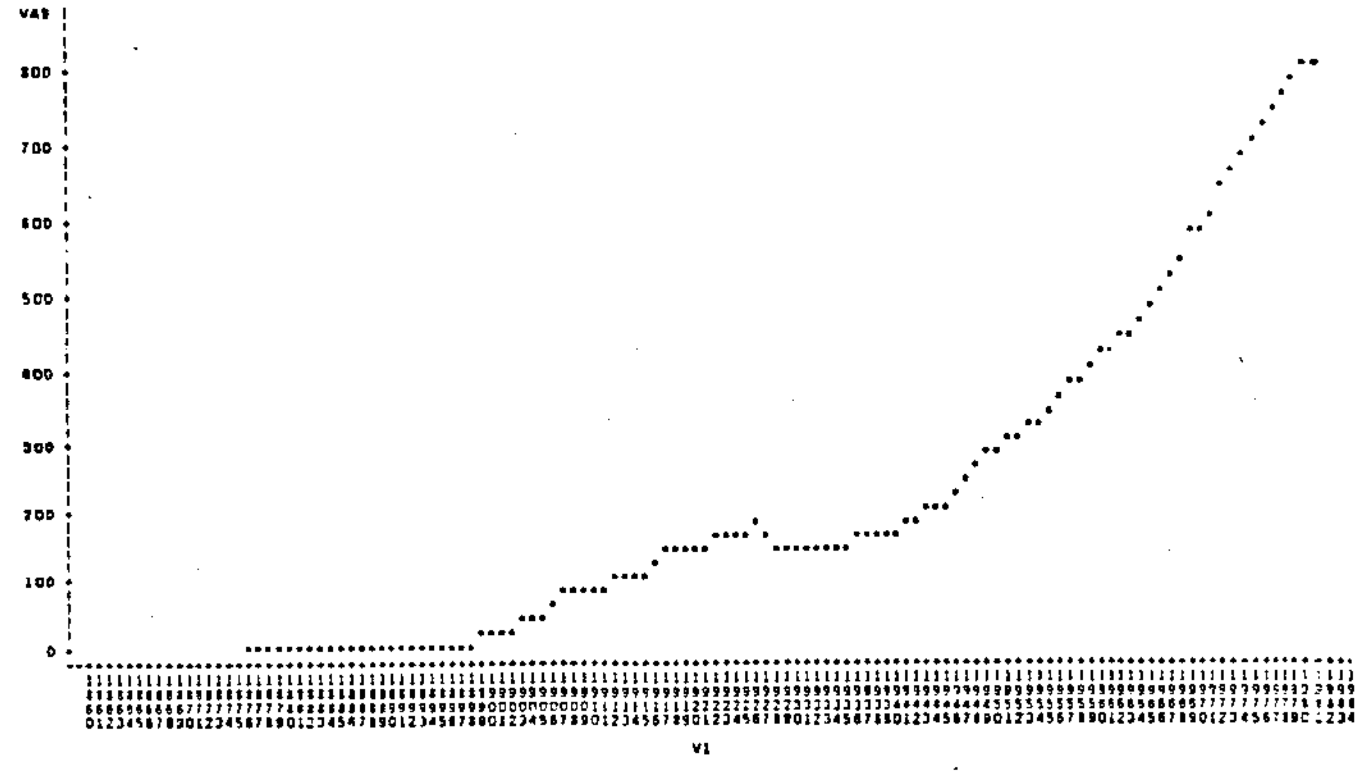
CABLE TV SYSTEMS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



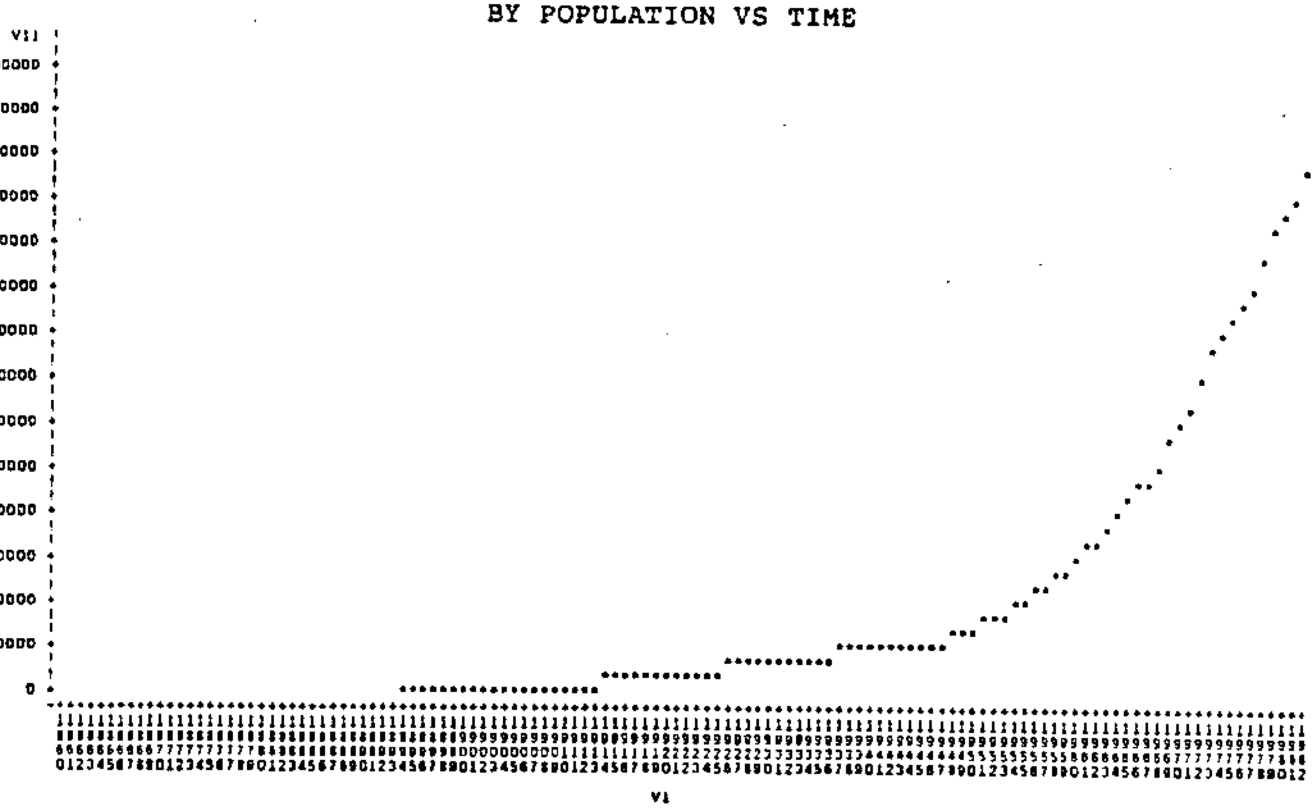
TELEPHONES DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



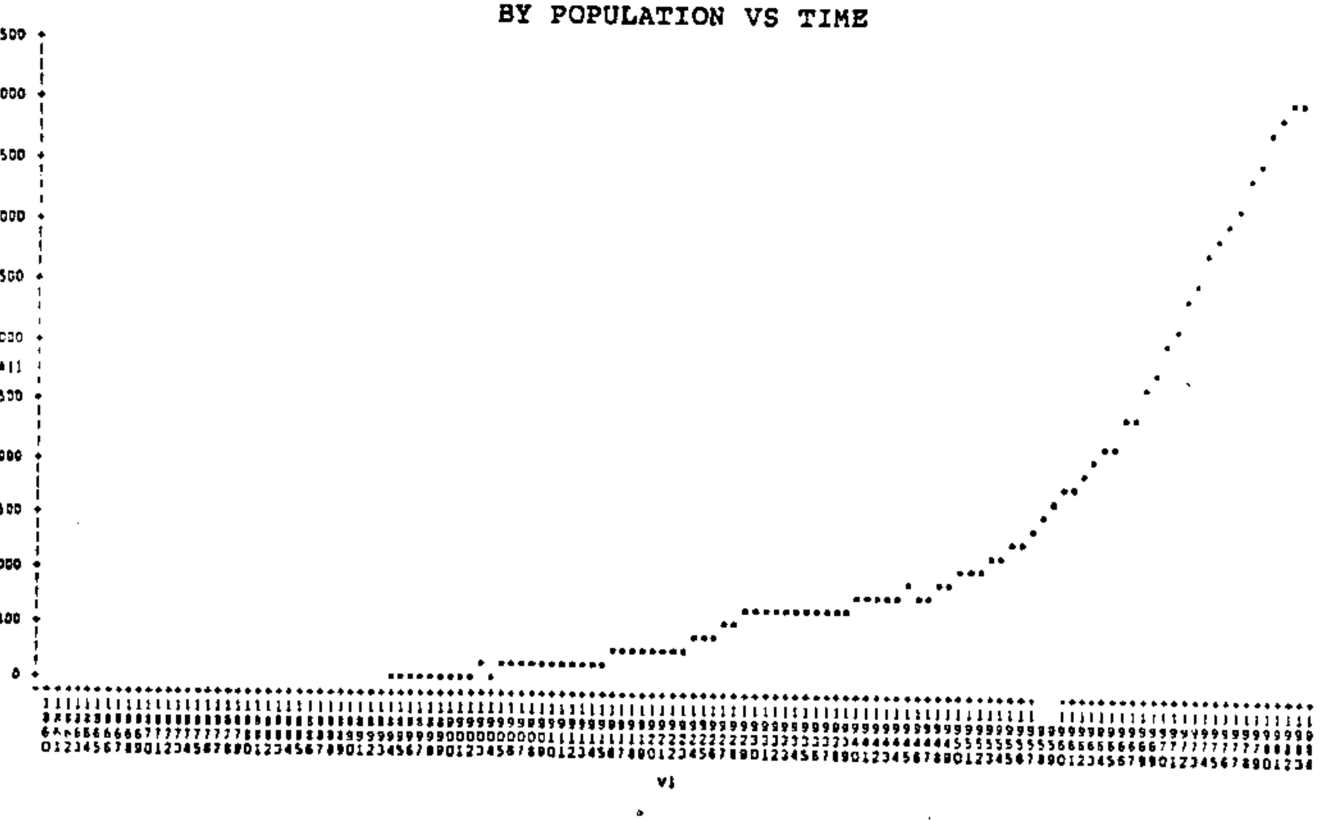
TELEPHONES DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



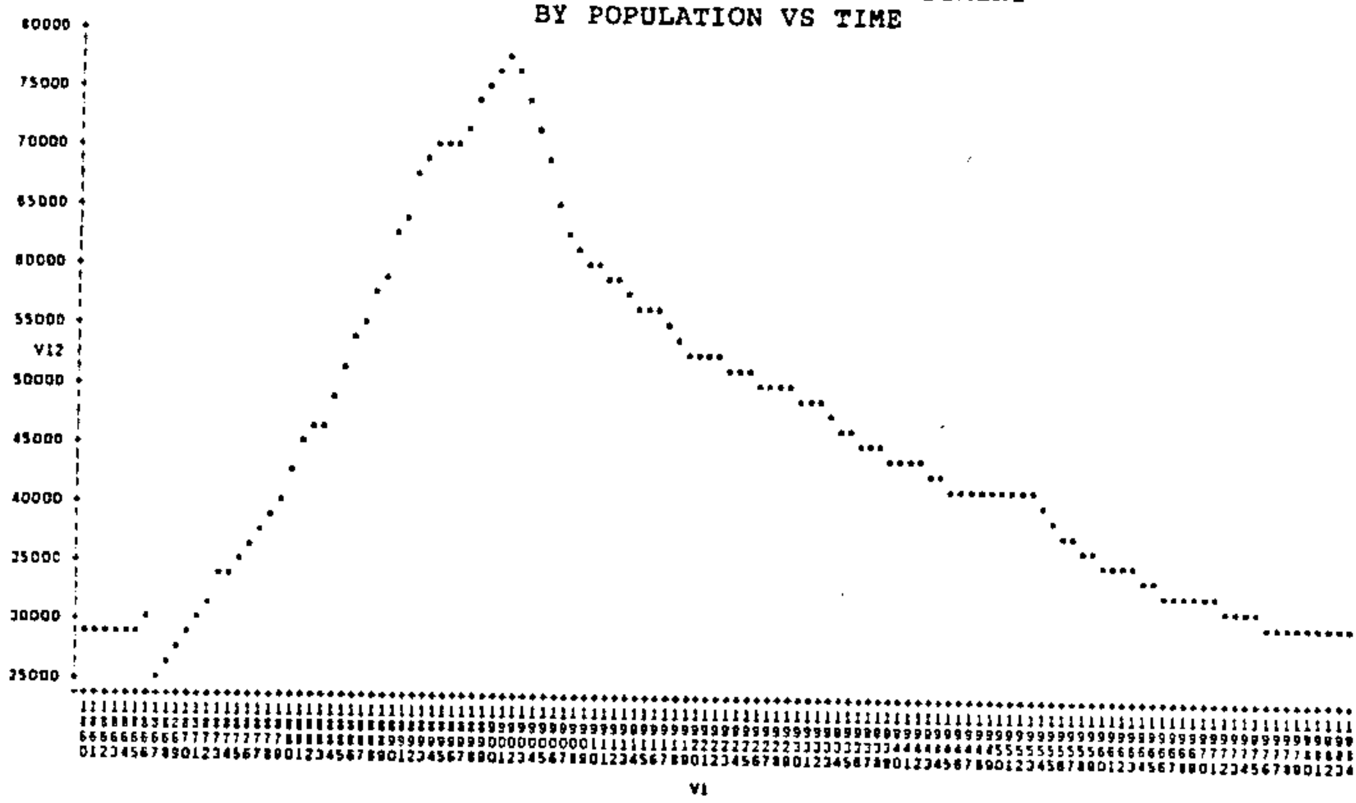
MILES OF WIRE DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



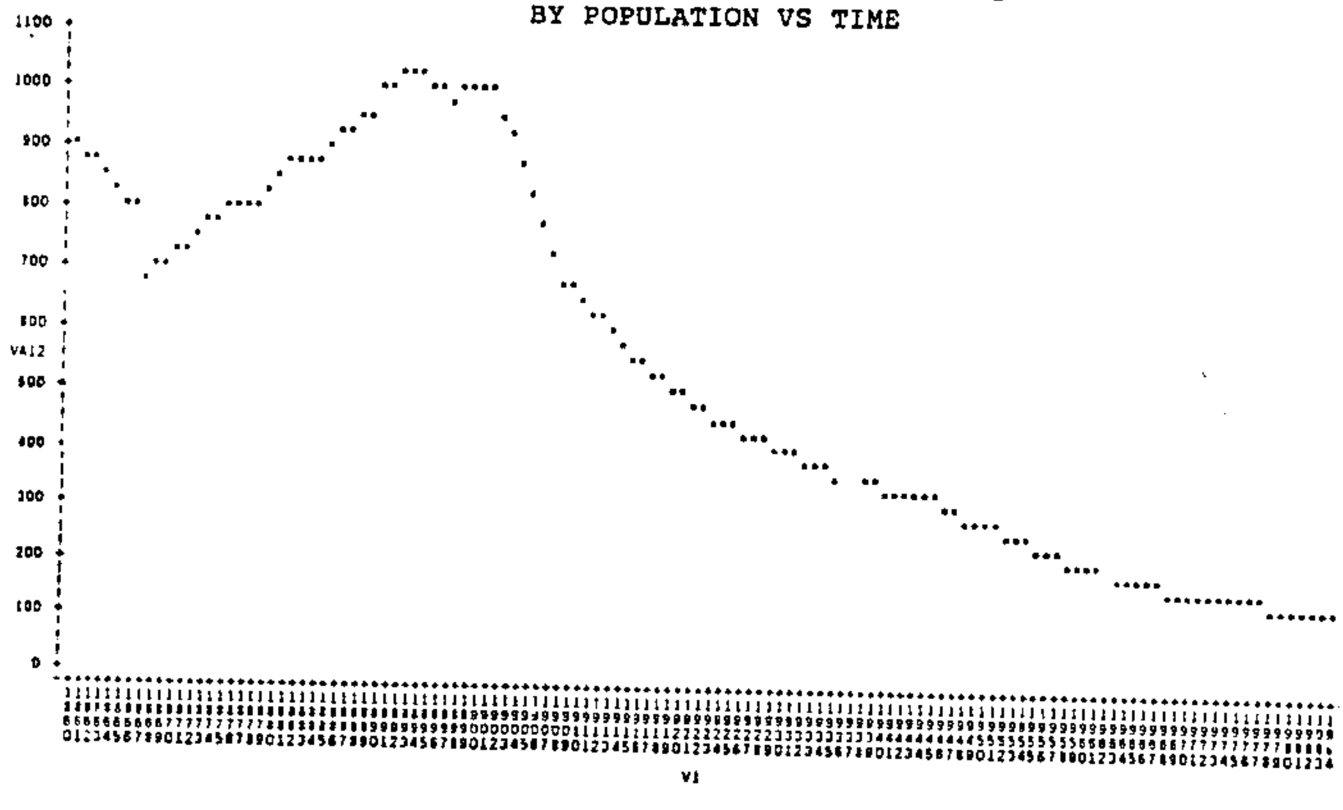
MILES OF WIRE DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



POST OFFICES DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



POST OFFICES DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



APPENDIX C

INFORMATION GENERATION VARIABLES DATA AND GRAPHS

Legends Used

(TP) = Time Period

(MHRB) = Matter Handled in Post Offices Raw Data Before Adjustment by Population

(NBRB) = Number of Books Raw Data Before Adjustment by Population

(PERB) = Periodicals Raw Data Before Adjustment by Population

(NERB) = Newspapers Raw Data Before Adjustment by Population

(NCRB) = Newspaper Circulation Raw Data Before Adjustment by Population

(ADRB) = Average Daily Conversation Raw Data Before Adjustment by Population

(RSRB) = Radio Sets Raw Data Before Adjustment by Population

(TSRB) = TV Sets Raw Data Before Adjustment by Population

(MHRA) = Matter Handled in Post Offices Raw Data After Adjustment by Population

(NBRA) = Number of Books Raw Data After Adjustment by Population

(PERA) = Periodicals Raw Data After Adjustment by Population

(NERA) = Newspapers Raw Data After Adjustment by Population

(NCRA) = Newspaper Circulation Raw Data After Adjustment by Population

(ADRA) = Average Daily Conversation Raw Data After Adjustment by Population

(RSRA) = Radio Sets Raw Data After Adjustment by Population

(TSRA) = TV Sets Raw Data After Adjustment by Population

(MHBB) = Matter Handled in Post Offices Data in Bits Before Adjustment by Population

(NBBB) = Number of Books Data in Bits Before Adjustment by Population

(PEBB) = Periodicals Data in Bits Before Adjustment by Population

(NEBB) = Newspapers Data in Bits Before Adjustment by Population

(NCBB) = Newspaper Circulation Data in Bits Before Adjustment by Population

(ADBB) = Average Daily Conversation Data in Bits Before Adjustment by Population

(RSBB) = Radio Sets Data in Bits Before Adjustment by Population

(TSBB) = TV Sets Data in Bits Before Adjustment by Population

(MHBA) = Matter Handled in Post Offices Data in Bits After Adjustment by Population

(NBBA) = Number of Books Data in Bits After Adjustment by Population

(PEBA) = Periodicals Data in Bits After Adjustment by Population

(NEBA) = Newspapers Data in Bits After Adjustment by Population

(NCBA) = Newspaper Circulation Data in Bits After Adjustment by Population

(ADBA) = Average Daily Conversation Data in Bits After Adjustment by Population

(RSBA) = Radio Sets Data in Bits After Adjustment by Population

(TSBA) = TV Sets Data in Bits After Adjustment by Population

INFORMATION FLOW DATA BEFORE ADJUSTMENT BY POPULATION

(TP)	(MHRB)	(NBRB)	(PERB)	(NERB)	(NCRB)	(ADRB)	(RSRB)	(TSRB)
1880		2078						
1881		2891						
1882		3472						
1883		3481						
1884		4083						
1885		4030						
1886	3747000	4876						
1887	3495100	4437						
1888	3576100	4631						
1889	3860200	4014						
1890	4005403	4558						
1891	4388900	4865						
1892	4774575	4862						
1893	5021841	5134						
1894	4918090	4484						
1895	5134281	5468				2575		
1896	5893719	5703				3423		
1897	5781002	4926				4461		
1898	6214447	4886				5782		
1899	6578310	5321				7709		
1900	7128890	6358				7882		
1901	7424390	8141				11005		
1902	8085447	7833				14330		
1903	8887467	7885				15582		
1904	9502460	8291				17683		
1905	10187508	8112				21678		
1906	11361081	7138				25941		
1907	12255666	9620				29784		
1908	13384089	9254				31985		
1909	14004577	10801				33754		
1910	14850102	13470				36181		
1911	16900552	11123				38150		
1912	17588858	10803				40808		
1913	18567445	12230				40973		
1914	18018184	12010				41034		
1915	18464923	9734				44820		
1916	18813662	10445				49578		
1917	20362401	10080				51841		
1918	20811140	9237				50108		
1919	21259879	8594	4798			48887		
1920	21708618	8422	3771	2042	27791	51814		
1921	22157357	8329	3747	2028	28424	53755		
1922	22606096	8638	3788	2033	29780	57000	180	
1923	23054832	8883	3838	2036	31454	61830	500	
1924	23884397	8012	4182	2014	32988	64400	1500	
1925	24873982	8574	4498	2008	33738	67300	2000	
1926	25463529	8925	4577	2001	38002	71180	1750	
1927	28898556	10153	4858	1849	37987	73685	2350	
1928	28837005	10354	4808	1839	37873	77300	3250	
1929	27951548	10187	5157	1944	39426	82850	4428	
1930	27887823	10027	5022	1842	39588	83520	3789	
1931	28544352	10307	4887	1823	38781	82500	3594	
1932	24306744	9035	4173	1913	36408	77000	2888	
1933	19868458	6092	3458	1811	35175	72000	4157	

INFORMATION FLOW DATA BEFORE ADJUSTMENT BY POPULATION

(TP)	(MHRB)	(NBRB)	(PERB)	(NERB)	(NCRB)	(ADRB)	(RSRB)	(TSRB)
1934	20825827	8198	5002	1929	36709	73400	4479	
1935	22331752	8768	8546	1950	38156	76000	6030	
1936	23571315	10436	8670	1989	40292	81954	8749	
1937	25801279	10912	8720	1983	41819	88480	8083	
1938	26041979	11087	8412	1936	38572	87688	7142	
1939	28444848	10840	8848	1888	39671	82311	10763	
1940	27749487	11328	8432	1878	41132	98783	11831	
1941	29235791	11112	7141	1857	42090	104310	13842	
1942	30117633	9525	7374	1787	43375	107087	4307	
1943	32818282	8325	7040	1754	44383	105277	7244	
1944	34830815	6970	8672	1744	45955	108329	10181	
1945	37812087	6548	6569	1749	48384	111980	13118	
1946	36318158	7735	6693	1763	50928	128098	15955	6
1947	37427706	9182	7083	1769	51673	139422	20000	179
1948	40280374	9897	7346	1781	52285	152158	18500	975
1949	43555108	10892	7570	1780	52848	160581	17400	3000
1950	45063737	11022	8980	1772	53828	170623	13468	7464
1951	46908410	11255	7835	1773	54018	175923	11928	5385
1952	49805875	11840	7711	1786	53851	181123	10431	6098
1953	50848158	12050	7792	1785	54472	184229	12852	7218
1954	52213170	11901	8092	1785	55072	201548	10028	7347
1955	55233584	12589	7648	1780	56147	213010	14133	7757
1956	58441218	12538	8738	1781	57102	227244	15318	7387
1957	59077633	13142	8722	1755	57805	238570	14505	8399
1958	60129911	13462	8927	1751	57418	252298	11747	4920
1959	61247220	14878	9004	1755	58300	269350	15622	6349
1960	63874604	15012	8422	1763	58882	285388	17127	5708
1961	64932859	18060	9275	1761	59281	297110	17374	6178
1962	66493190	21804	8483	1760	59849	318506	19182	6471
1963	67852738	25784	8843	1754	58905	328888	18282	7130
1964	69876477	28451	9798	1763	60412	345200	[illegible]	8107
1965	71873186	29595	8890	1751	60358	367800	24119	8382
1966	75607302	30050	10002	1754	61397	389500	23595	7285
1967	78368572	28782	9238	1749	61581	406000	21898	5104
1968	79516731	30387	9400	1752	62535	428900	22586	5813
1969	82034501	29579	9434	1758	62060	460200	20549	5309
1970	84881833	38071	9573	1748	62109	485200	44427	9483
1971	87000000	37692	9657	1749	62231	525000	47610	11197
1972	87200000	38053	9690	1761	62510	546000	55311	13507
1973	87900000	39851	9630	1774	63147	576000	50198	17367
1974	90100000	40846	9755	1788	61877	613000	43982	15779
1975	93300000	39372	9657	1758	60655	627000	34515	10673
1976	98100000	35141	9372	1761	60976	644000	44101	14131
1977	92200000	42780	8732	1753	61485	679000	52829	15431
1978	98900000	41218	9582	1758	61980	733000	49035	17407
1979	99800000	45182	9719	1763	62200	758000	40028	18619
1980	105300000	42377	10236	1745	62200	787000	39574	18532
1981	110100000	48783	10873	1730	61400	800000	44359	18478
1982	114311000		10688	1711	62500	932207	44088	16406
1983	119381000		10952	1701	62500	1069014	48535	19681
1984	131545000		10808	1688	63100	1188220	62050	22364

INFORMATION FLOW DATA AFTER ADJUSTMENT BY POPULATION

(TP)	(MHRA)	(NBRA)	(PERA)	(NERA)	(NCRA)	(ADRA)	(RSRA)	(TSRA)
1880	.	41.304	.	.	.	.	.	.
1881	.	58.030	.	.	.	.	.	.
1882	.	65.721	.	.	.	.	.	.
1883	.	84.344	.	.	.	.	.	.
1884	.	73.819	.	.	.	.	.	.
1885	.	71.129	.	.	.	.	.	.
1886	64.873	80.707	.	.	.	.	.	.
1887	58.022	74.828	.	.	.	.	.	.
1888	58.113	78.551	.	.	.	.	.	.
1889	62.488	84.978	.	.	.	.	.	.
1890	63.521	72.301	.	.	.	.	.	.
1891	67.887	72.482	.	.	.	.	.	.
1892	72.740	74.041	.	.	.	.	.	.
1893	74.986	78.681	.	.	.	.	.	.
1894	72.048	85.678	.	.	.	.	.	.
1895	73.780	78.800	.	.	.	3.7008	.	.
1896	80.323	80.454	.		.	4.8289	.	.
1897	80.081	88.265	.	.	.	6.1788	.	.
1898	84.557	68.682	.	.	.	7.8401	.	.
1899	87.920	71.137	.	.	.	10.3083	.	.
1900	83.692	83.522	.	.	.	10.3574	.	.
1901	95.875	104.810		.	.	14.2580	.	.
1902	102.089	88.902	.	.	.	18.0834	.	.
1903	110.288	87.581	.	.	.	19.3325	.	.
1904	115.802	100.884	.	.	.	21.5243	.	.
1905	121.589	98.802	.	.	.	25.8882	.	.
1906	133.034	93.585	.	.	.	30.3759	.	.
1907	140.870	110.575	.	.	.	34.234	.	.
1908	150.886	104.329	.	.	.	36.071	.	.
1909	154.747	120.453	.	.	.	37.297	.	.
1910	160.715	145.779	.	.	.	38.135	.	.
1911	179.985	118.456	.	.	.	40.828	.	.
1912	184.581	114.407	.	.	.	42.812	.	.
1913	191.023	125.823	.	.	.	42.153	.	.
1914	181.889	121.191	.	.	.	41.407	.	.
1915	183.881	99.858	.	.	.	44.587	.	.
1916	185.232	102.402	.	.	.	48.608	.	.
1917	187.119	97.388	.	.	.	50.282	.	.
1918	201.659	89.508	.	.	.	48.552	.	.
1919	203.444	82.238	45.8947		.	46.782		.
1920	203.837	79.080	35.4085	18.1737	280.848	48.852	.	.
1921	204.215	76.765	34.5348	18.8912	281.872	49.544	.	.
1922	205.323	78.458	34.4081	16.4860	270.481	51.771	0.908	.
1923	205.847	79.134	34.1878	18.1788	280.839	55.027	4.484	.
1924	209.153	71.983	38.4783	17.6512	289.211	58.442	13.148	.
1925	213.074	82.877	38.8258	17.3402	281.358	58.117	17.271	.
1926	217.066	84.540	38.9884	17.0443	308.881	80.830	14.906	.
1927	224.257	85.318	38.1513	16.3782	318.050	83.803	18.748	.
1928	222.714	85.825	40.7303	16.0813	315.129	84.148	26.871	.
1929	229.487	83.637	42.3398	15.9808	323.685	87.857	31.355	.
1930	228.548	81.454	40.7981	15.7758	321.800	67.847	30.780	.
1931	213.895	83.054	38.3795	15.4958	212.337	68.478	28.981	
1932	194.788	72.388	33.4375	15.3293	281.731	61.699	19.588	
1933	158.188	84.427	27.5388	15.2150	280.058	57.225	33.087	.

INFORMATION FLOW DATA AFTER ADJUSTMENT BY POPULATION

(TP)	(MHRA)	(NBRA)	(PERA)	(NERA)	(NCRA)	(ADRA)	(RSRA)	(TSRA)
1934	183.178	64.358	38.5728	15.2811	280.418	58.070	35.435	.
1935	175.428	68.881	51.4218	15.3181	288.733	58.701	47.388	.
1936	184.007	81.486	52.0887	15.5268	314.536	83.077	84.385	.
1937	200.320	84.720	52.1738	15.3880	321.578	87.143	42.758	.
1938	200.832	85.262	48.3881	14.8253	304.868	87.556	55.023	.
1939	202.023	81.283	52.2895	14.4232	303.083	70.520	82.223	.
1940	209.430	85.484	48.5434	14.1736	310.430	74.553	88.281	.
1941	218.887	83.111	53.4108	13.8883	314.734	78.018	102.034	.
1942	223.757	70.785	54.7845	13.2784	322.251	79.545	31.888	.
1943	242.918	81.621	52.1085	12.9830	324.504	78.885	53.620	.
1944	280.871	52.094	48.8282	13.0246	343.204	73.408	78.034	.
1945	284.188	48.085	48.2428	13.1108	362.888	83.943	88.338	.
1946	258.125	54.875	47.5883	12.5302	361.862	91.042	113.387	0.0428
1947	258.734	83.720	48.1534	12.2762	351.581	88.754	138.783	1.2422
1948	274.577	67.464	50.0750	12.1404	358.408	103.718	112.474	8.6462
1949	281.728	72.854	50.7033	11.8223	353.858	107.563	76.358	20.0838
1950	288.887	72.581	45.8188	11.6858	354.371	112.328	88.884	48.1378
1951	304.600	73.084	48.5778	11.5138	350.788	114.238	77.455	34.8875
1952	318.081	75.703	49.3031	11.4184	344.855	115.808	88.484	38.8770
1953	320.428	75.768	48.0083	11.2284	342.581	122.157	80.130	45.3138
1954	322.503	73.508	48.8815	10.8018	340.181	124.488	81.838	45.3788
1955	334.548	78.251	48.3234	10.6802	340.078	128.018	85.803	48.8828
1956	335.780	74.587	51.8620	10.4758	338.881	135.184	81.124	43.9441
1957	345.080	78.784	50.8483	10.2512	337.848	138.838	84.725	37.3773
1958	345.378	77.323	51.7751	10.0574	328.788	144.818	67.473	28.2586
1959	345.834	82.888	50.8413	9.8087	328.193	152.088	88.210	35.8488
1960	353.748	83.400	46.7889	9.7844	327.122	158.348	95.150	31.7111
1961	354.824	88.888	50.8831	9.82295	323.831	162.355	94.940	33.7598
1962	357.875	117.880	51.0388	9.47255	322.115	170.348	103.132	34.8278
1963	359.981	138.785	51.1585	9.30504	312.493	174.485	98.887	37.8248
1964	384.607	148.880	51.2718	9.22554	318.128	180.838	100.245	42.4228
1965	371.438	147.778	48.4598	9.04910	311.826	190.078	124.848	43.3178
1966	388.540	153.830	51.1350	8.88728	313.881	198.131	120.828	37.7444
1967	388.793	145.830	48.7747	8.85570	311.701	205.570	109.883	25.8430
1968	391.780	152.382	47.1414	8.73838	313.818	234.082	113.170	28.1525
1969	407.172	148.867	48.8421	8.72890	308.143	228.500	102.031	28.3805
1970	418.087	170.818	48.8283	8.58863	304.451	237.943	217.778	48.4853
1971	420.886	182.263	48.8873	8.45745	300.824	253.888	230.222	54.1441
1972	418.827	181.811	48.2872	8.41378	298.882	280.870	284.287	64.5342
1973	415.789	188.883	45.5535	8.38167	298.700	272.488	237.455	82.1523
1974	422.410	191.488	45.7337	8.28880	290.084	287.388	208.245	71.8318
1975	414.385	182.701	44.8121	8.14849	281.482	280.851	180.182	48.8287
1976	412.884	181.484	45.3878	8.08283	280.221	285.858	202.870	84.8403
1977	418.472	194.831	44.2788	7.87543	278.777	308.817	240.782	70.2047
1978	448.288	185.874	43.1427	7.80835	278.108	330.022	218.278	78.3748
1979	444.348	201.187	43.2725	7.84851	278.837	338.588	178.224	73.8838
1980	487.870	188.518	45.0528	7.81048	273.788	348.281	174.181	81.5888
1981	480.157	212.781	47.4182	7.54470	267.771	348.188	182.454	80.5817
1982	483.784	.	48.1885	7.38083	268.878	402.881	180.445	70.8883
1983	510.830	.	48.8835	7.27358	267.437	457.430	207.881	84.2148
1984	558.172	.	45.8848	7.18253	267.746	501.853	283.281	84.8788

INFORMATION FLOW DATA IN BITS BEFORE ADJUSTMENT BY POPULATION

(TP)	(MHBB)	(NBBB)	(PEBB)	(NEBB)	(NCBB)	(ADBB)	(RSBB)	(TSBB)
1880		11.0186						
1881		11.5464						
1882		11.7816						
1883		11.7653						
1884		11.9972						
1885		11.9788						
1886	21.8373	12.1811						
1887	21.7388	12.1154						
1888	21.7700	12.1771						
1889	21.8802	11.9708						
1890	21.9335	12.1545						
1891	22.0592	12.1877						
1892	22.1875	12.2473						
1893	22.2598	12.3259						
1894	22.2300	12.1308						
1895	22.2917	12.4171				11.3304		
1896	22.4400	12.4775				11.7410		
1897	22.4828	12.2868				12.1232		
1898	22.5872	12.2544				12.4974		
1899	22.8488	12.3775				12.9123		
1900	22.7655	12.6339				12.9443		
1901	22.8238	12.9910				13.4337		
1902	22.9488	12.9353				13.8068		
1903	23.0833	12.9412				13.9278		
1904	23.1798	13.0173				14.1108		
1905	23.2803	12.8858				14.4038		
1906	23.4378	12.8015				14.6829		
1907	23.5488	13.2318				14.8022		
1908	23.8718	13.1759				14.9858		
1909	23.7394	13.4122				15.0428		
1910	23.8240	13.7175				15.1421		
1911	24.0106	13.4413				15.2194		
1912	24.0881	13.4124				15.3095		
1913	24.1483	13.5781				15.3224		
1914	24.1807	13.5519				15.3245		
1915	24.2144	13.7488				15.4518		
1916	24.2473	13.3505				15.5974		
1917	24.2794	13.2983				15.6048		
1918	24.3108	13.1732				15.6127		
1919	24.3418	13.0681	12.2278			15.5772		
1920	24.3718	13.0399	11.8807	10.9858	14.7823	15.6611		
1921	24.4013	13.0239	11.8715	10.9858	14.7948	15.7141		
1922	24.4302	13.0798	11.8872	10.8804	14.8821	15.7887	9.8439	
1923	24.4586	13.1138	11.9028	10.9915	14.9410	15.9113	9.9659	
1924	24.5084	13.1370	12.0231	10.8758	15.0101	15.9748	10.5507	
1925	24.5585	13.2248	12.1344	10.9715	15.0421	16.0383	10.8658	
1926	24.6031	13.2788	12.1802	10.9685	15.1358	16.1282	10.7731	
1927	24.6898	13.3098	12.1858	10.9285	15.2125	16.1887	11.1984	
1928	24.6777	13.3379	12.2809	10.9211	15.2127	16.2382	11.6882	
1929	24.7384	13.3144	12.3323	10.9248	15.2688	16.3347	12.1124	
1930	24.7331	13.2918	12.2840	10.9233	15.2728	16.3498	11.8878	
1931	24.6818	13.3313	12.2547	10.9091	15.2423	16.3321	11.8114	
1932	24.5348	13.1413	12.0268	10.9018	15.1520	16.2326	11.2562	
1933	24.2440	12.8823	11.7581	10.9001	15.1023	16.1357	12.0213	

INFORMATION FLOW DATA IN BITS BEFORE ADJUSTMENT BY POPULATION

(TP)	(MHBB)	(NBBB)	(PEBB)	(NEBB)	(NCBB)	(ADBB)	(RSBB)	(TSBB)
1934	24.2078	13.0011	12.2883	10.9138	15.1838	16.1835	12.1290	
1935	24.4128	13.0877	12.6784	10.8293	15.2198	16.2137	12.5578	
1936	24.4905	13.3483	12.7035	10.8578	15.2882	16.3225	13.0100	
1937	24.8208	13.4138	12.7142	10.8535	15.3380	16.4001	12.9807	
1938	24.8343	13.4340	12.8488	10.8198	15.2722	16.4201	12.8021	
1939	24.8585	13.3772	12.7410	10.8028	15.2758	16.4842	13.3838	
1940	24.7280	13.4678	12.8511	10.8750	15.3280	16.5920	13.5303	
1941	24.8012	13.4398	12.8019	10.8588	15.3408	16.8705	13.7358	
1942	24.8441	13.2175	12.8482	10.8033	15.4048	16.7082	12.0725	
1943	24.8880	13.0232	12.7814	10.7784	15.4380	16.8975	12.8228	
1944	25.0580	12.7868	12.7038	10.7882	15.4878	16.6982	13.3136	
1945	25.1782	12.6788	12.8815	10.7723	15.5622	16.7729	13.6793	
1946	25.1142	12.8172	12.7084	10.7838	15.6362	16.9089	13.9817	2.5850
1947	25.1576	13.1648	12.7801	10.7887	15.6571	17.0881	14.2877	7.4838
1948	25.2838	13.2728	12.8427	10.7985	15.6741	17.2152	14.0102	9.9293
1949	25.3763	13.4110	12.8861	10.7977	15.6895	17.2930	13.4787	11.5507
1950	25.4255	13.4281	12.7649	10.7912	15.7181	17.3805	13.7172	12.8657
1951	25.4833	13.4583	12.8884	10.7920	15.7212	17.4248	13.5421	12.3947
1952	25.5727	13.5314	12.8127	10.8025	15.7184	17.4886	13.3488	12.5736
1953	25.8025	13.5587	12.8278	10.8017	15.7332	17.5874	13.6897	12.8170
1954	25.8379	13.5388	12.9823	10.7855	15.7480	17.8208	13.2917	12.8429
1955	25.7190	13.6188	12.9008	10.7814	15.7788	17.7006	13.7858	12.9213
1956	25.7502	13.8140	13.0898	10.7822	15.8013	17.7938	13.9029	12.8508
1957	25.8181	13.8819	13.0804	10.7773	15.8189	17.8701	13.8243	12.6438
1958	25.8416	13.7186	13.1240	10.7740	15.8082	17.9448	13.5200	12.2644
1959	25.8881	13.8607	13.1384	10.7773	15.8312	18.0391	13.9313	12.6323
1960	25.8242	13.8738	13.0388	10.7838	15.8455	18.1228	14.0640	12.4788
1961	25.8524	14.3405	13.1791	10.7822	15.8548	18.1100	14.0848	12.5929
1962	25.8867	14.4189	13.2111	10.7814	15.8690	18.2718	14.2260	12.8586
1963	26.0150	14.6542	13.2353	10.7784	15.8481	18.3271	14.1581	12.7997
1964	26.0542	14.7982	13.2583	10.7838	15.8825	18.3971	14.7220	12.9850
1965	26.0889	14.8035	13.1341	10.7740	15.8813	18.4888	14.5579	13.0331
1966	26.1720	14.8751	13.2880	10.7784	15.8050	18.5713	14.5282	12.8307
1967	26.2237	14.8118	13.1734	10.7723	15.9097	18.6311	14.4053	12.3174
1968	26.2448	14.8912	13.1984	10.7748	15.9324	18.7035	14.4619	12.5051
1969	26.2892	14.8523	13.2037	10.7787	15.9214	18.8119	14.3268	12.3742
1970	26.3380	15.1388	13.2248	10.7715	15.9225	18.8882	15.4391	13.2111
1971	26.3745	15.2020	13.2374	10.7723	15.9253	19.0020	15.5390	13.4508
1972	26.3778	15.2157	13.2423	10.7822	15.9318	19.0585	15.7553	13.7214
1973	26.3894	15.2858	13.2333	10.7928	15.9464	19.1357	15.8153	14.0841
1974	26.4250	15.3179	13.2518	10.7878	15.9171	19.2255	15.4250	13.8993
1975	26.4122	15.2848	13.2374	10.7781	15.8883	19.2581	15.0749	13.3817
1976	26.4202	15.1008	13.2891	10.7822	15.8880	19.2887	15.4785	13.7888
1977	26.4583	15.3848	13.2485	10.7758	15.9082	19.3731	15.6817	13.9135
1978	26.5595	15.3309	13.2281	10.7781	15.9187	19.4835	15.5518	14.0874
1979	26.5725	15.4835	13.2488	10.7838	15.9248	19.5280	15.2888	14.0205
1980	26.6838	15.3710	13.3214	10.7890	15.9246	19.5880	15.2723	14.1777
1981	26.7142	15.5744	13.4085	10.7586	15.9080	19.8098	15.4388	14.1738
1982	26.7884		13.3837	10.7408	15.9316	19.9303	15.4781	14.0019
1983	26.8310		13.4188	10.7322	15.9316	20.0278	15.5887	14.2645
1984	26.8710		13.3988	10.7211	15.9454	20.1837	15.9211	14.4507

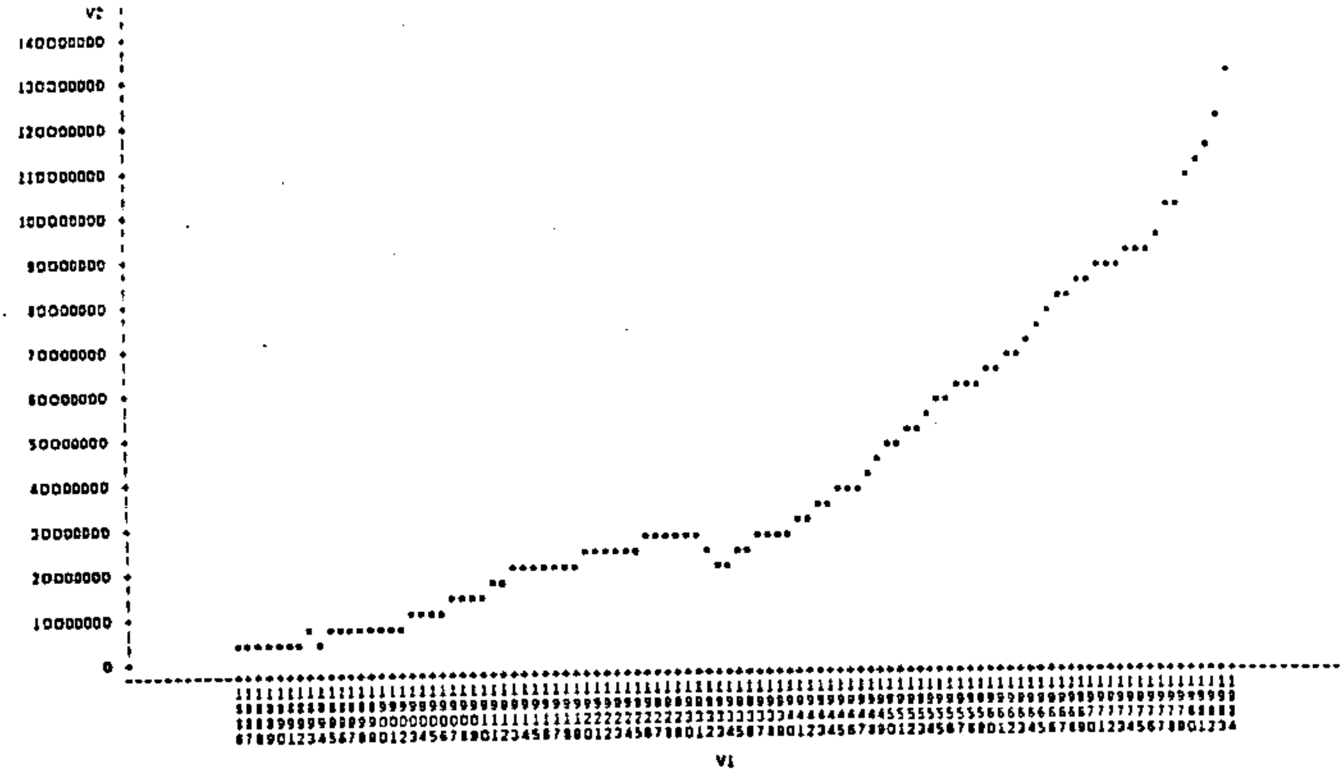
INFORMATION FLOW DATA IN BITS AFTER ADJUSTMENT BY POPULATION

(TP)	(MHBA)	(NBBA)	(PEBA)	(NEBA)	(NCBA)	(ADBA)	(RSBA)	(TSBA)
1880		5.38810	.	.	.	.	.	.
1881	.	5.85874	.	.	.	.	.	.
1882	.	6.03851	.	.	.	.	.	.
1883	.	6.00772	.	.	.	.	.	.
1884	.	6.20581	.	.	.	.	.	.
1885	.	6.15238	.	.	.	.	.	.
1886	6.01508	6.33482	.	.	.	.	.	.
1887	5.88318	6.27743	.	.	.	.	.	.
1888	5.88540	6.25834	.	.	.	.	.	.
1889	5.88551	6.02187	.	.	.	.	.	.
1890	5.88817	6.17584	.	.	.	.	.	.
1891	6.08527	6.17855	.	.	.	.	.	.
1892	6.18489	6.21028	.	.	.	.	.	.
1893	6.22858	6.28042	.	.	.	.	.	.
1894	6.17088	6.03728	.	.	.	.	.	.
1895	6.20535	6.28846	.	.	.	1.88783	.	.
1896	6.22775	6.33010	.	.	.	2.27171	.	.
1897	6.32340	6.08308	.	.	.	2.82752	.	.
1898	6.40188	6.05488	.	.	.	2.87087	.	.
1899	6.45812	6.15253	.	.	.	3.38545	.	.
1900	6.54889	6.38408	.	.	.	3.37258	.	.
1901	6.58007	6.71201	.	.	.	3.83380	.	.
1902	6.87388	6.82782	.	.	.	4.17738	.	.
1903	6.78483	6.60852	.	.	.	4.27288	.	.
1904	6.85302	6.85928	.	.	.	4.42780	.	.
1905	6.82563	6.58888	.	.	.	4.88300	.	.
1906	7.05565	6.38534	.	.	.	4.82485	.	.
1907	7.13822	6.78888	.	.	.	5.08738	.	.
1908	7.23521	6.70500	.	.	.	5.17277	.	
1909	7.27378	6.81233	.	.	.	5.22100	.	
1910	7.32838	7.18784	.	.	.	5.28040		
1911	7.48173	6.88821	.	.	.	5.34441		.
1912	7.52785	6.83803	.	.		5.41318	.	.
1913	7.57780	6.87525	.	.	.	5.38757	.	.
1914	7.58413	6.82114	.	.	.	5.37178	.	.
1915	7.58754	6.58777	.	.	.	5.47888	.	.
1916	7.68805	6.87830	.	.		5.68308	.	.
1917	7.82282	6.60565	.	.	.	5.85198	.	.
1918	7.85577	6.48381	.	.	.	5.80147	.	.
1919	7.88848	6.38175	5.52028	.	.	5.54788		
1920	7.87127	6.30524	5.14802	4.28108	1.02782	5.60442	.	.
1921	7.87385	6.28238	5.10887	4.22428	1.05327	5.83083	.	.
1922	7.88175	6.28381	5.10455	4.20872	1.07828	5.89408	-0.12881	.
1923	7.68843	6.30828	5.08540	4.18417	1.13380	5.78208	2.15889	.
1924	7.70842	6.30348	5.18881	4.14188	1.17598	5.81888	3.71858	.
1925	7.73521	6.38841	5.27893	4.11905	1.18884	5.88080	4.11028	.
1926	7.78189	6.40158	5.38480	4.08122	1.29050	5.82187	3.88789	.
1927	7.88981	6.41480	5.28089	4.03370	1.31784	5.85185	4.30382	.
1928	7.78805	6.42501	5.34803	4.00821	1.29880	6.00338	4.75333	.
1929	7.84227	6.38807	5.40385	3.98844	1.33848	6.03483	5.18407	.
1930	7.82366	6.34782	5.35038	3.97864	1.32813	6.08422	4.84381	.
1931	7.74076	6.37588	5.28937	3.95378	1.28888	6.05482	4.85802	.
1932	7.60558	6.17783	5.08340	3.93815	1.18848	5.84717	4.29273	.
1933	7.30550	6.00858	4.78345	3.82742	1.12857	5.88108	5.04883	.

INFORMATION FLOW DATA IN BITS AFTER ADJUSTMENT BY POPULATION

(TP)	(MHBA)	(NBBA)	(PEBA)	(NEBA)	(NCBA)	(ADBA)	(RSBA)	(TSBA)
1934	7.35031	8.01820	5.30844	3.83178	8.18188	5.85971	5.14711	
1935	7.45472	8.10581	5.88431	3.83717	8.22753	5.88870	5.58583	
1936	7.52382	8.34815	5.70234	3.85870	8.28708	5.88847	6.00888	
1937	7.64817	8.40484	5.70528	3.84448	8.32802	8.08816	5.87188	
1938	7.84840	8.41383	5.82641	3.88872	8.25205	8.07802	5.78187	
1939	7.85831	8.34488	5.70872	3.85032	8.24248	8.13887	8.38147	
1940	7.71032	8.41778	5.80120	3.82513	8.27813	8.22020	6.48044	
1941	7.77258	8.37888	5.73805	3.78580	8.28788	8.21573	8.87281	
1942	7.80578	8.14487	5.77570	3.73078	8.33204	8.31388	4.88883	
1943	7.82433	5.84535	5.70348	3.88855	8.38018	8.29788	5.74488	
1944	8.02720	5.70183	5.83888	3.70317	8.42282	8.31124	8.24858	
1945	8.15075	5.81722	5.82184	3.71270	8.50283	8.38134	8.81885	
1946	8.01182	5.78071	5.57188	2.84734	8.48868	8.50848	6.82524	-4.5515
1947	8.02088	5.88387	5.81822	3.81778	8.48820	8.58824	7.11878	0.3128
1948	8.10108	6.07805	5.84802	3.80175	8.47738	8.88854	8.81345	2.7325
1949	8.18848	8.18881	5.88401	3.57558	8.48744	8.74803	8.25488	4.3287
1950	8.21270	8.18812	5.81788	3.54418	8.48812	8.81155	8.47027	5.8188
1951	8.25077	8.18148	5.83183	3.52518	8.45437	8.83587	8.27528	5.1278
1952	8.31783	6.24228	5.82381	3.51342	8.43827	8.85558	8.03848	5.2848
1953	8.32388	8.24388	5.81480	3.48883	8.42034	8.83258	6.33882	5.5041
1954	8.33317	8.18824	5.84332	3.44848	8.41007	8.85828	5.85278	5.5040
1955	8.38808	8.25288	5.53387	3.41418	8.40873	7.01144	8.41858	5.5541
1956	8.38128	8.22084	5.88861	3.38800	8.40808	7.07878	8.50878	5.4578
1957	8.43078	8.26238	5.87080	3.35772	8.38837	7.12882	8.40472	5.2241
1958	8.43202	8.27283	5.88018	3.33018	8.38544	7.17807	8.07823	4.8207
1959	8.43384	8.38228	5.88783	3.30883	8.38278	7.24877	8.48287	5.1838
1960	8.48858	8.38188	5.54108	3.28188	8.35388	7.30877	8.57213	4.8888
1961	8.47086	8.82481	5.88343	3.28848	8.33810	7.34301	8.58884	5.07722
1962	8.48331	8.88130	5.87352	3.24375	8.33143	7.41234	8.88135	5.12217
1963	8.48170	7.08577	5.87885	3.21801	8.28788	7.44878	8.59872	5.24127
1964	8.51020	7.21801	5.88008	3.20583	8.30428	7.48898	8.44183	5.40877
1965	8.53888	7.20728	5.53782	3.17777	8.28507	7.57044	8.88188	5.43888
1966	8.58448	7.28331	5.87824	3.18887	8.28412	7.83757	8.81443	5.21805
1967	8.83224	7.18817	5.54788	3.14881	8.28402	7.88348	8.77857	4.88170
1968	8.83845	7.25183	5.55882	3.13527	8.28285	7.74208	8.82234	4.88555
1969	8.88850	7.18827	5.54873	3.12580	8.28748	7.83805	8.87288	4.72030
1970	8.70074	7.48813	5.55233	3.08808	8.25007	7.88387	7.78872	5.53870
1971	8.71884	7.50888	5.54527	3.08022	8.23325	7.88784	7.84888	5.75873
1972	8.70281	7.50828	5.53285	3.07275	8.22237	8.02718	8.04585	6.01188
1973	8.88874	7.58211	5.50848	3.06188	8.22280	8.03885	7.88151	6.38023
1974	8.72250	7.58117	5.51518	3.05118	8.18038	8.18888	7.88821	6.18252
1975	8.88483	7.51334	5.48582	3.02853	8.13878	8.18483	7.32338	5.83013
1976	8.88888	7.33533	5.50358	3.01884	8.13042	8.20824	7.88288	6.07104
1977	8.71243	7.80480	5.48847	2.88558	8.12813	8.27108	7.81184	6.13350
1978	8.70882	7.53585	5.47105	2.88301	8.12488	8.38848	7.75873	6.28231
1979	8.78534	7.85228	5.45338	2.87288	8.11341	8.38488	7.47734	6.20833
1980	8.88888	7.54317	5.48358	2.84118	8.08811	8.43828	7.44485	6.34881
1981	8.80738	7.73328	5.58737	2.81548	8.08438	8.44862	7.58585	6.33251
1982	8.84774	.	5.52884	2.88578	8.07878	8.85348	7.57323	6.14707
1983	8.88870	.	5.55038	2.86385	8.08305	8.83741	7.88822	6.38800
1984	9.12457	.	5.51832	2.84047	8.08472	8.88111	8.04051	6.38855

MATTER HANDLED IN POST OFFICES DATA BEFORE ADJUSTMENT BY POPULATION VS TIME



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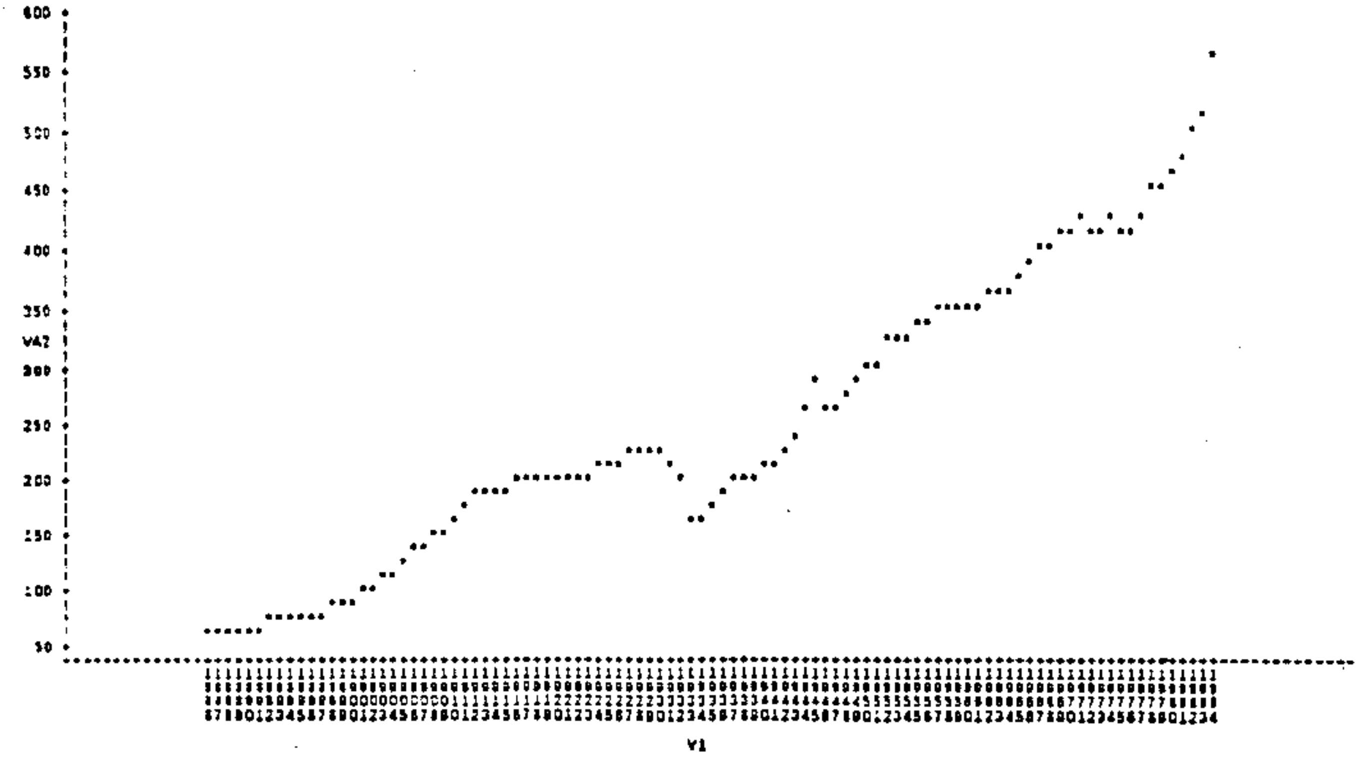

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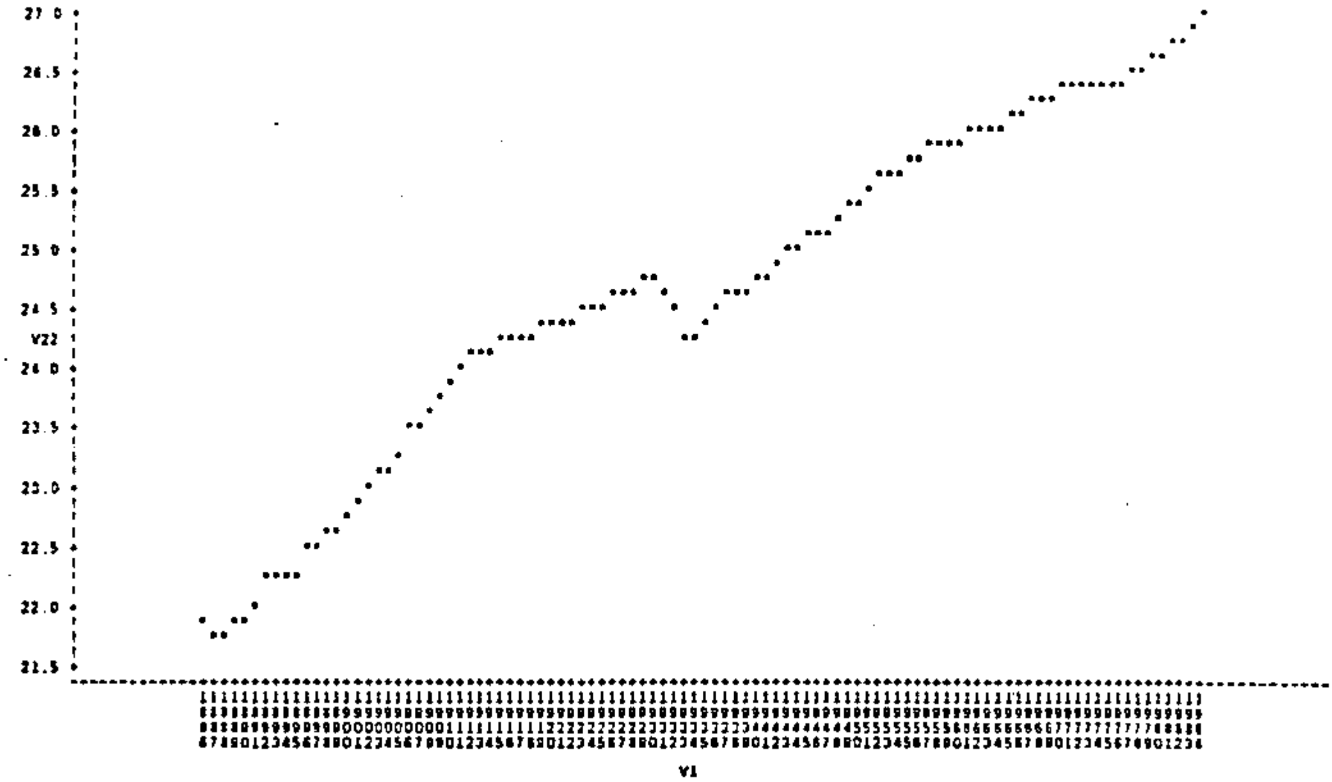

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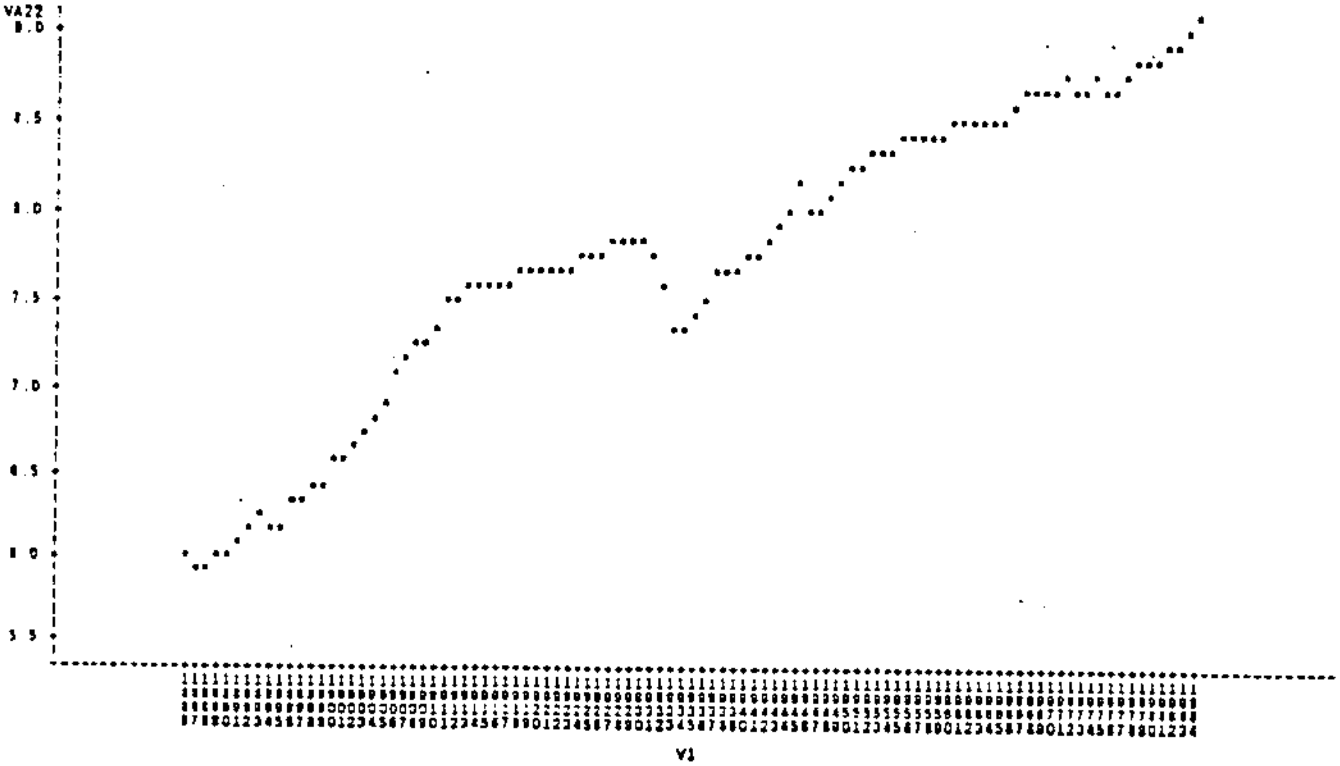
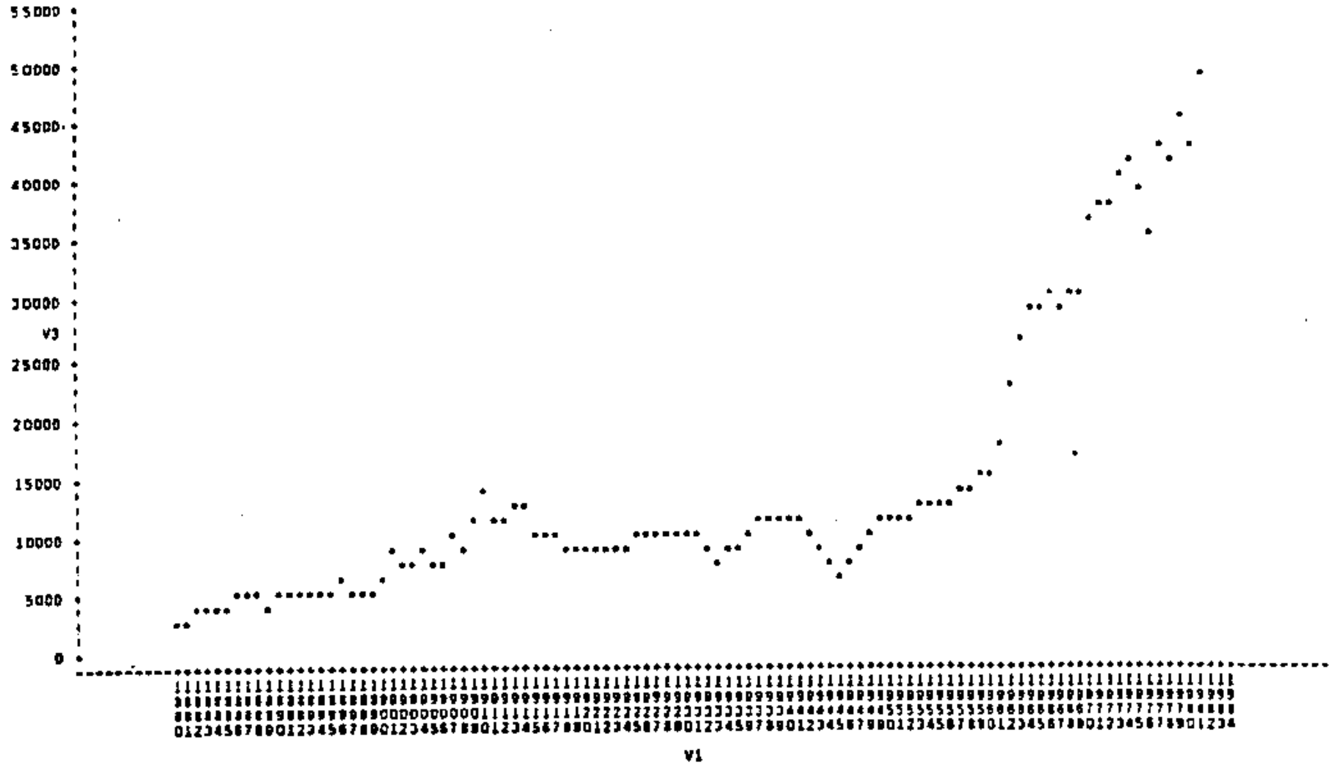


BOOKS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



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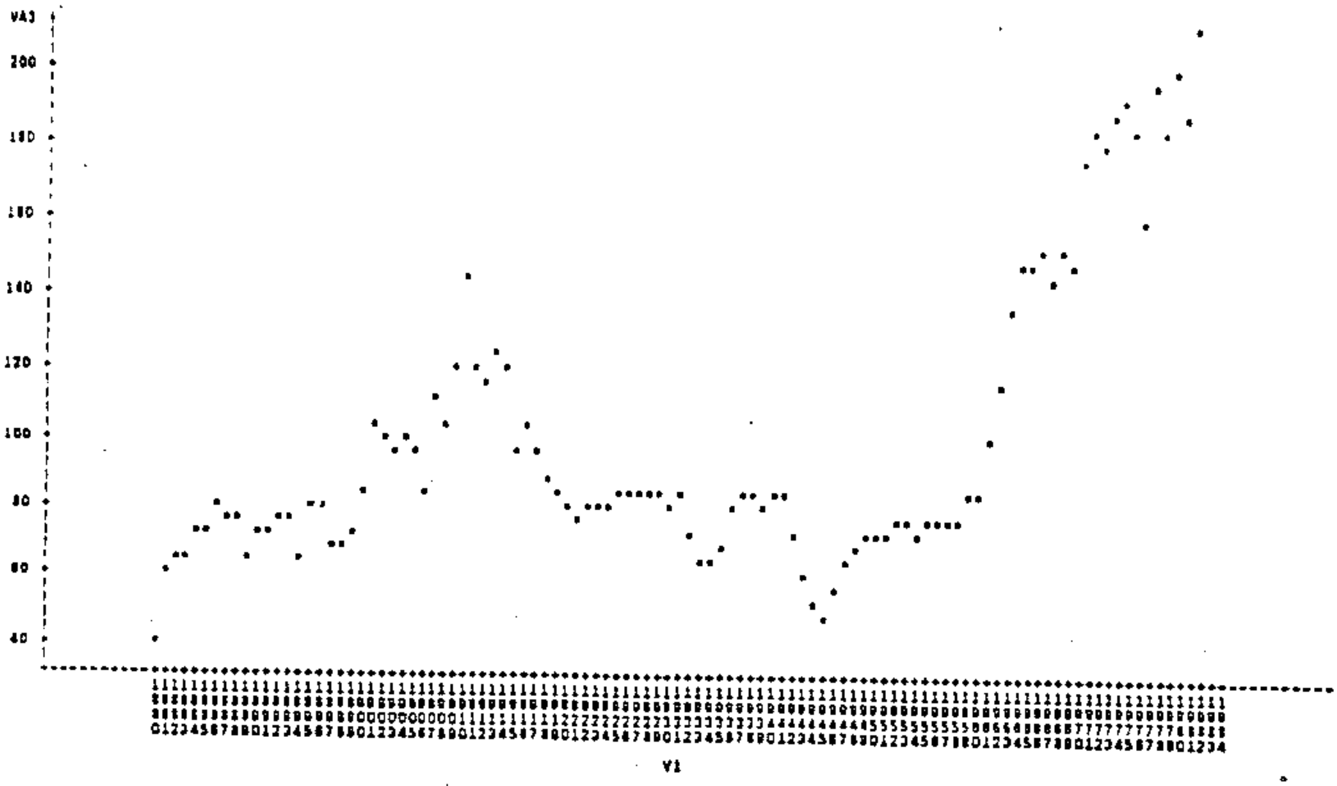

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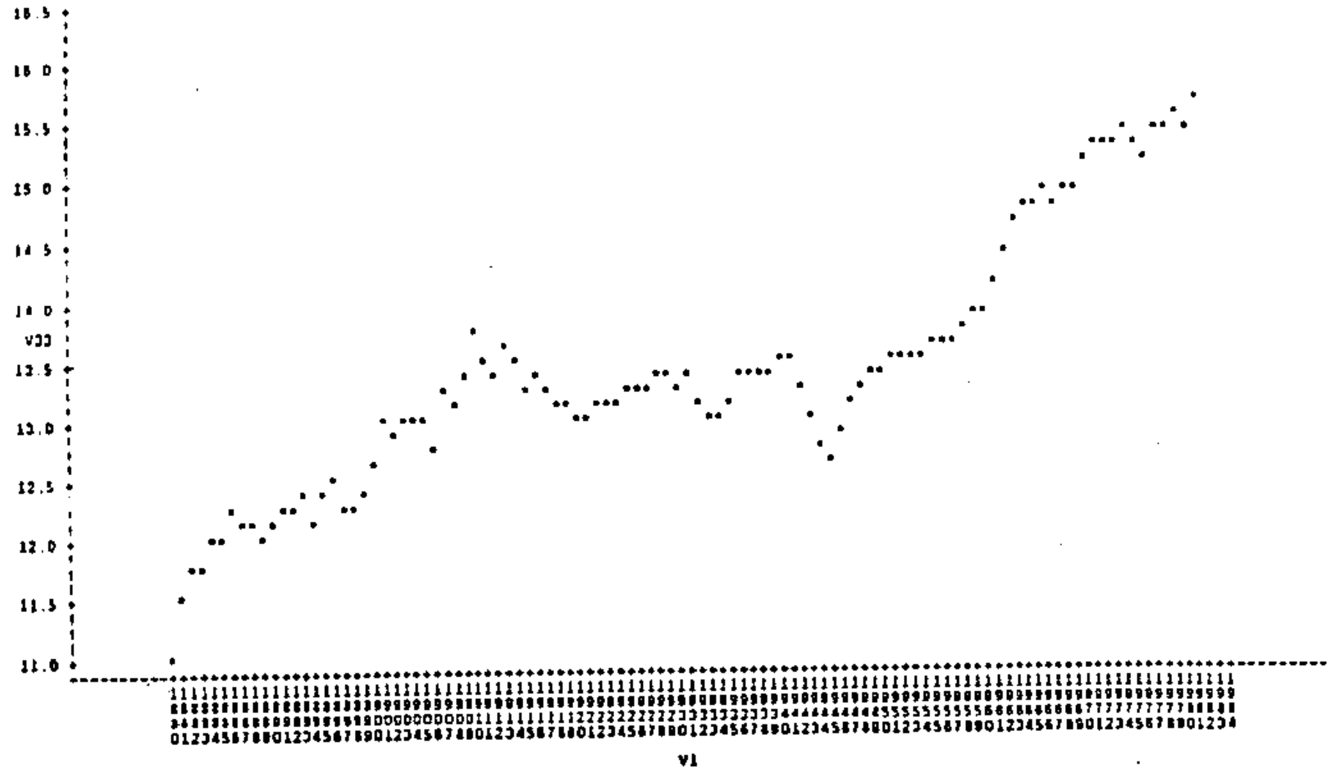

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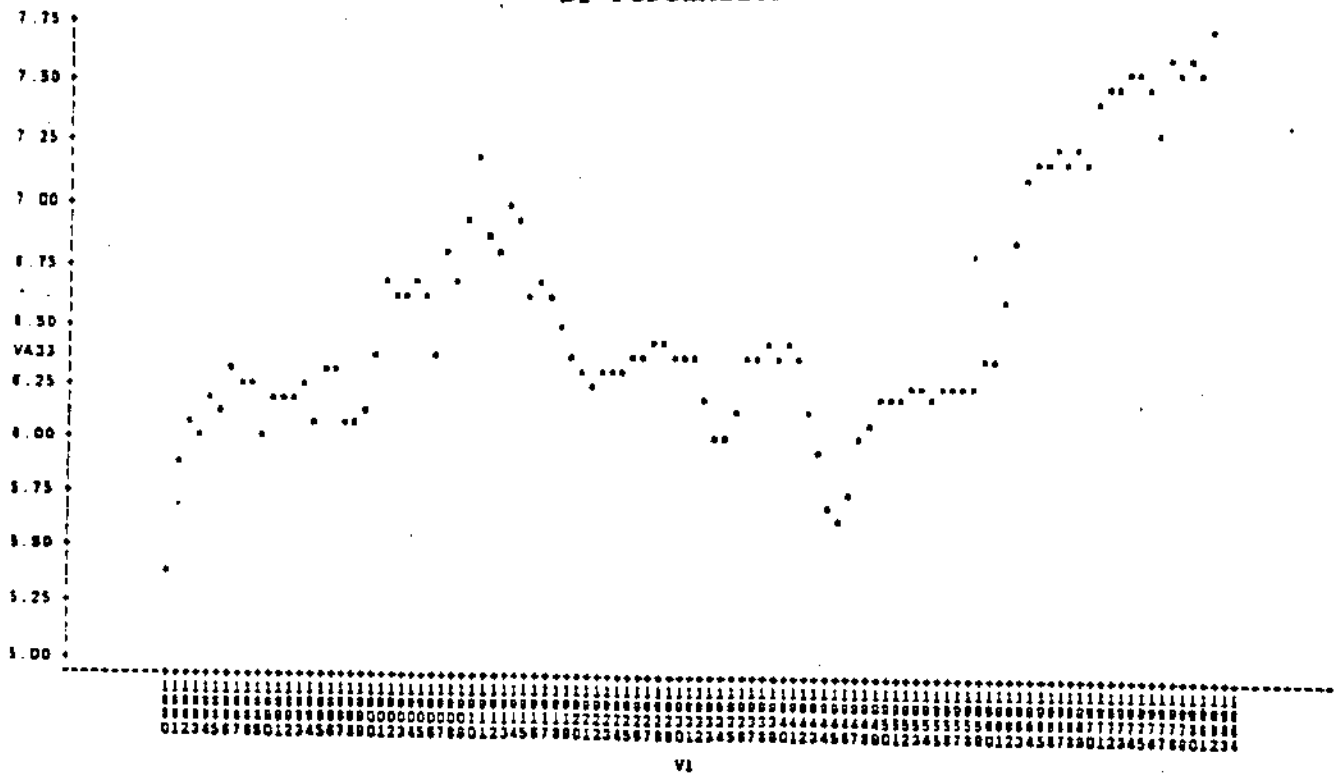
BY POPULATION VS TIME



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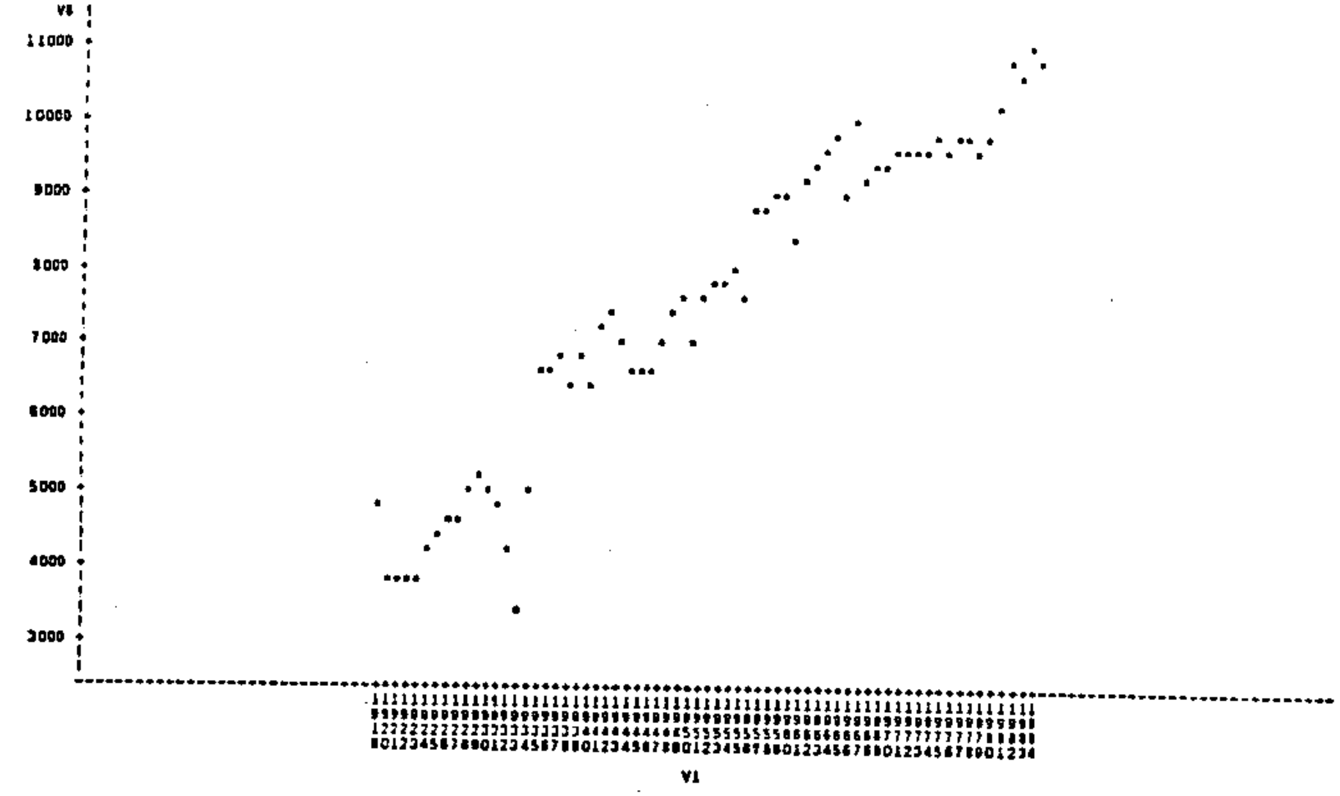

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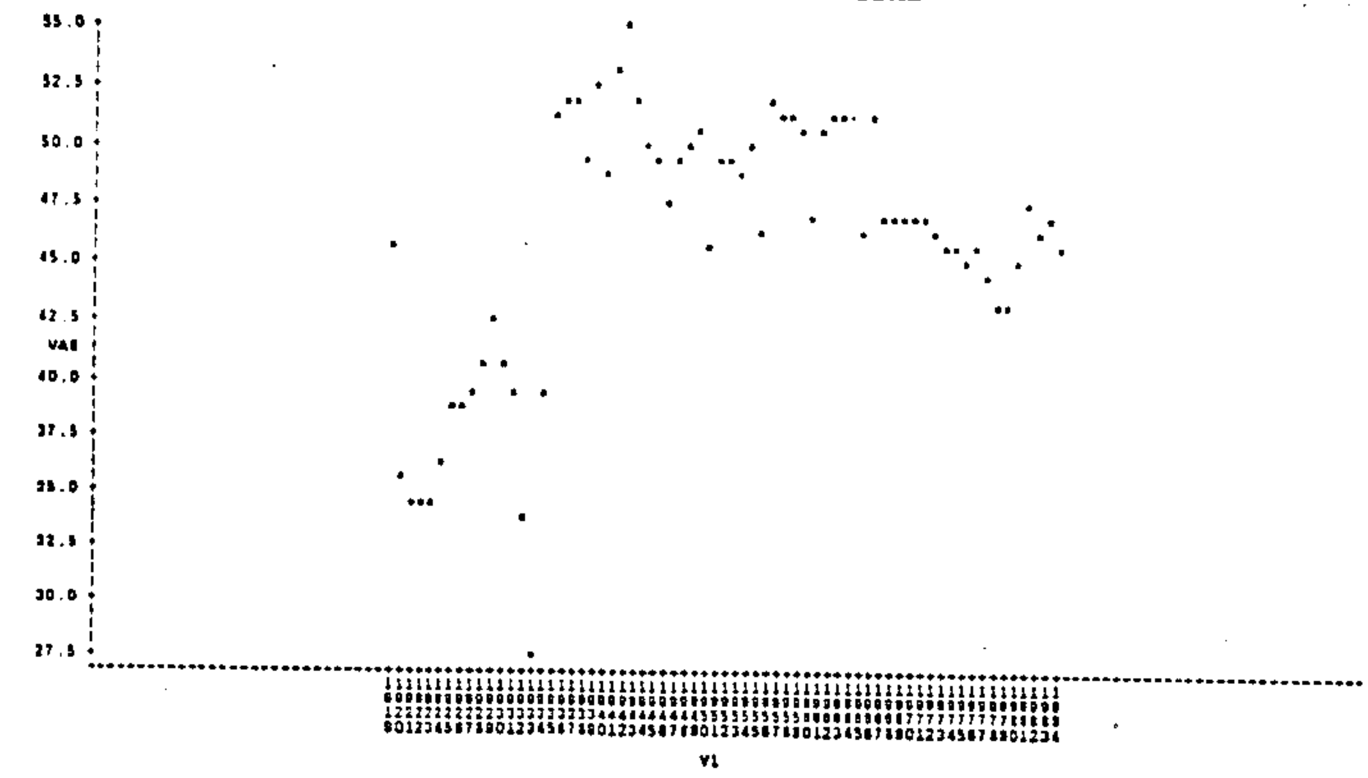

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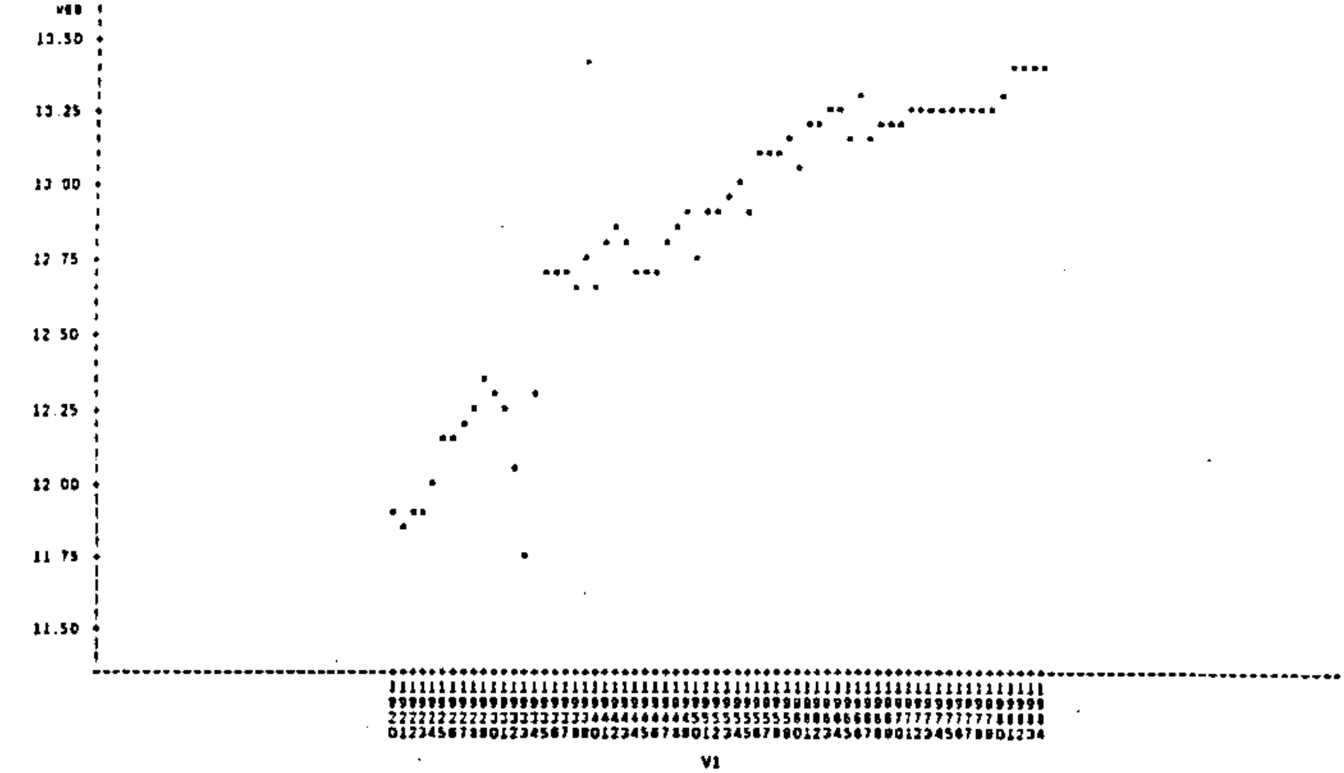

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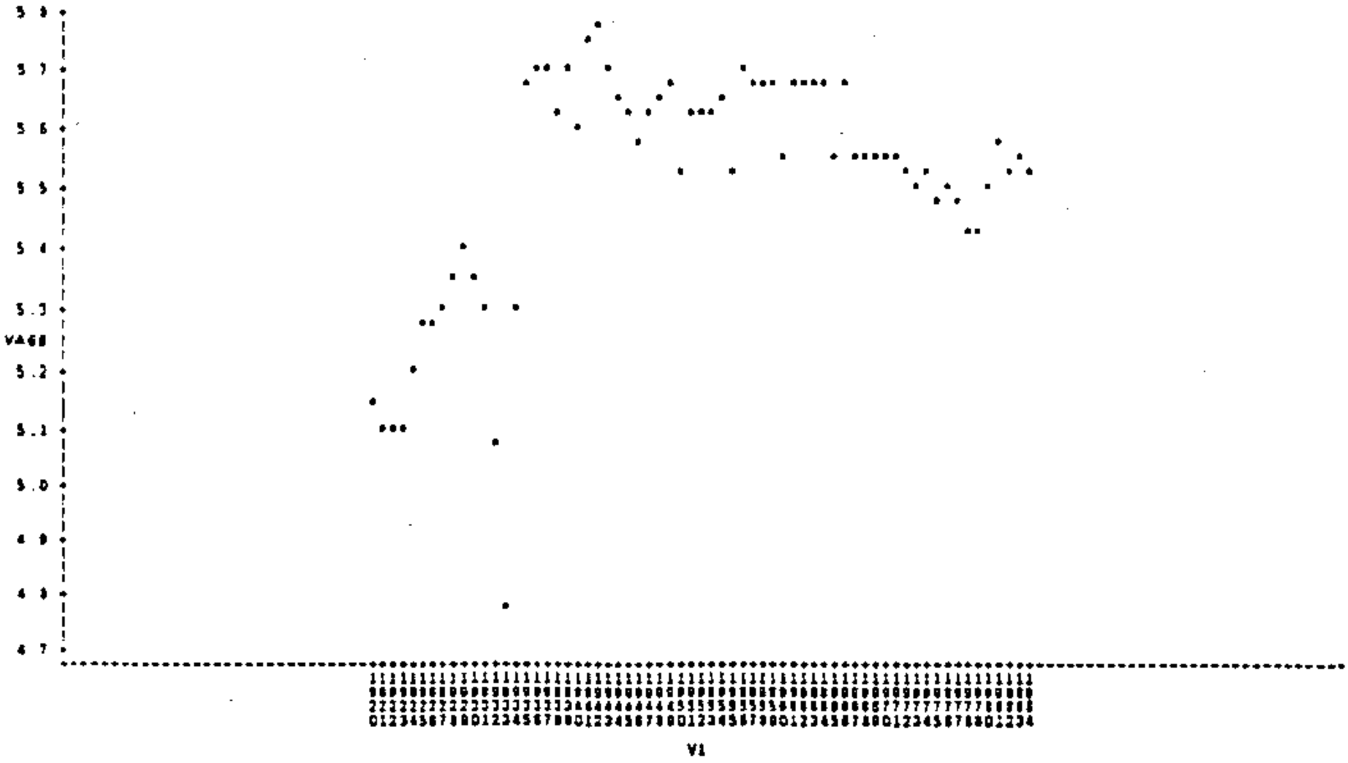
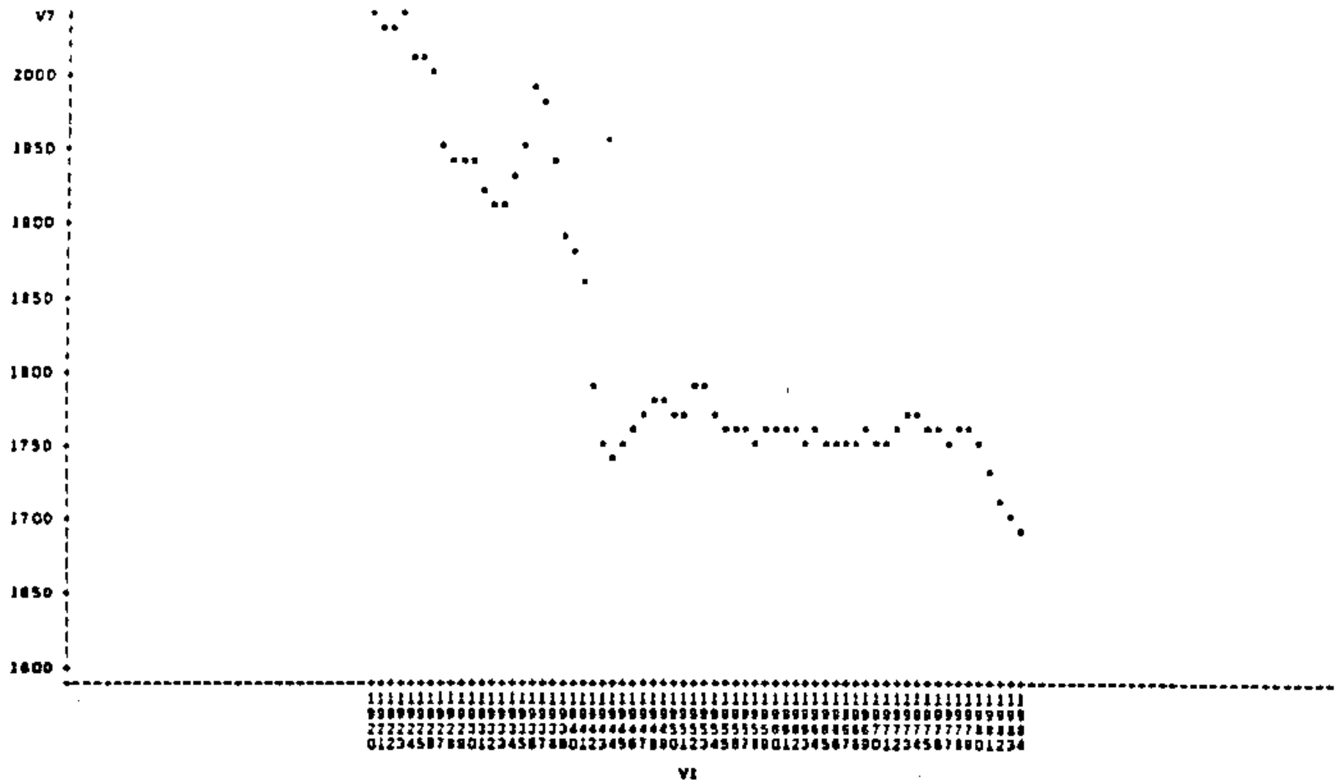


NEWSPAPERS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



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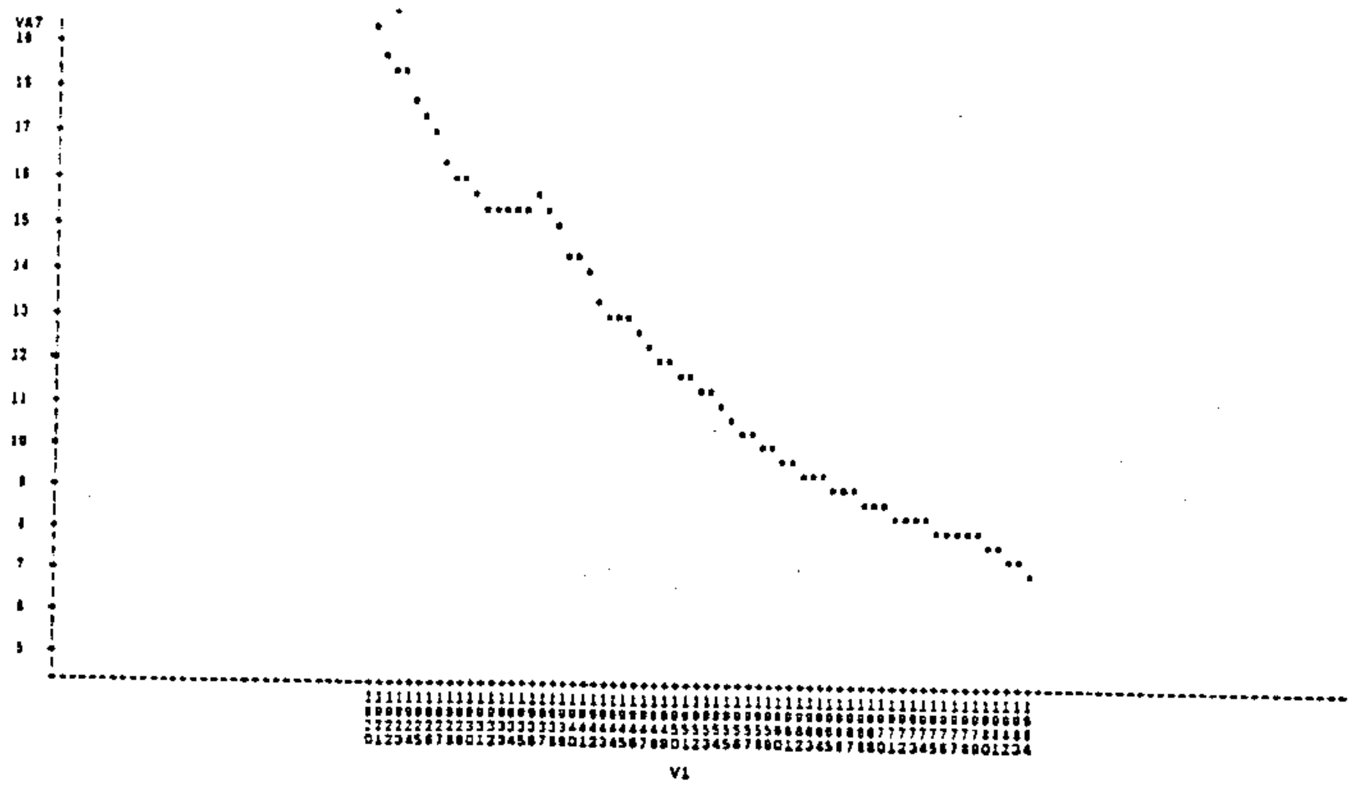
BY POPULATION VS TIME



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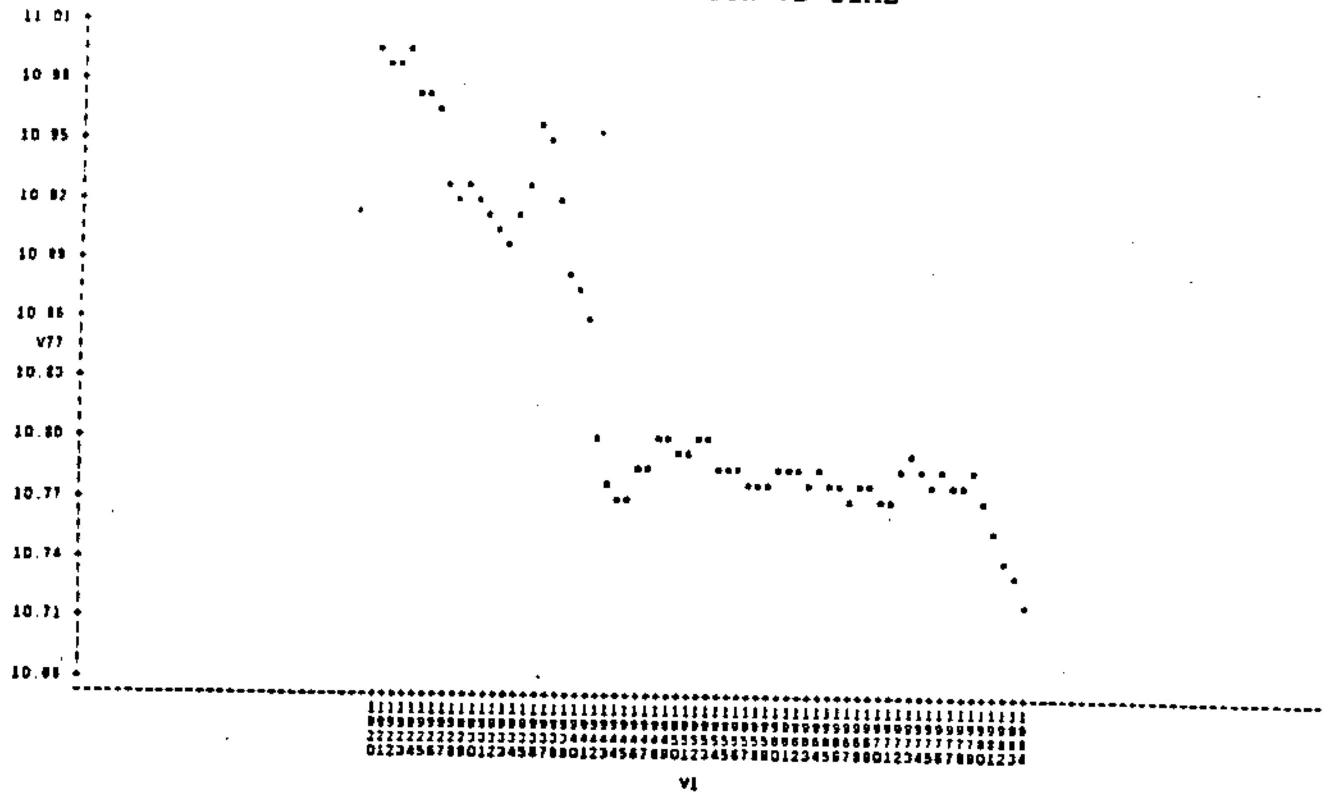

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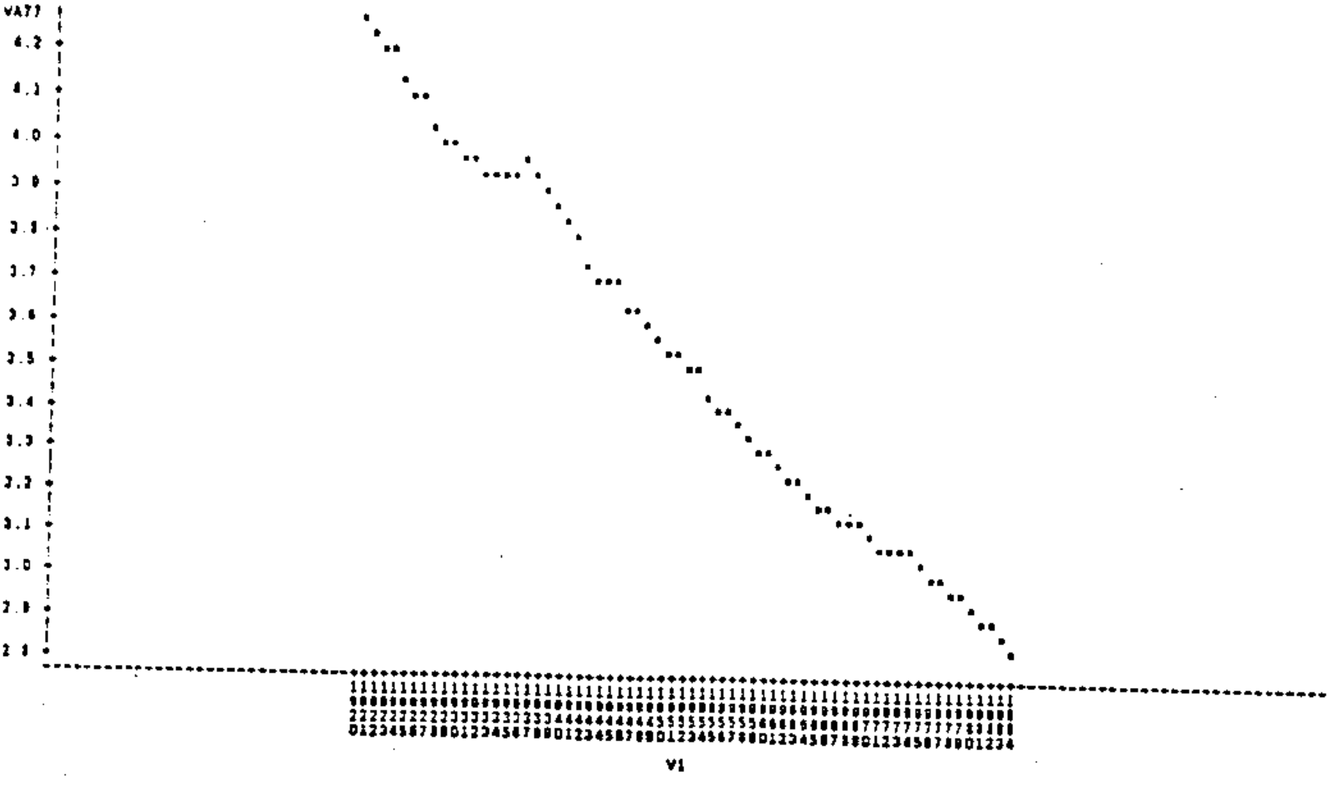
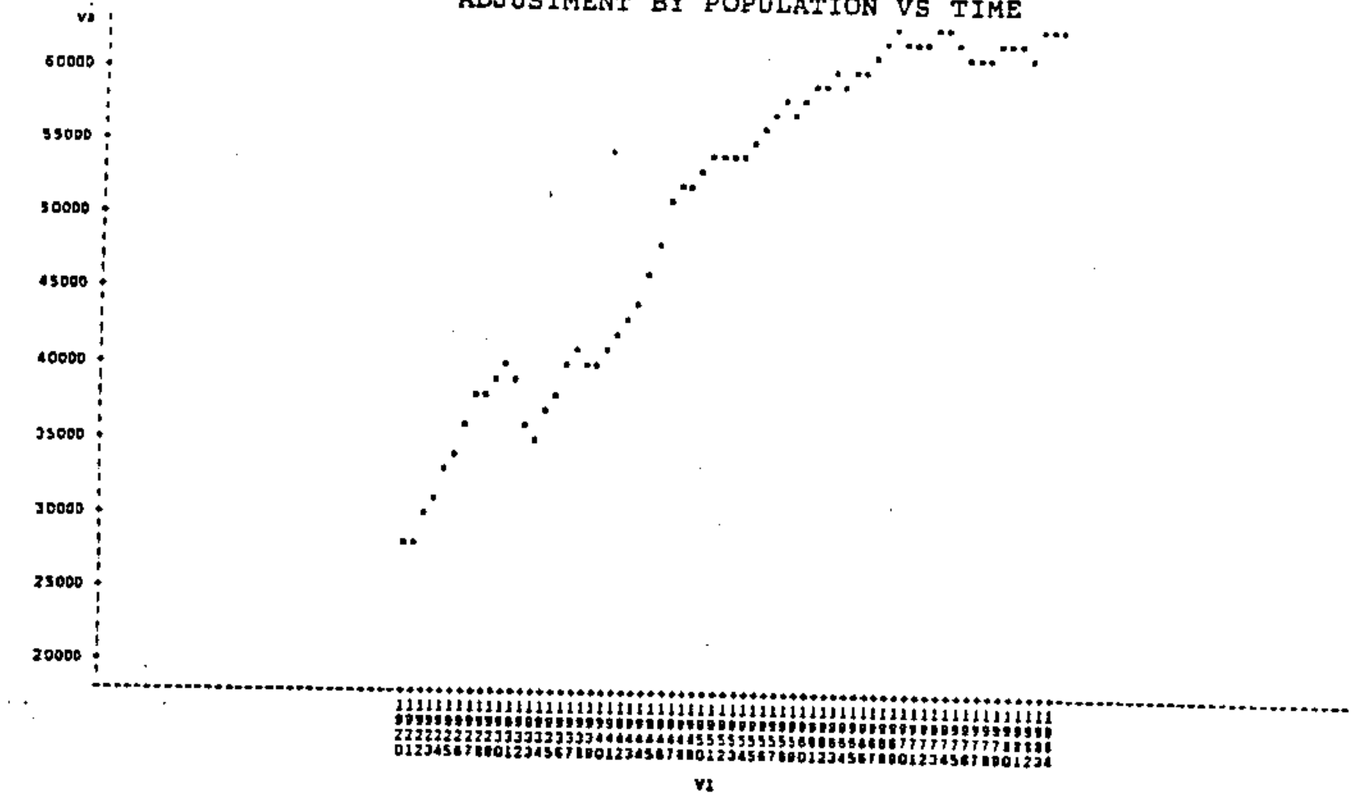
BY POPULATION VS TIME



NEWSPAPERS CIRCULATIONS DATA BEFORE
ADJUSTMENT BY POPULATION VS TIME



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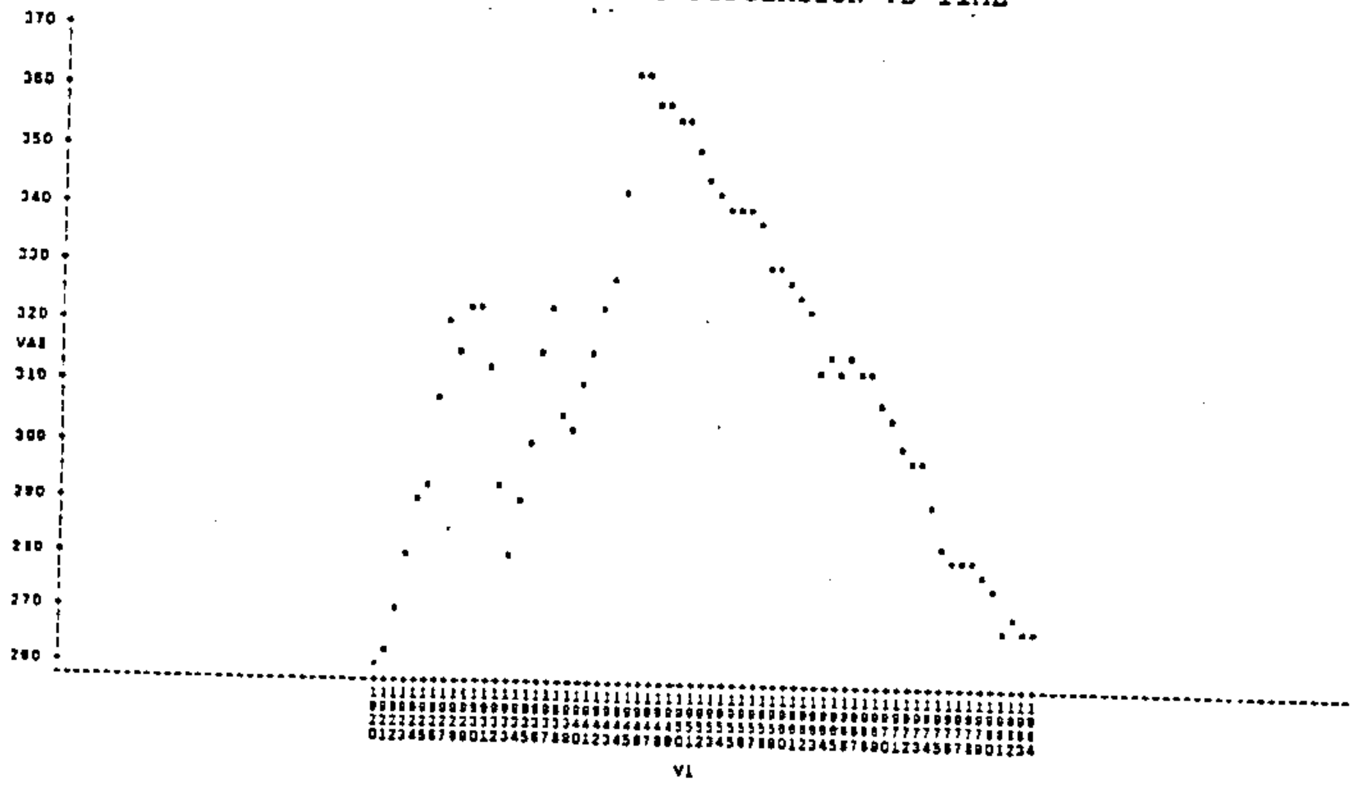
ADJUSTMENT BY POPULATION VS TIME



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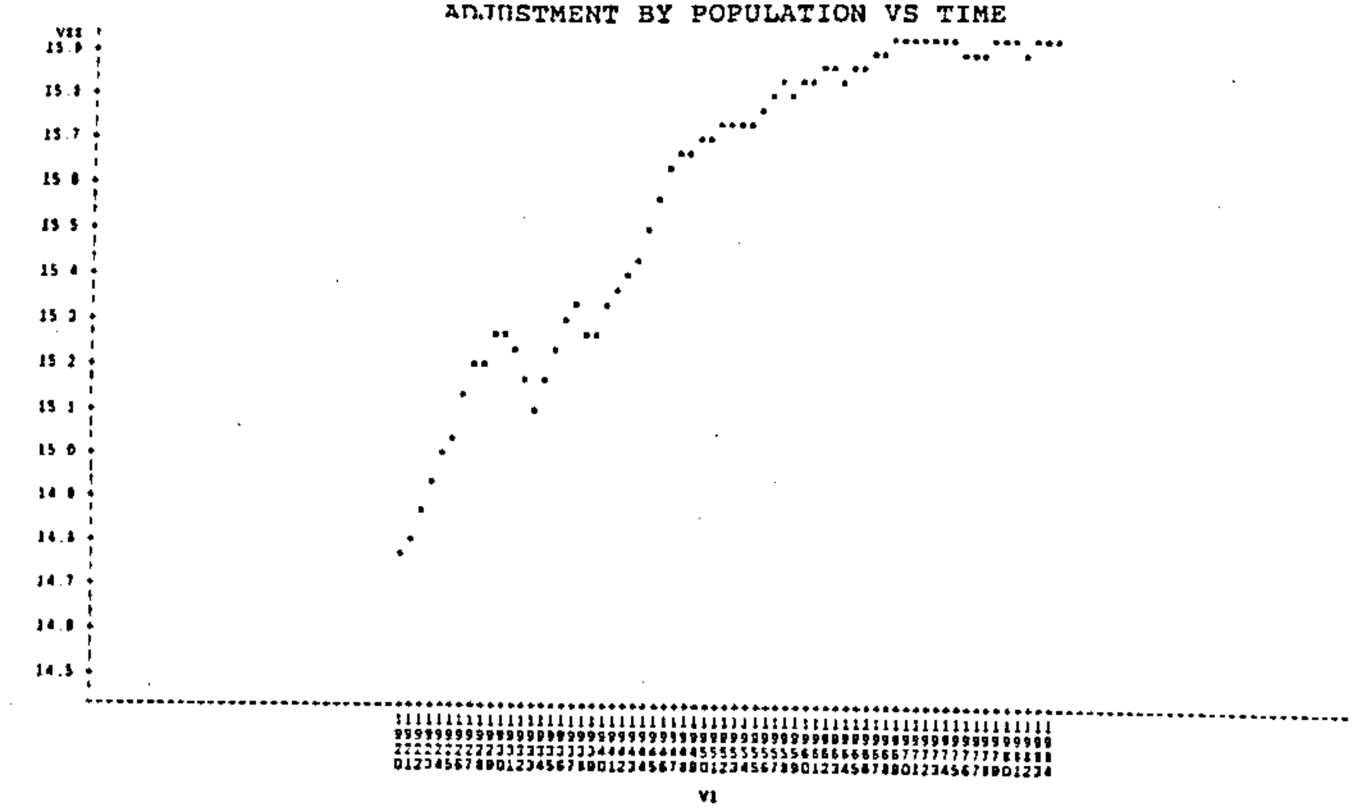
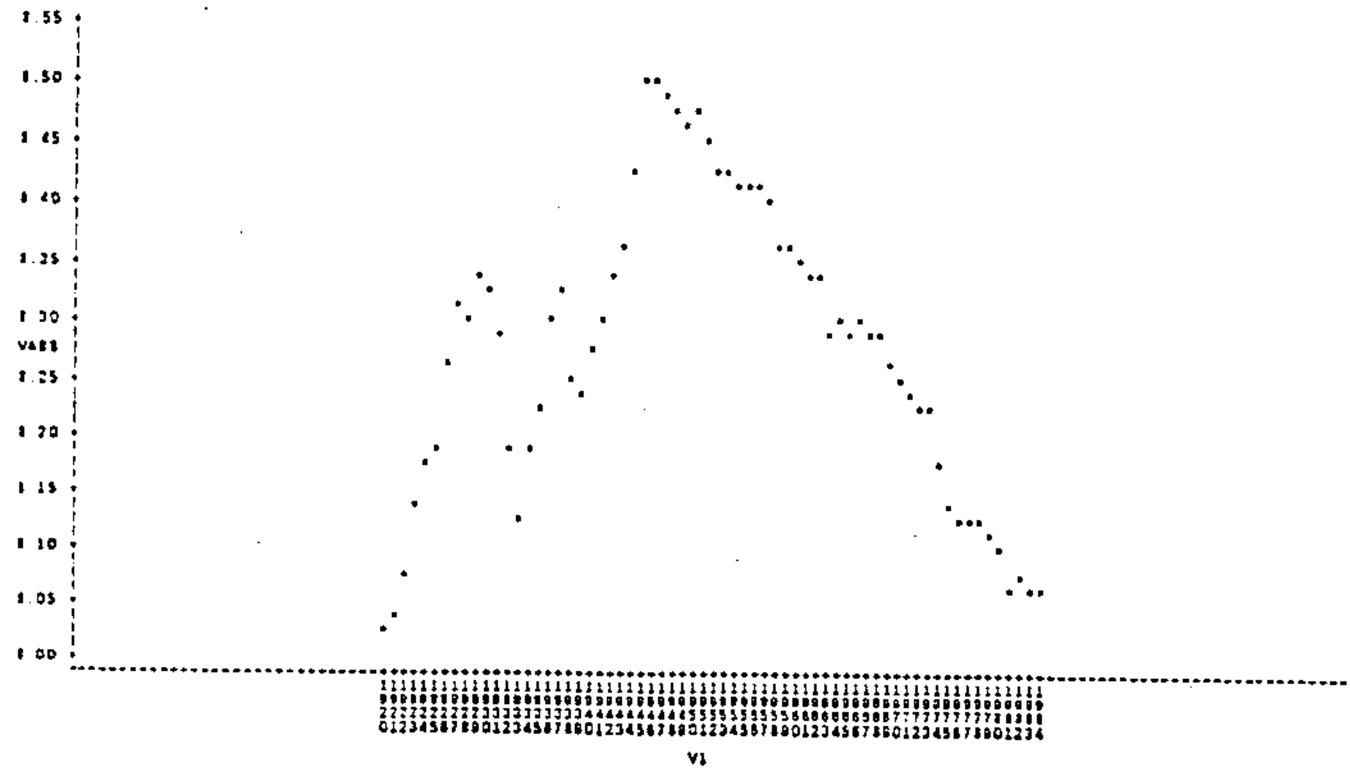
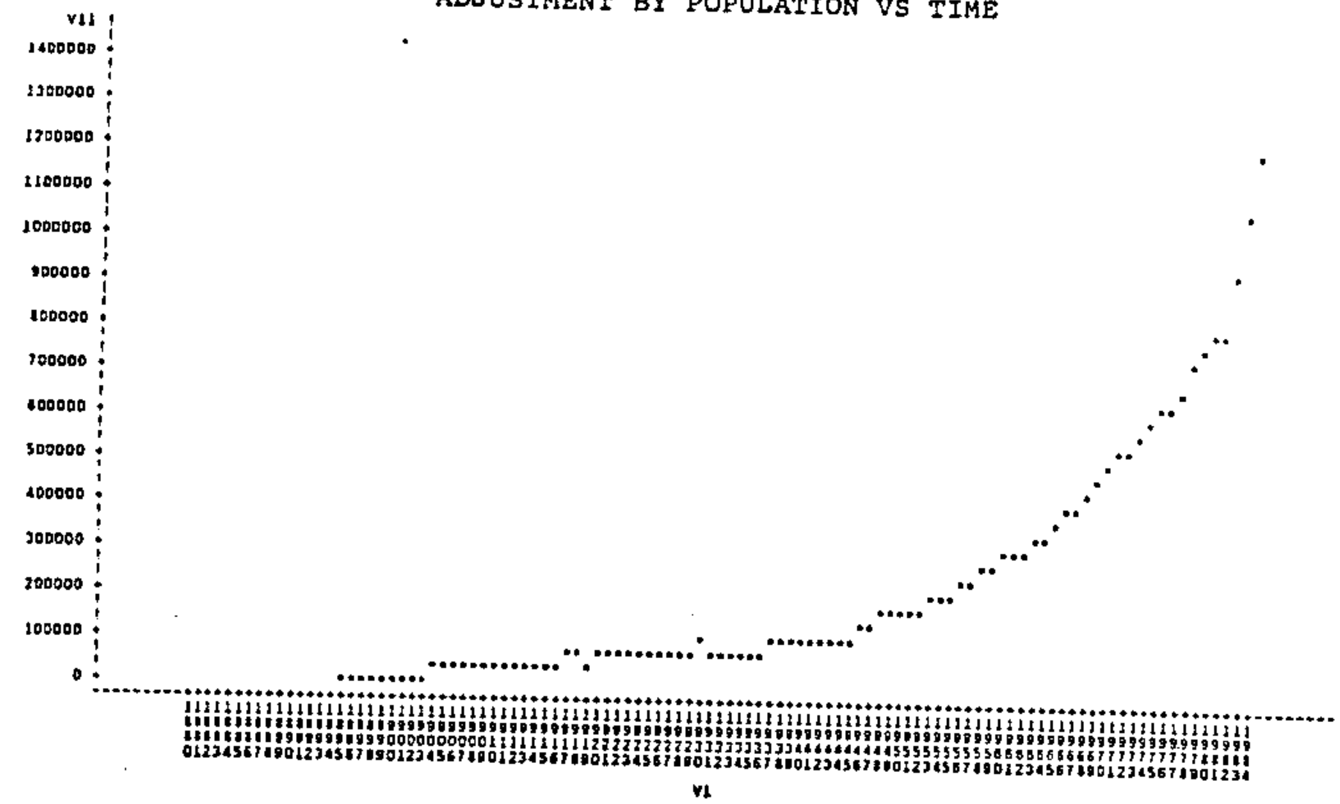


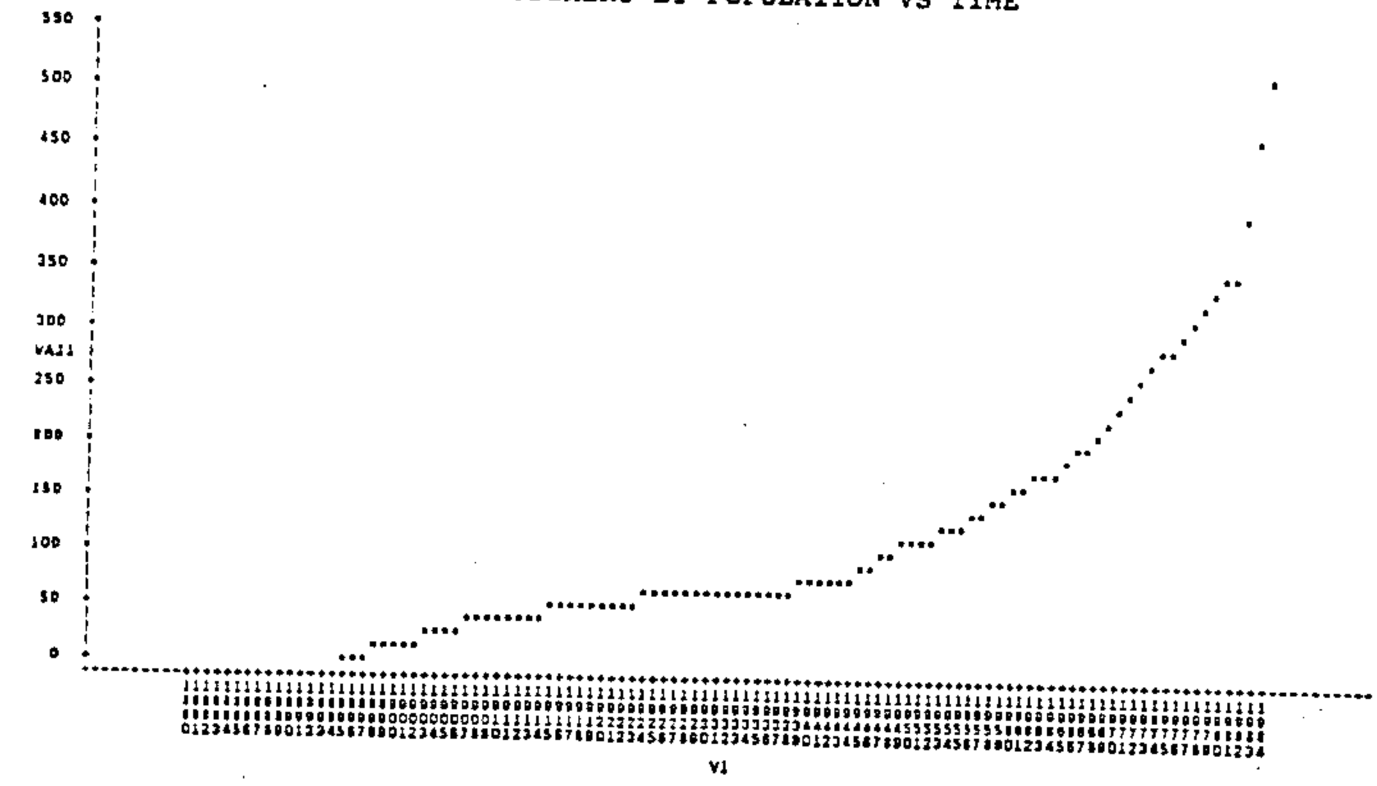
NEWSPAPERS CIRCULATION DATA IN BITS AFTER ADJUSTMENT BY POPULATION VS TIME



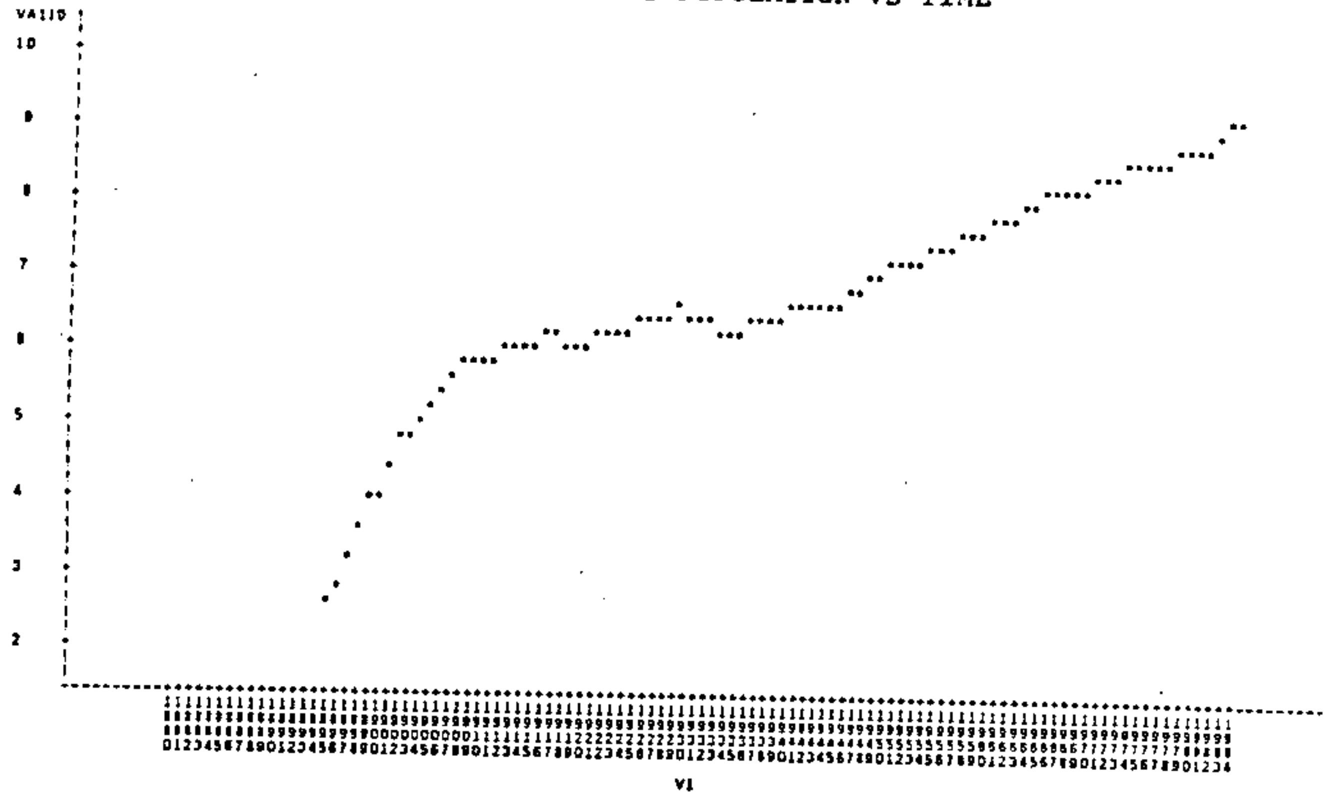
AVERAGE DAILY CONVERSATIONS DATA BEFORE ADJUSTMENT BY POPULATION VS TIME



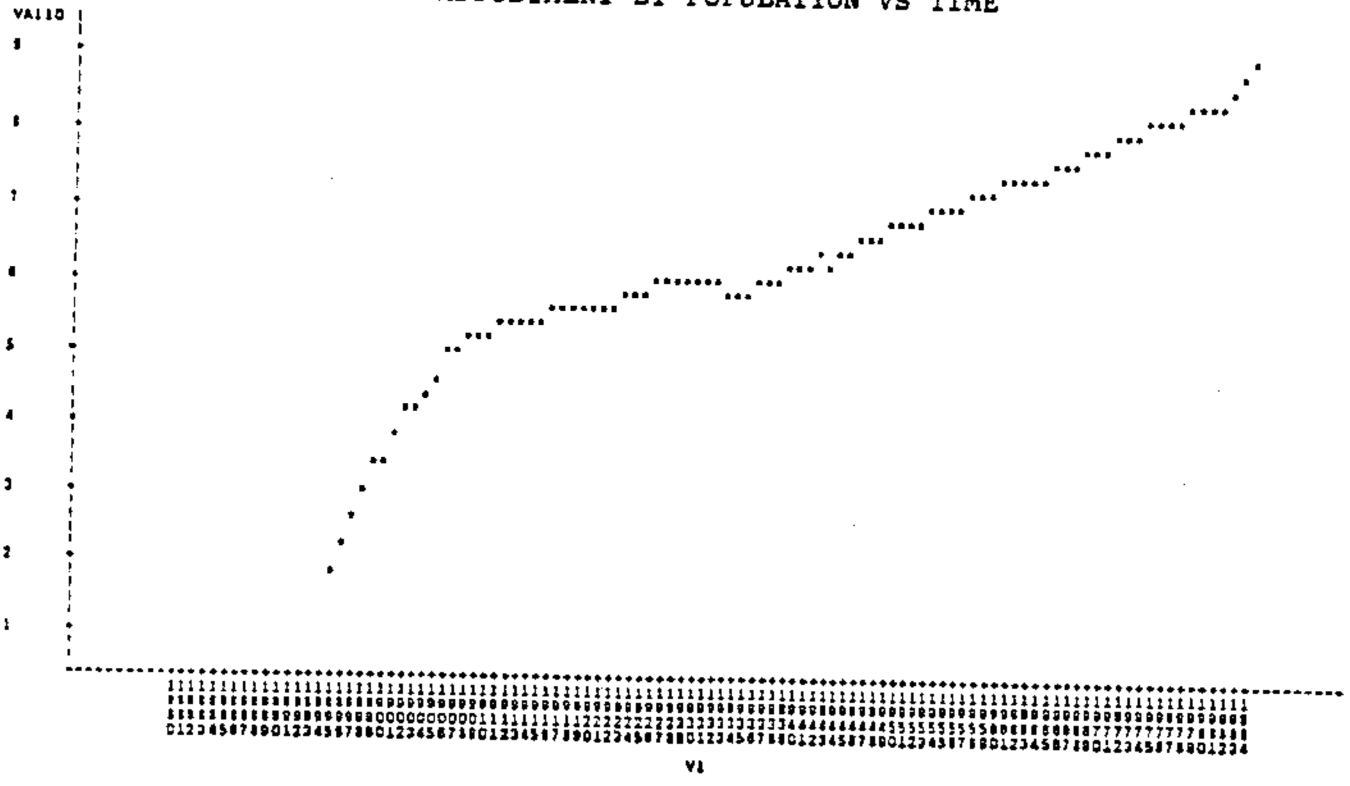
AVERAGE DAILY CONVERSATIONS DATA AFTER ADJUSTMENT BY POPULATION VS TIME



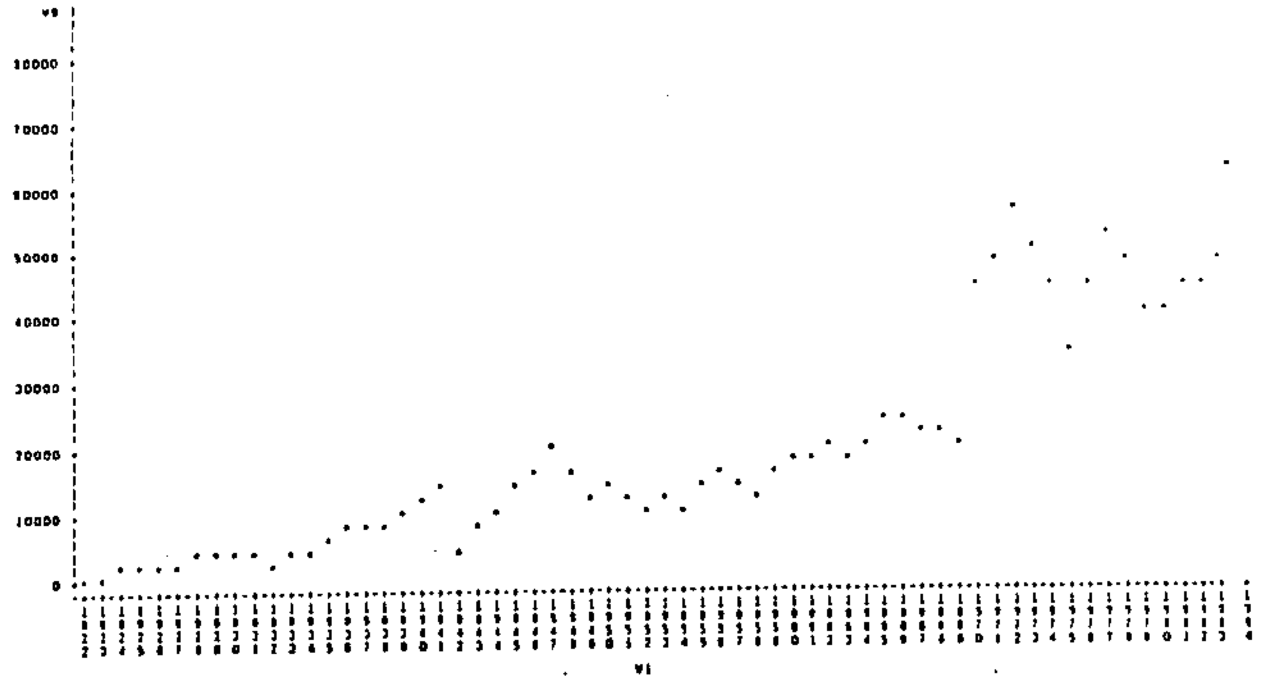
AVERAGE DAILY CONVERSATIONS DATA IN BITS BEFORE
ADJUSTMENT BY POPULATION VS TIME



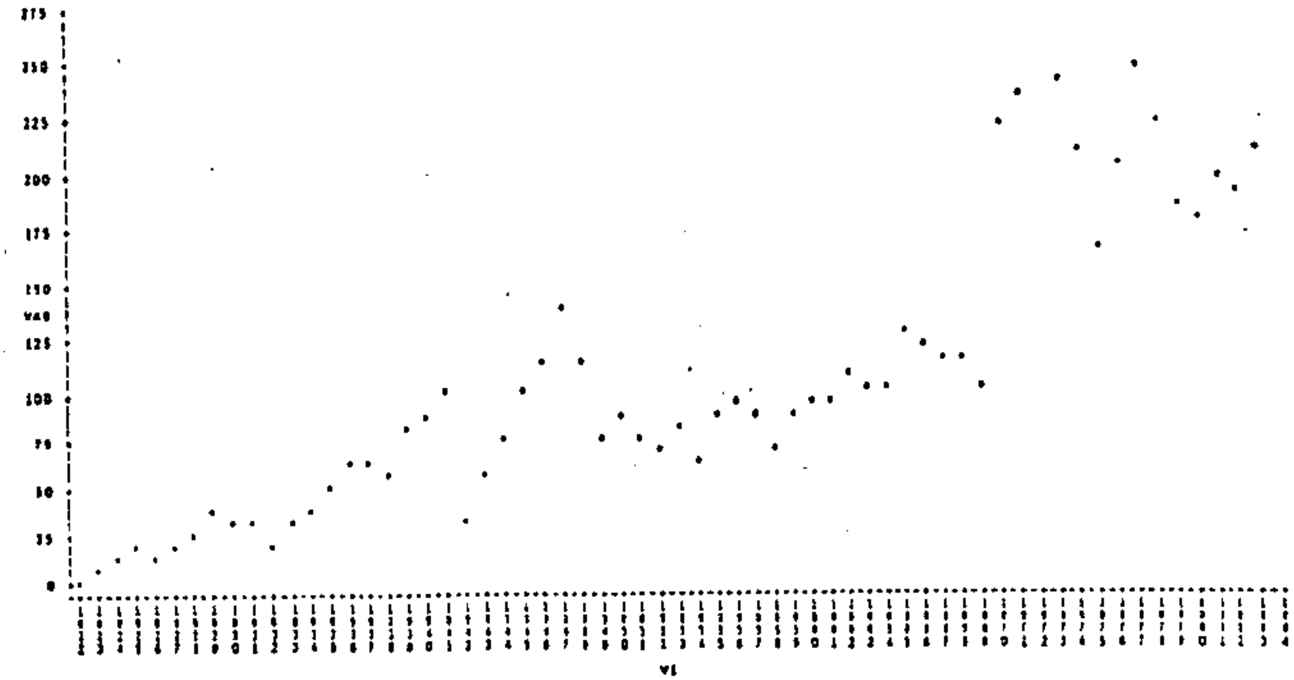
AVERAGE DAILY CONVERSATIONS DATA IN BITS AFTER
ADJUSTMENT BY POPULATION VS TIME



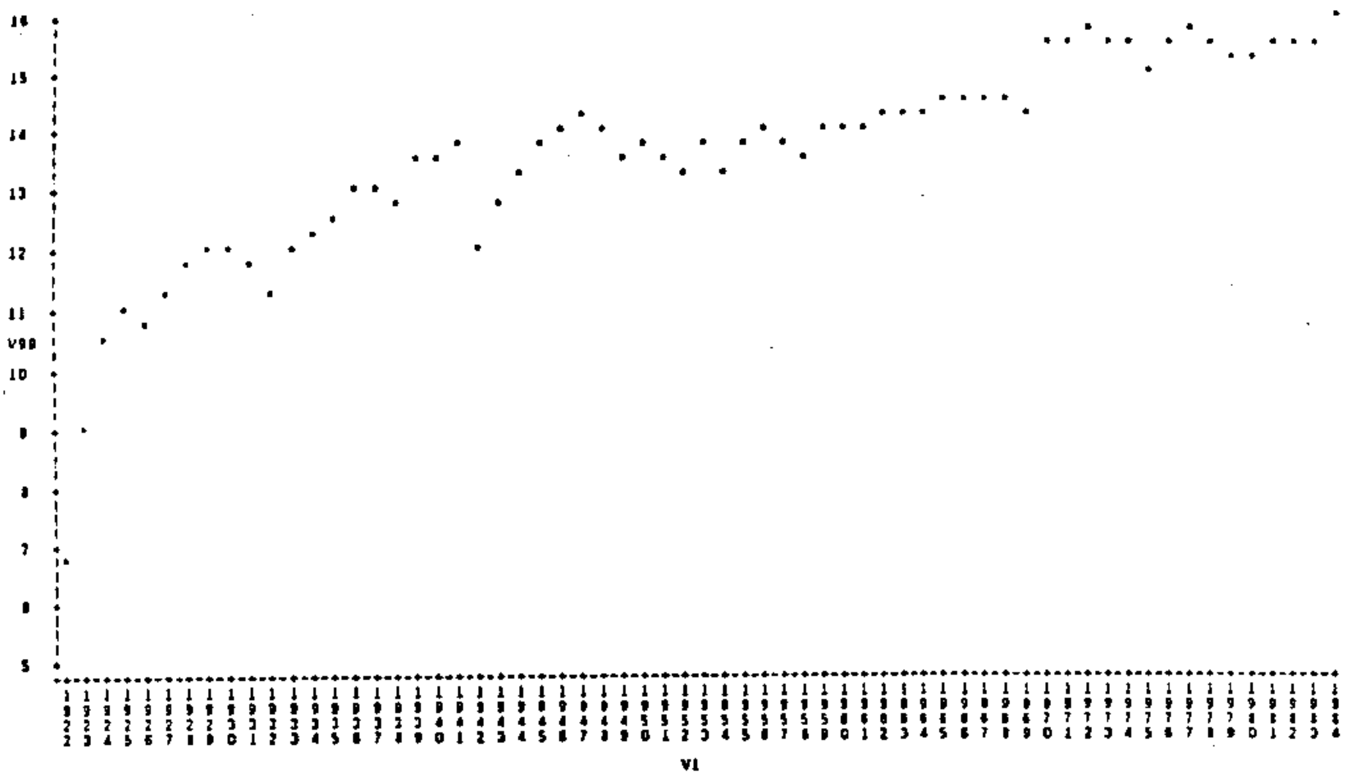
RADIO SETS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



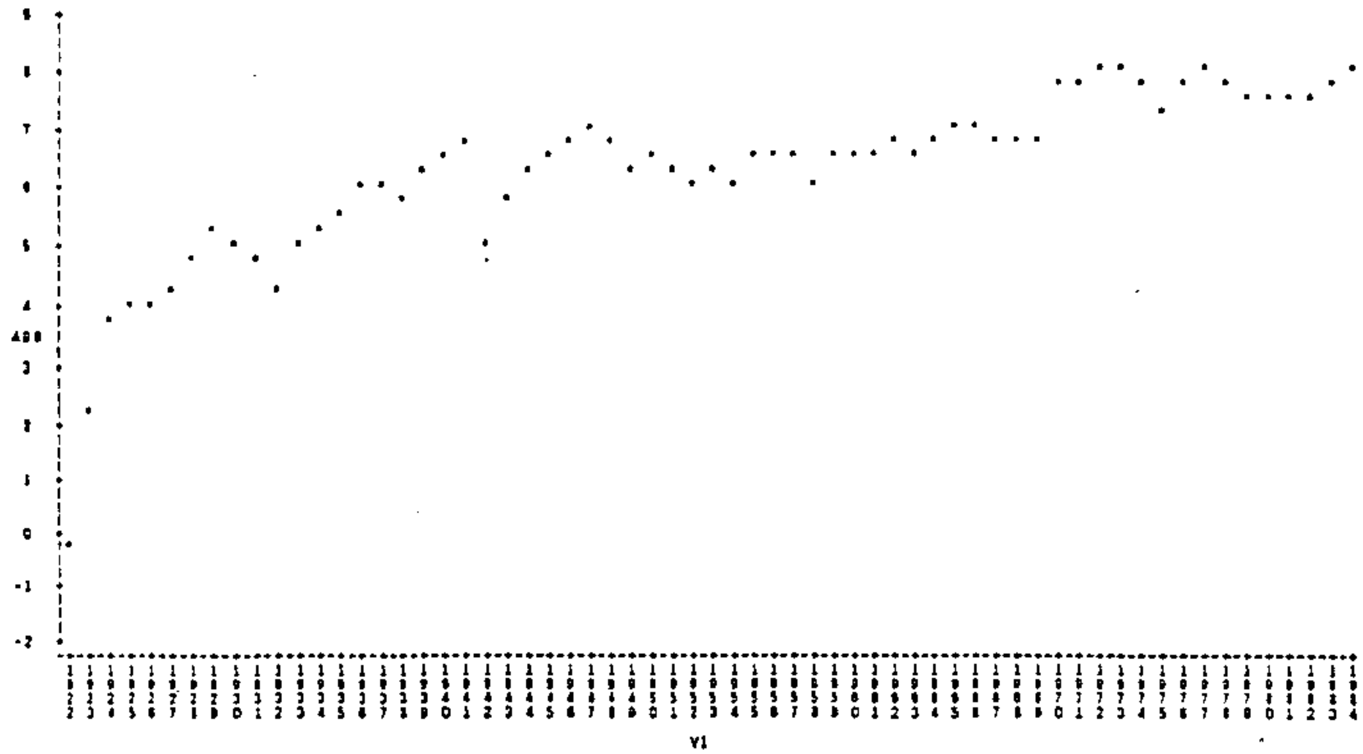
RADIO SETS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



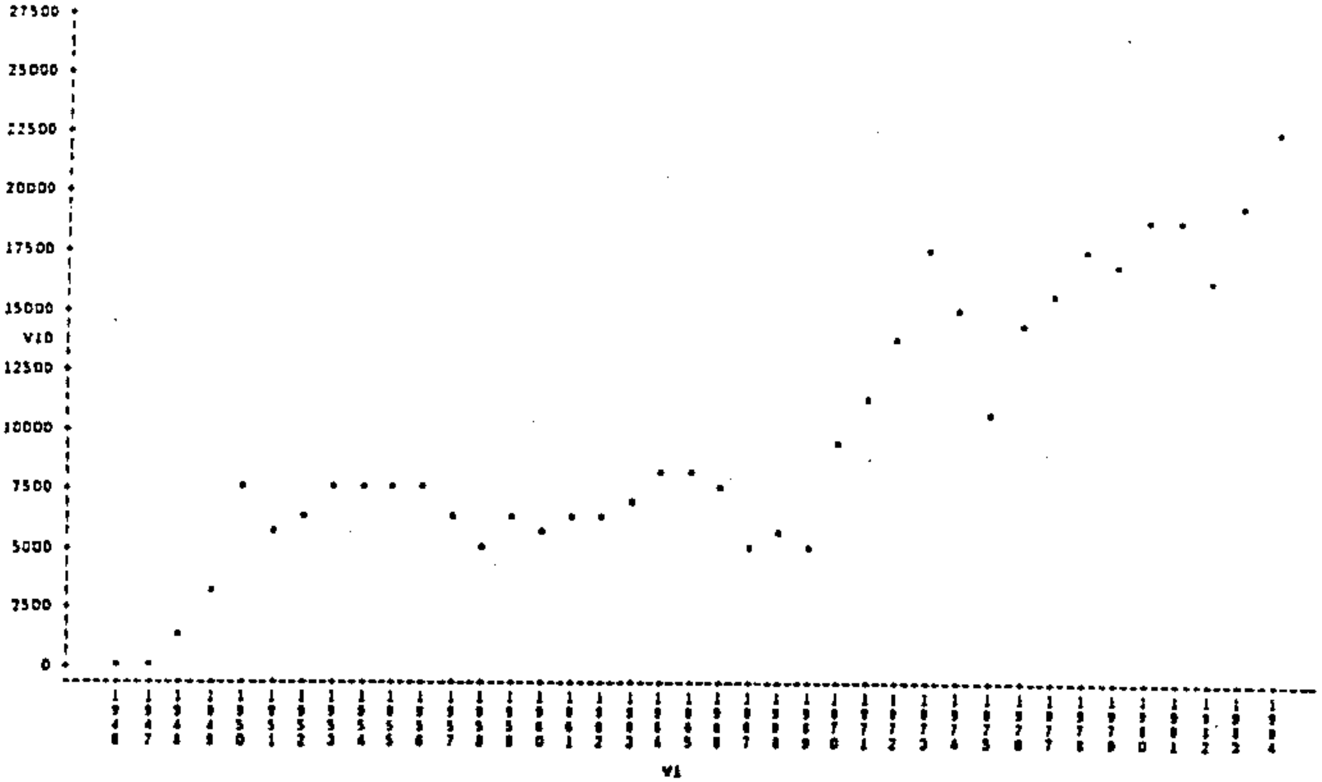
RADIO SETS DATA IN BITS BEFORE ADJUSTMENT
BY POPULATION VS TIME



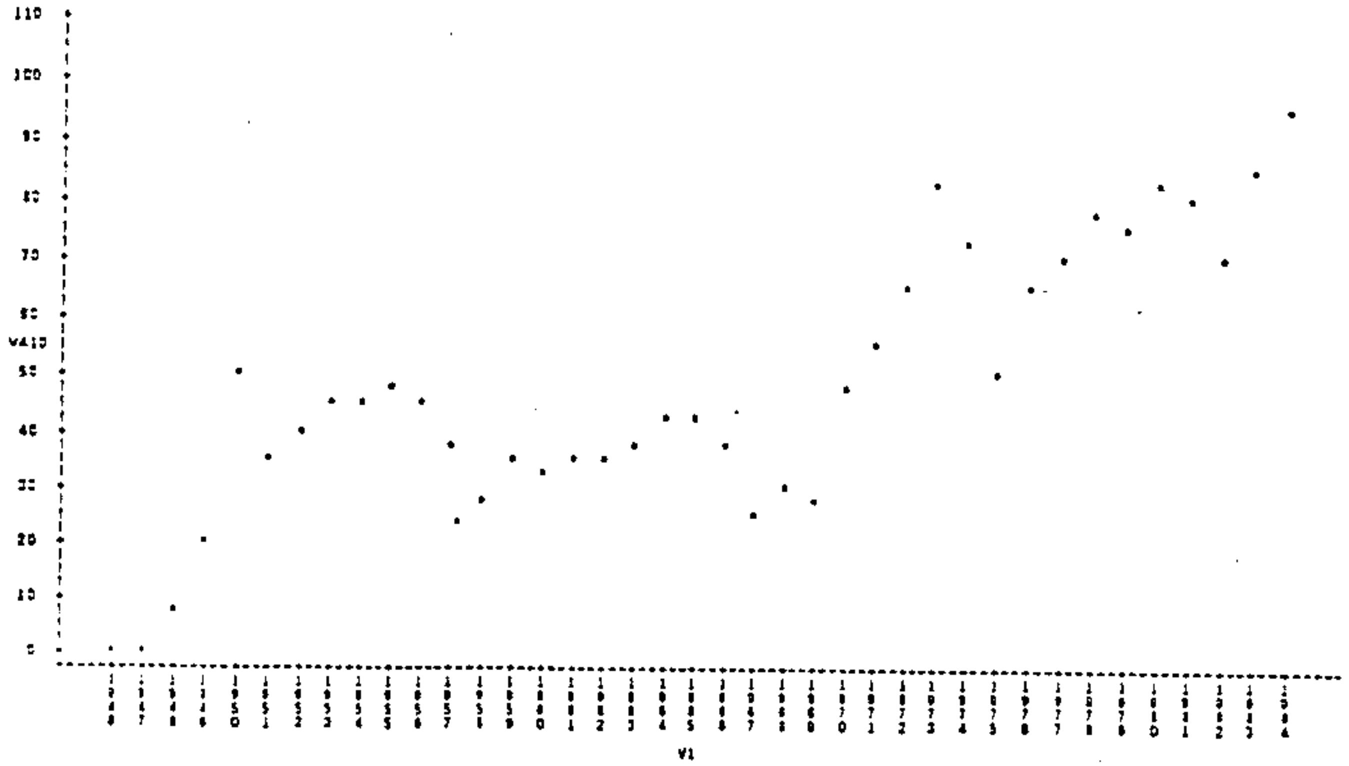
RADIO SETS DATA IN BITS AFTER ADJUSTMENT
BY POPULATION VS TIME



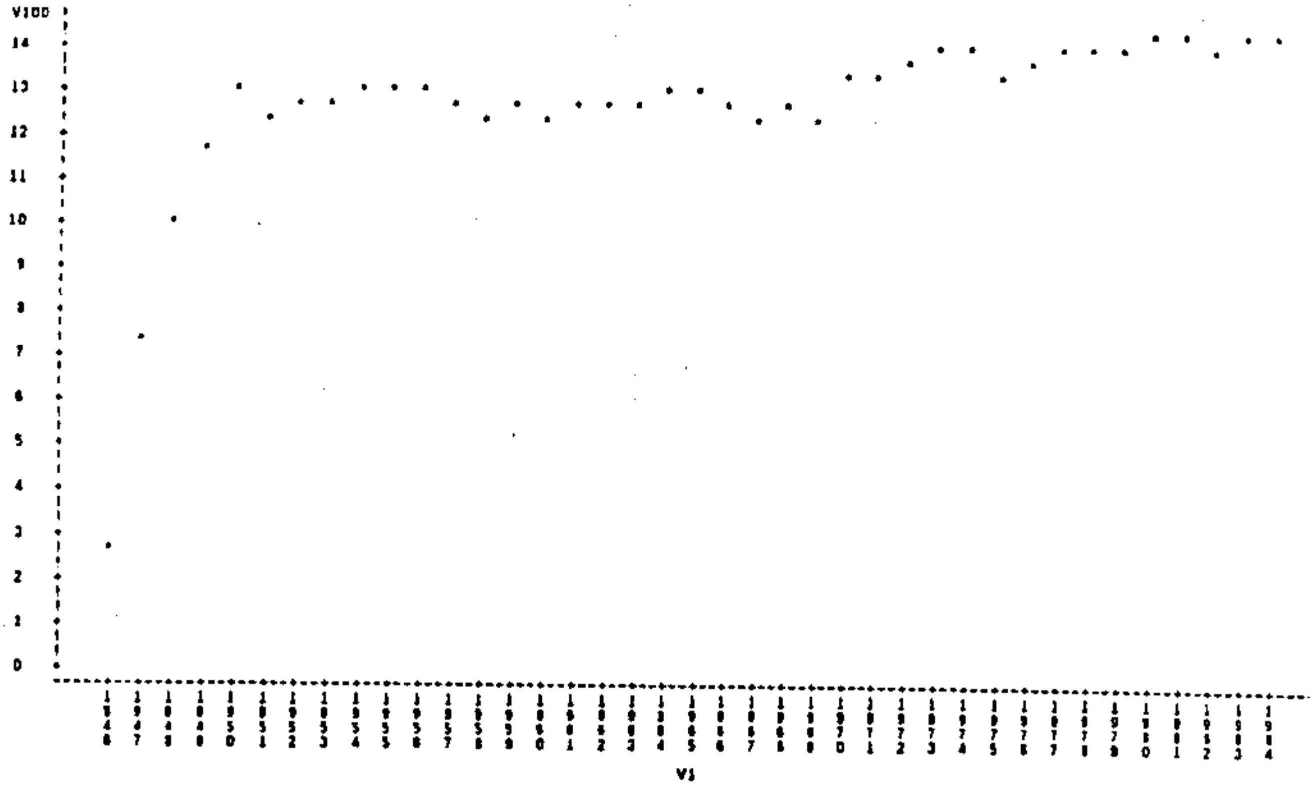
TV SETS DATA BEFORE ADJUSTMENT
BY POPULATION VS TIME



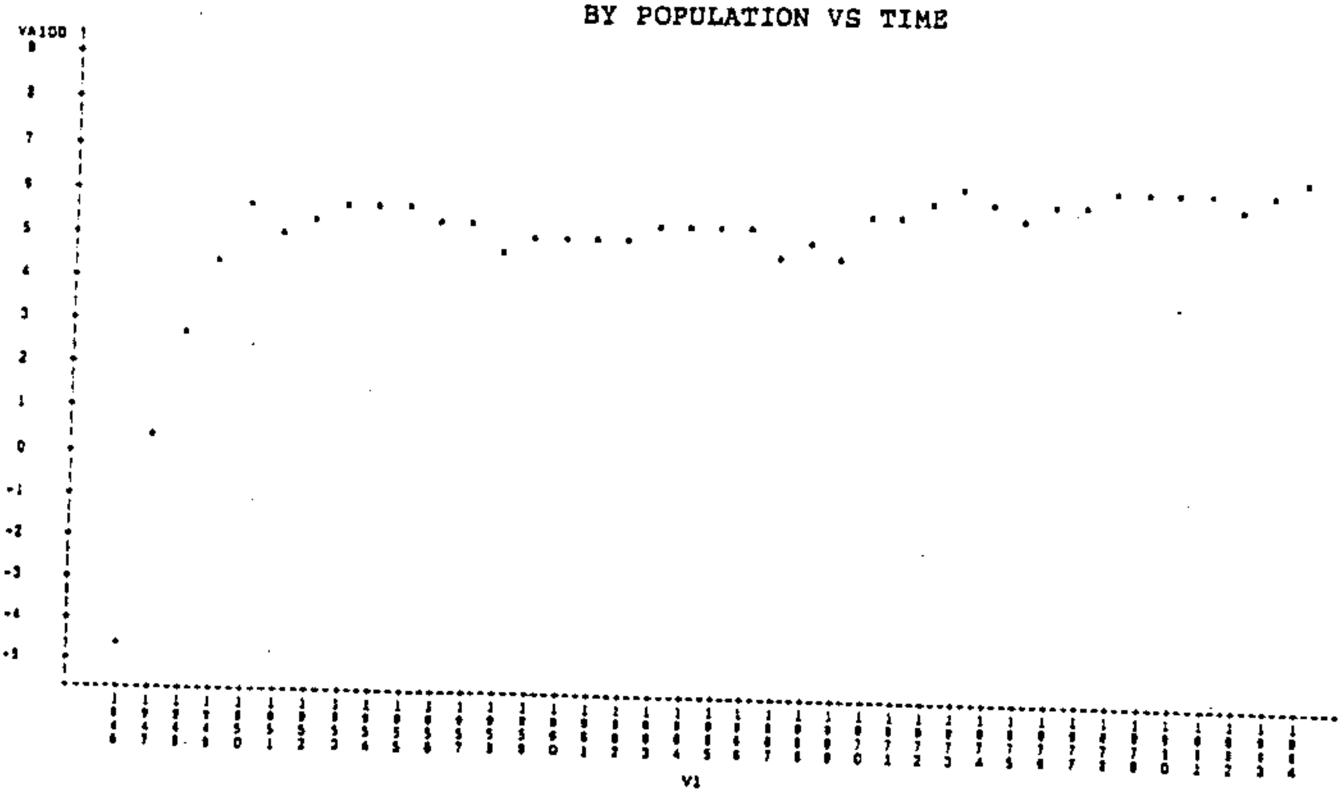
TV SETS DATA AFTER ADJUSTMENT
BY POPULATION VS TIME



TV SETS DATA IN BITS BEFORE ADJUSTMENT
BY POPULATION VS TIME

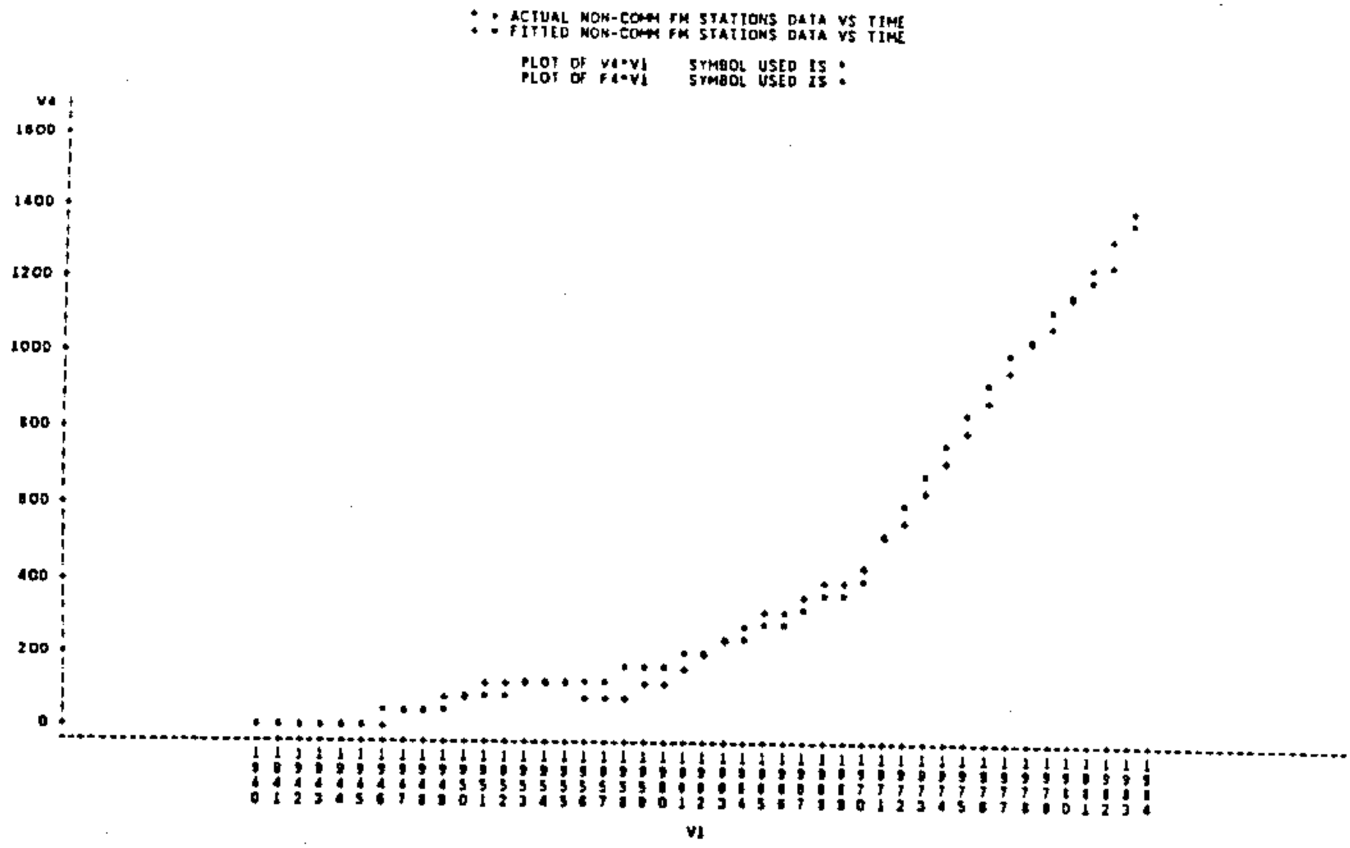


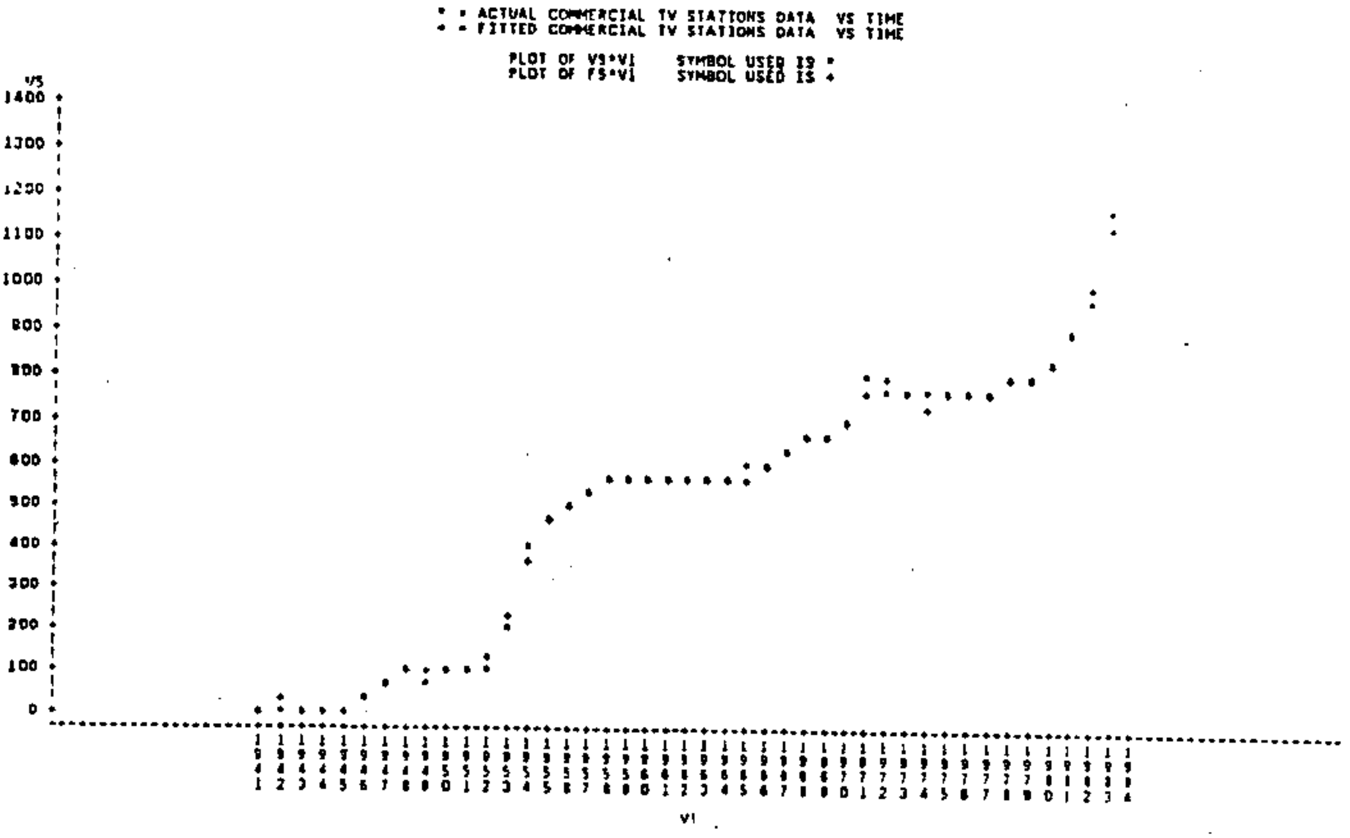
TV SETS DATA IN BITS AFTER ADJUSTMENT
BY POPULATION VS TIME

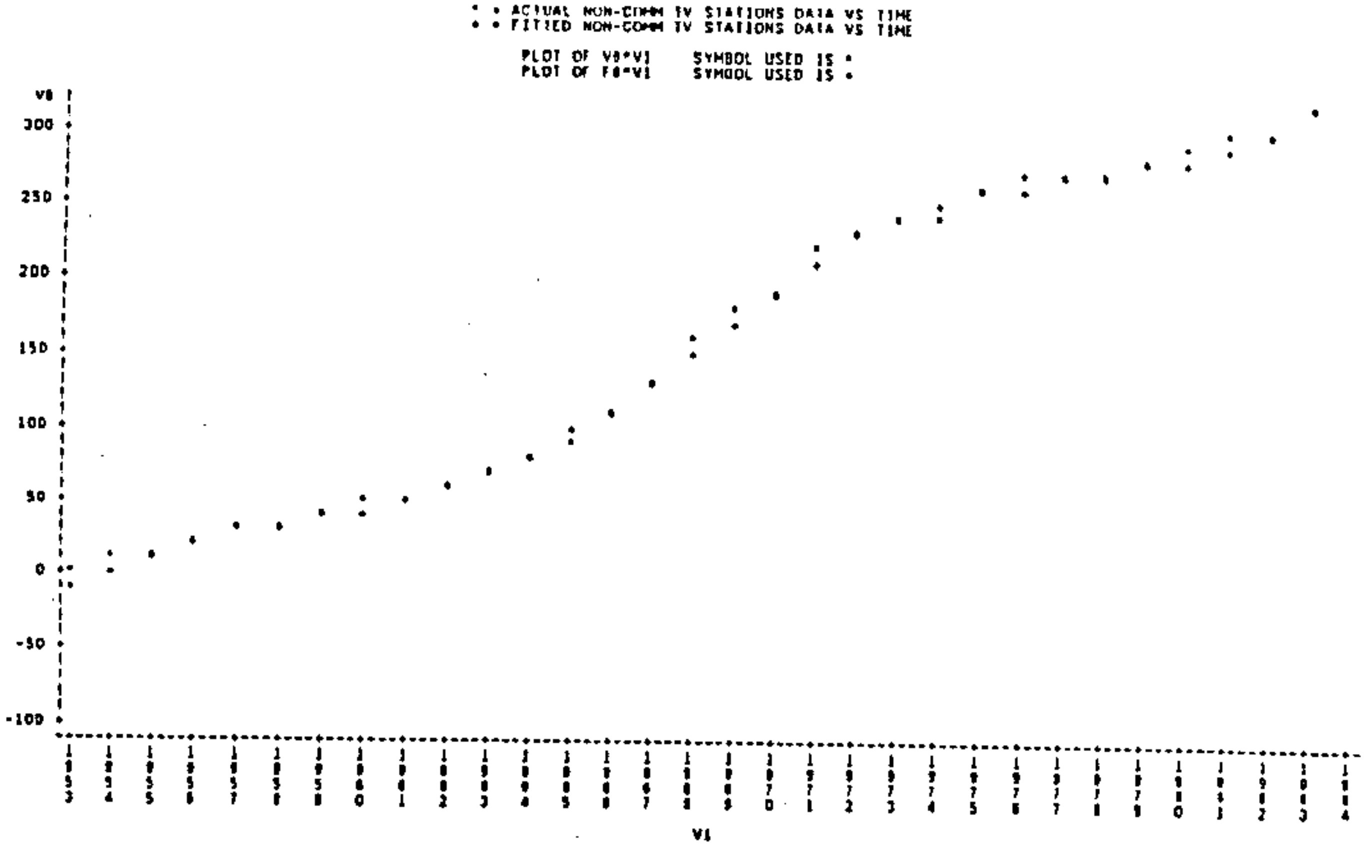


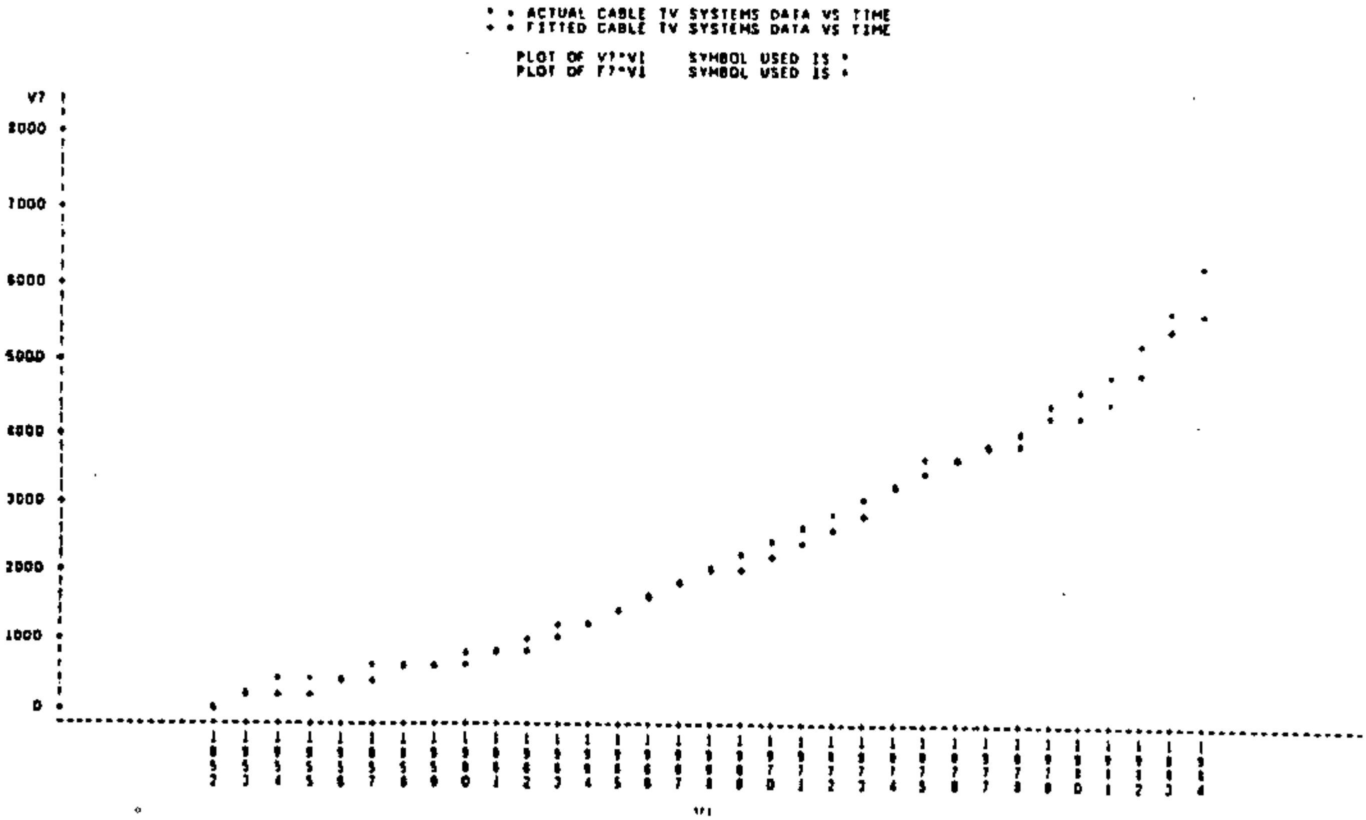
APPENDIX D

VALIDATION OF THE FITTING TECHNIQUE (CYCLE REGRESSION)


* = ACTUAL NON-COMM FM STATIONS DATA VS TIME
+ = FITTED NON-COMM FM STATIONS DATA VS TIME
PLOT OF V4*V1 SYMBOL USED IS *
PLOT OF F4*V1 SYMBOL USED IS +
V4
1600
1400
1200
1000
800
600
400
200
0
V1

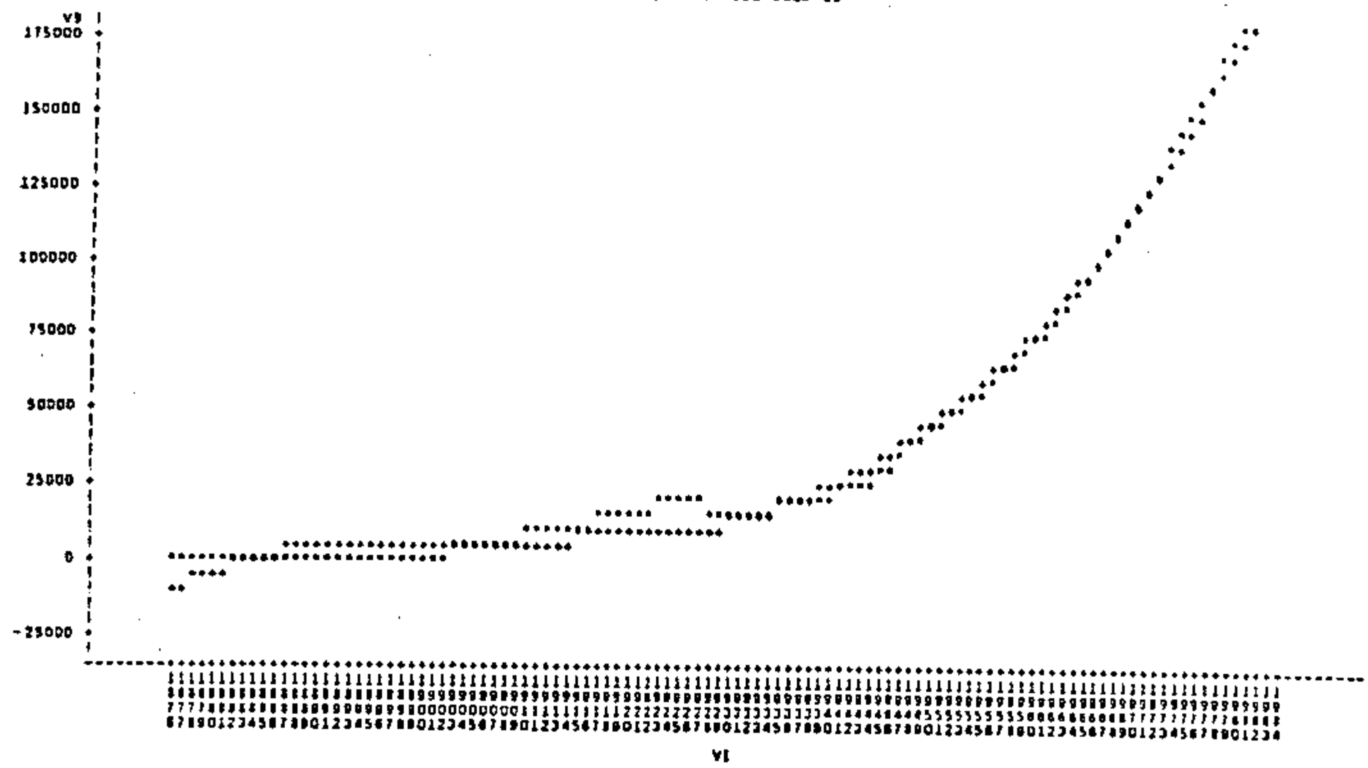

* = ACTUAL COMMERCIAL TV STATIONS DATA VS TIME
+ = FITTED COMMERCIAL TV STATIONS DATA VS TIME
PLOT OF V5*V1 SYMBOL USED IS *
PLOT OF F5*V1 SYMBOL USED IS +
V5
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
V1


* • ACTUAL NON-COMM TV STATIONS DATA VS TIME
+ • FITTED NON-COMM TV STATIONS DATA VS TIME
PLOT OF V8*V1 SYMBOL USED IS *
PLOT OF F8*V1 SYMBOL USED IS +
V8
V1


* • ACTUAL CABLE TV SYSTEMS DATA VS TIME
+ • FITTED CABLE TV SYSTEMS DATA VS TIME
PLOT OF V7*V1 SYMBOL USED IS *
PLOT OF F7*V1 SYMBOL USED IS +
V7

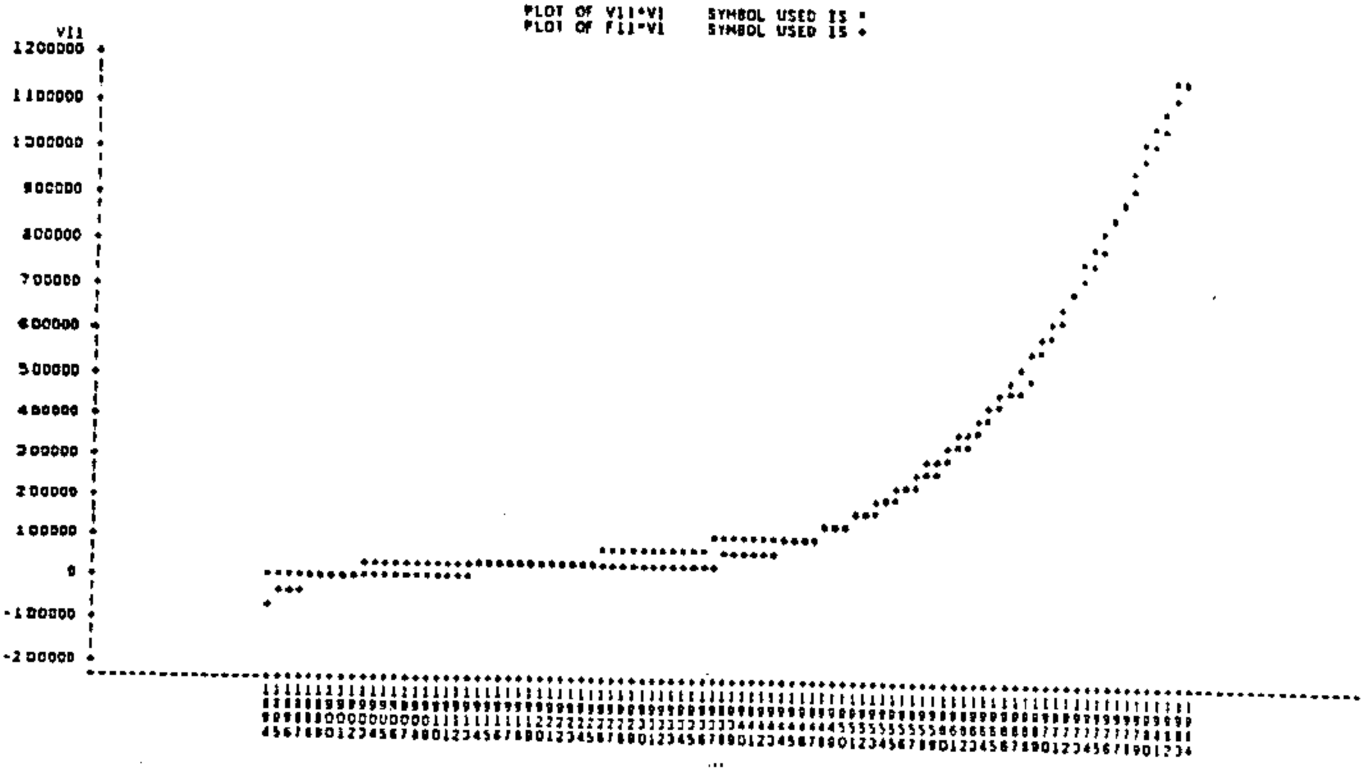
* = ACTUAL TELEPHONES DATA VS TIME
\+ = FITTED TELEPHONES DATA VS TIME

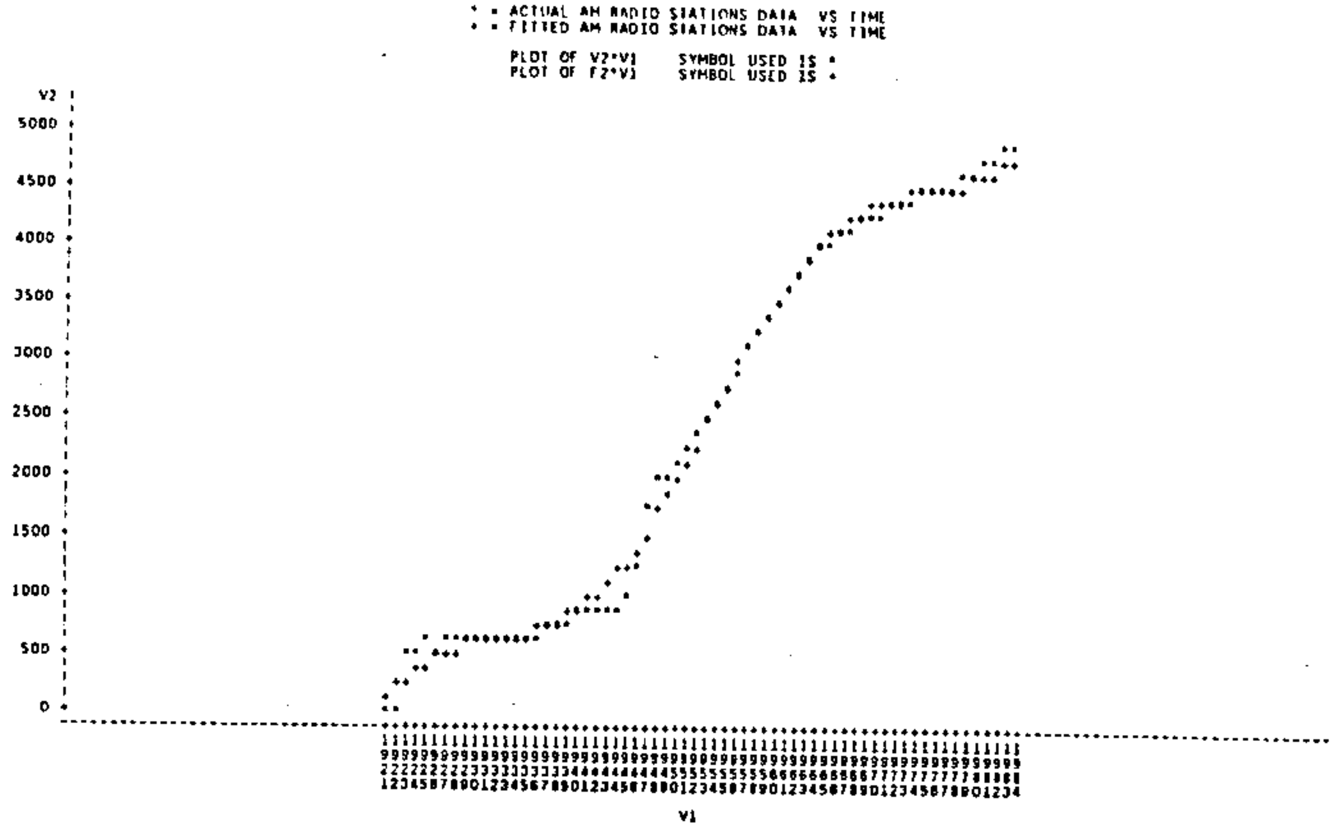
PLOT OF V9*V1 SYMBOL USED IS *
PLOT OF F9*V1 SYMBOL USED IS +

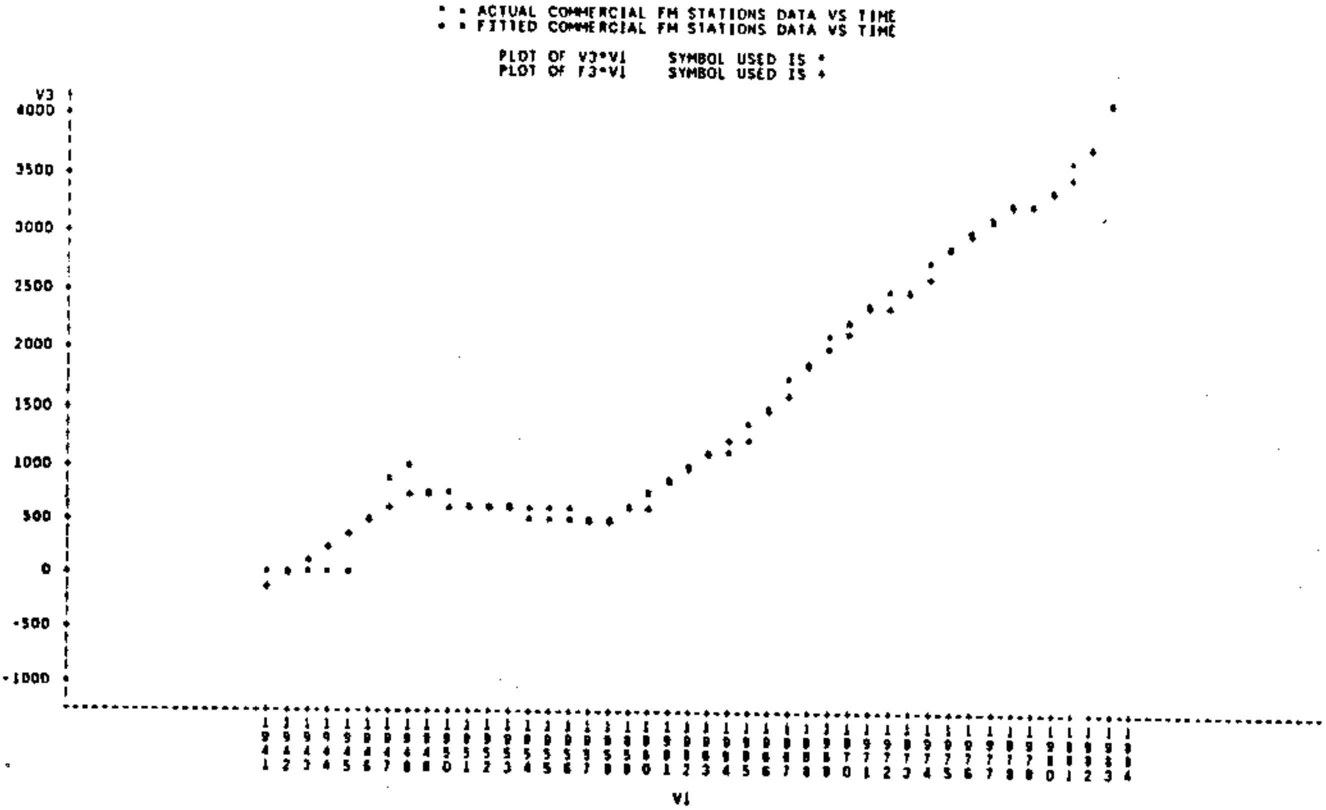


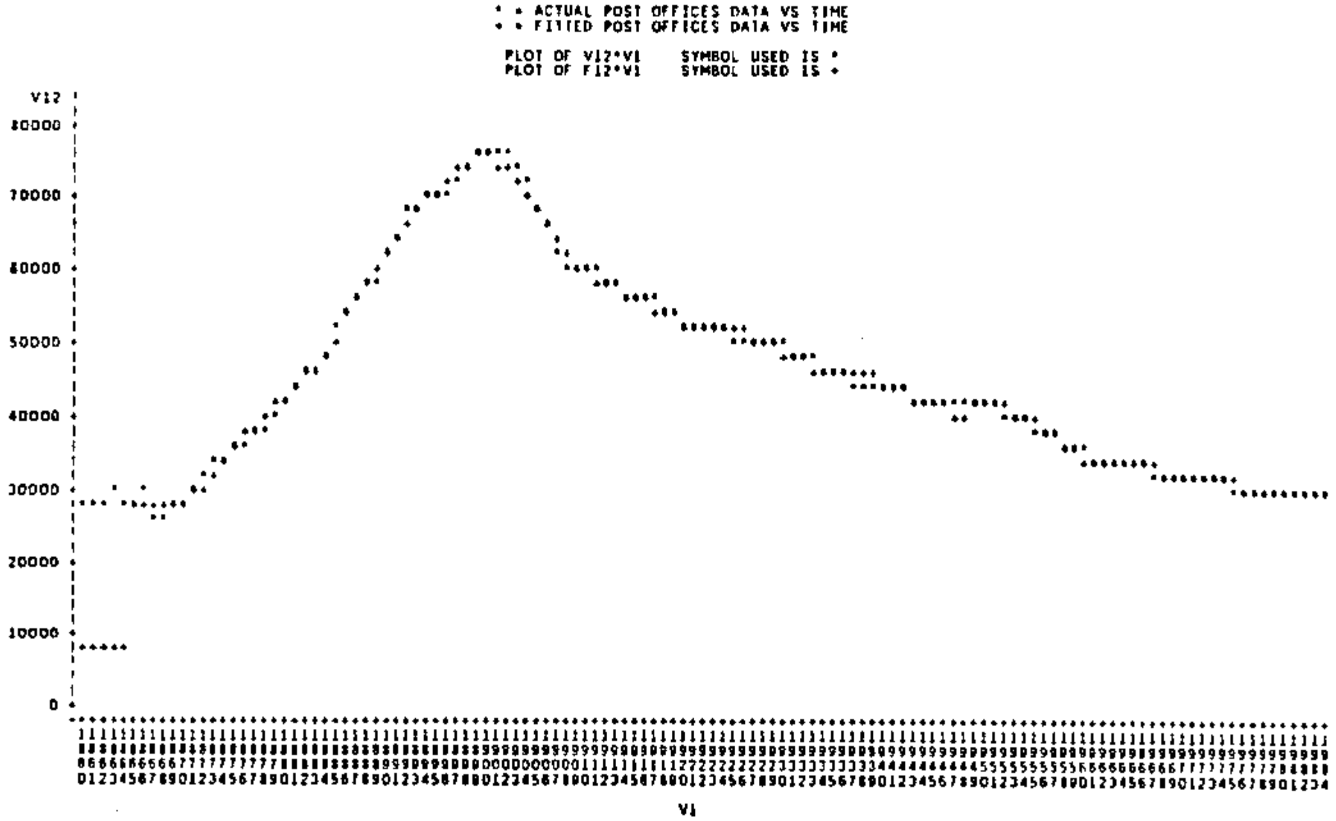
* = ACTUAL MILES OF WIRE DATA VS TIME
\+ = FITTED MILES OF WIRE DATA VS TIME

PLOT OF V11*V1 SYMBOL USED IS *
PLOT OF F11*V1 SYMBOL USED IS +




* = ACTUAL AM RADIO STATIONS DATA VS TIME
+ = FITTED AM RADIO STATIONS DATA VS TIME
PLOT OF V2*V1 SYMBOL USED IS *
PLOT OF F2*V1 SYMBOL USED IS +
V2
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
V1


* = ACTUAL COMMERCIAL FM STATIONS DATA VS TIME
+ = FITTED COMMERCIAL FM STATIONS DATA VS TIME
PLOT OF V3*V1 SYMBOL USED IS *
PLOT OF F3*V1 SYMBOL USED IS +
V3
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
V1


* * ACTUAL POST OFFICES DATA VS TIME
+ + FITTED POST OFFICES DATA VS TIME
PLOT OF V12*V1 SYMBOL USED IS *
PLOT OF F12*V1 SYMBOL USED IS +
V12
V1

APPENDIX E

FREQUENCY DATA OF FIRST AND SECOND DERIVATIVES FOR THE ORIGINAL DATA OF INFORMATION GENERATION AND INFORMATION FLOW

Frequency Data of First and Second Derivatives
Classification for COPYRIGHTS at alpha = .Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	34	38.3
PN	17	14.8
PU	51	44.3
NP	Ø	Ø
NN	Ø	Ø
NU	Ø	Ø
NS	3	2.6
TOTAL	115	1ØØ

Frequency Data of First and Second Derivatives
Classification for INVENTIONS at alpha = .Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	26	2Ø.8
PN	35	28.Ø
PU	13	1Ø.4
NP	4	3.2
NN	8	6.4
NU	12	9.6
NS	27	21.6
TOTAL	125	1ØØ

Frequency Data of First and Second Derivatives
Classification for DESIGNS at alpha = .05

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	9	7.2
PN	8	6.4
PU	25	20.0
NP	5	4.0
NN	2	2.4
NU	15	12.0
NS	60	48.0
TOTAL	125	100

Frequency Data of First and Second Derivatives
Classification for DOCTORATES at alpha = .05

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	21	18.8
PN	0	0.0
PU	35	31.3
NP	10	9.0
NN	0	0.0
NU	8	7.1
NS	8	7.1
TOTAL	112	100

Frequency Data of First and Second Derivatives
Classification for L.C. HOLDINGS at alpha = .Ø5

Classification	No Adjustment 186Ø - 1984	
	Number	%
PP	52	61.2
PN	6	7.1
PU	1Ø	11.8
NP	Ø	Ø
NN	Ø	Ø
NU	Ø	Ø
NS	17	2Ø.Ø
TOTAL	85	1ØØ

Frequency Data of First and Second Derivatives
Classification for MATTER HANDLED
IN POST OFFICES at alpha=.Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	49	49.5
PN	26	26.3
PU	9	9.1
NP	Ø	Ø
NN	Ø	Ø
NU	Ø	Ø
NS	15	15.2
TOTAL	99	1ØØ

Frequency Data of First and Second Derivatives
Classification for BOOKS at alpha = .Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	47	46.1
PN	25	24.5
PU	Ø	Ø
NP	8	7.8
NN	8	7.8
NU	4	3.9
NS	1Ø	9.2
TOTAL	1Ø2	1ØØ

Frequency Data of First and Second Derivatives
Classification for PERIODICALS at alpha = .Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	Ø	Ø
PN	Ø	Ø
PU	4	6.1
NP	Ø	Ø
NN	Ø	Ø
NU	Ø	Ø
NS	61	93.9
TOTAL	66	1ØØ

Frequency Data of First and Second Derivatives
Classification for NEWSPAPERS at alpha = .Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	Ø	Ø
PN	Ø	Ø
PU	4	6.2
NP	7	1Ø.8
NN	7	1Ø.8
NU	17	26.2
NS	3Ø	46.1
TOTAL	65	1ØØ

Frequency Data of First and Second Derivatives
Classification for NEWSPAPERS
CIRCULATION at alpha=.Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	2Ø	3Ø.8
PN	28	43.1
PU	5	7.7
NP	Ø	Ø
NN	Ø	Ø
NU	Ø	Ø
NS	12	18.5
TOTAL	65	1ØØ

Frequency Data of First and Second Derivatives
Classification for AVERAGE DAILY
CONVERSATIONS at alpha = .Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	53	58.2
PN	21	23.1
PU	Ø	Ø
NP	Ø	Ø
NN	Ø	Ø
NU	Ø	Ø
NS	17	18.6
TOTAL	91	1ØØ

Frequency Data of First and Second Derivatives
Classification for RADIO SETS at alpha = .Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	Ø	Ø
PN	Ø	Ø
PU	Ø	Ø
NP	Ø	Ø
NN	Ø	Ø
NU	Ø	Ø
NS	63	1ØØ
TOTAL	63	1ØØ

Frequency Data of First and Second Derivatives
Classification for TV SETS at alpha = .Ø5

Classification	No Adjustment 1860 - 1984	
	Number	%
PP	6	15.4
PN	14	35.9
PU	6	15.4
NP	Ø	Ø
NN	Ø	Ø
NU	Ø	Ø
NS	13	33.4
TOTAL	39	1ØØ

APPENDIX F

POPULATION GROWTH DATA AND GRAPH

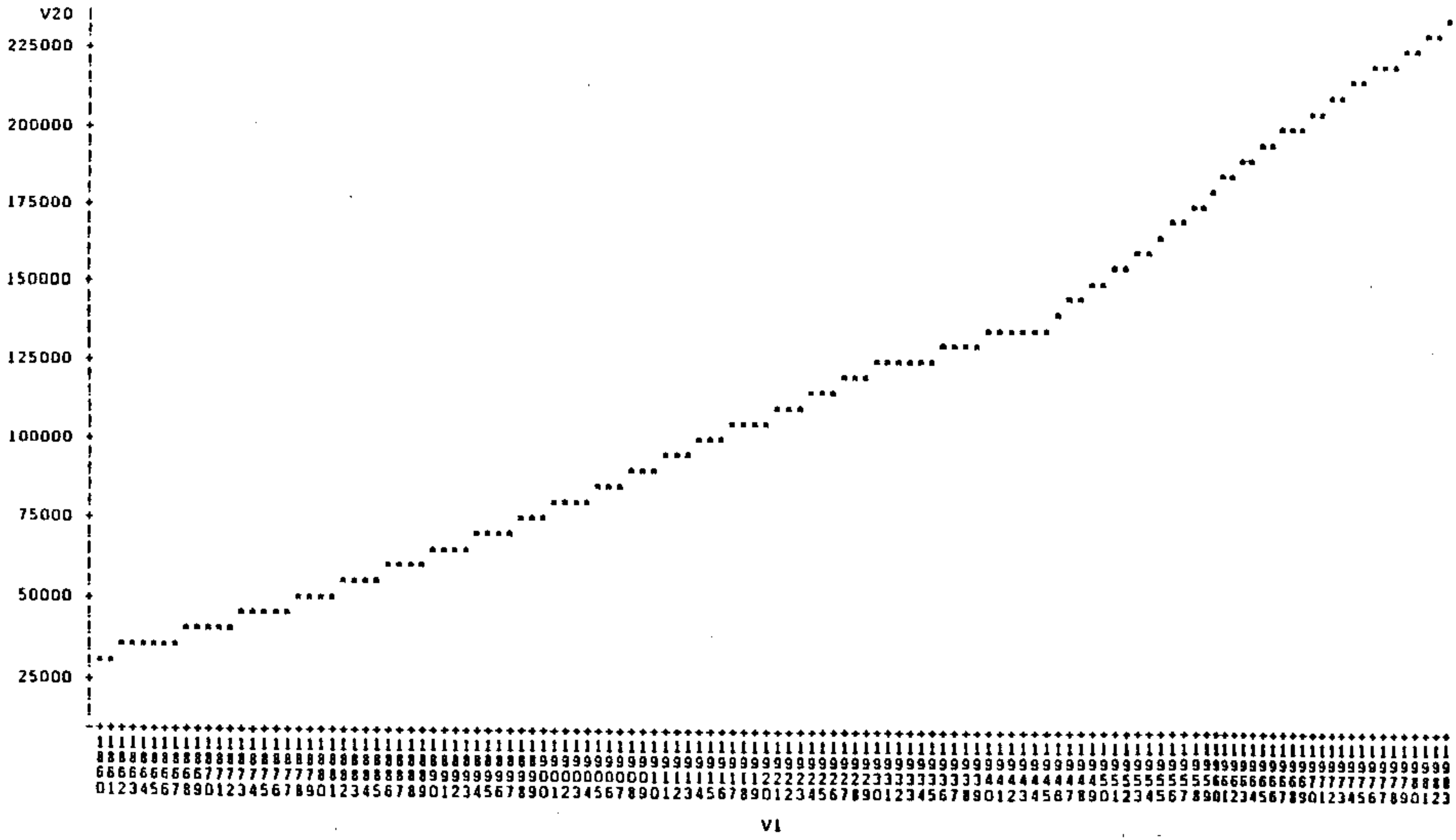
POPULATION GROWTH DATA IN THE USA

Time Period	Population in Thousands	Time Period	Population in Thousands
1860	31531	1891	64361
1861	32351	1892	65666
1862	33188	1893	66970
1863	34026	1894	68275
1864	34863	1895	69580
1865	35701	1896	70885
1866	36538	1897	72189
1867	37376	1898	73494
1868	38213	1899	74799
1869	39051	1900	76100
1870	39905	1901	77600
1871	40938	1902	79200
1872	41972	1903	80600
1873	43006	1904	82200
1874	44040	1905	83800
1875	45073	1906	85400
1876	46107	1907	87000
1877	47141	1908	88700
1878	48174	1909	90500
1879	49208	1910	92400
1880	50262	1911	93900
1881	51542	1912	95300
1882	52821	1913	97200
1883	54100	1914	99100
1884	55379	1915	100500
1885	56658	1916	102000
1886	57938	1917	103300
1887	59217	1918	103200
1888	60496	1919	104500
1889	61775	1920	106500
1890	[illegible]3056	1921	108500

POPULATION GROWTH DATA IN THE USA

Time Period	Population in Thousands	Time Period	Population in Thousands
1922	110100	1954	161900
1923	112000	1955	165100
1924	114100	1956	168100
1925	115800	1957	171200
1926	117400	1958	174100
1927	119000	1959	177100
1928	120500	1960	180000
1929	121800	1961	183000
1930	123100	1962	185800
1931	124100	1963	188500
1932	124800	1964	191100
1933	125600	1965	193500
1934	126400	1966	195600
1935	127300	1967	197500
1936	128100	1968	199400
1937	128800	1969	201400
1938	129800	1970	204000
1939	130900	1971	206800
1940	132500	1972	209300
1941	133700	1973	211400
1942	134600	1974	213300
1943	135100	1975	215500
1944	133900	1976	217600
1945	133400	1977	219800
1946	140700	1978	222100
1947	144100	1979	224600
1948	146700	1980	227200
1949	149300	1981	229300
1950	151900	1982	231500
1951	154000	1983	233700
1952	156400	1984	235671
1953	159000		

POPULATION GROWTH DATA VS TIME



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