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MASSMOD: A COMPUTER SIMULATION OF THE MASS MEDIA INDUSTRY 1945-1960

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MASSMOD: A COMPUTER SIMULATION OF THE MASS MEDIA INDUSTRY 1945-1960

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ABSTRACT

MASSMOD: A COMPUTER SIMULATION OF THE MASS MEDIA INDUSTRY 1945-1960

By

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This research applied systems simulation methodology to the study of the economic and structural behavior of the mass media industry from 1945 to 1960. Using historical data from a time period marked by the introduction of a new communications technology--television, the study had two major purposes: (1) the quantification of abstract theories about media structure and economics and the identification of integral relationships among media components, accomplished by the construction and validation of a computer simulation model called MASSMOD; and (2) the demonstration of the feasibility and usefulness of systems simulation to the study of media behavior, planning and policymaking, shown by a series of experiments which manipulated two policy variables in the model and compared alternate results to the benchmark model. Because of the shortage of past research that has applied systems simulation to the mass media as an industry, the research was designed to be exploratory.

MASSMOD, written in Minnesota FORTRAN, was built at a highly aggregate, industry-wide level. It consisted of four sectors: broadcast (AM and FM radio, VHF and UHF television), print (newspapers and consumer magazines), advertisers and consumers. Ordinary least squares regression routines were used to develop structural equations for the system. Postdictive validation techniques, using Theil's (1961) Inequality Coefficient, was employed to validate the model's output.

The system represented by MASSMOD showed a remarkable stability during 1945-1960, when television, first VHF and then UHF, was introduced to the system. The number of magazines and newspapers published in the period remained fairly constant; revenues grew slightly as both advertising expenditures on each medium and circulation increased. The print sector was not integrally linked to the broadcast sector in terms of sensitivity to change. AM stations increased in number and listenership, although earnings declined as advertising expenditures were transferred to television. FM stations grew steadily, while revenues and expenses declined, then took an upward swing. UHF television seemed the most unstable subsector, with most variables decreasing in value and earnings in the red.

The experiments performed on the system, which assumed that initial conditions were the same as the historical situation, indicated that the system would remain remarkably the same under different policy parameters. Only a total FM and/or a total UHF broadcasting system would make those media prominent and profitable, though still not as successful as historical AM radio or VHF television. UHF television had little effect on VHF television, even when UHF frequencies were introduced in 1945, instead of 1952 as was the case historically.

MASSMOD presents a simple, valid mathematical representation of the mass media industry from 1945-1960. It lived up to its purpose as an exploratory effort into the use of systems simulation as an appropriate tool for study of the behavior of the mass media industry. Supported by additional data, the model needs to be expanded and improved, so that mathematical relationships and theoretical speculations which are not included in MASSMOD, especially in the FM and UHF sectors, may be investigated. To be used as a real forecasting tool, the model needs to be updated to describe industry behavior in the 1960's and 1970's.

Despite its shortcomings, MASSMOD has pulled together elements of a media system too often studied in isolation, and quantified abstract relationships. It is a simulation of a historical reality, available for experimentation and questioning. At the minimum, this study has suggested an approach that someone with access to a rich data base could use to make accurate predictions of the consequences of policy decisions made to influence the behavior of the mass media system.

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CHAPTER 1

INTRODUCTION

Problem Statement

Mass media watchers--from amateur consumers to trained academicians--are fluent in the "blue sky" possibilities of new communications technologies, most notably, cable television, satellites, fiber optics. But, little has been done to actually assess, much less predict, the impact of such technological developments on the consumer and the media industry or to identify optimum conditions for the acceptance and diffusion of that technology among the population. With no such research in existence, media policymakers, such as the Federal Communications Commission (FCC), are forced to develop regulations which react to, rather than anticipate, the effects of the technology and media industries must plan somewhat blindly.

Reasons for this lack of research are twofold: the relative youth of the mass media and the complexity of the policymaking process itself.

The mass media, as a relatively new area of academic interest, have been studied using the techniques of many disciplines--psychology, sociology, economics, aesthetics, information science, marketing, management science, economics and more. These studies, for the most part, each have emphasized one perspective and also one medium. Thus, a fair amount of information about the mass media and their effects does exist, such as the consumption studies of Steiner (1963), Bower (1973), Roper (1977), and the Newspaper Advertising Bureau (1972, 1978); the functional approach of Bogart (1956), Mendelsohn (1964), and Wright (1975); and the industrial economics positions of Noll, Peck and McGowan (1973), Eoyang (1974), Owen (1975), and Stuart (1976). What does not exist is a synthesis of this research, an integration of these disparate studies which defines the interrelationships of mass media effects and components, such as broadcasters, advertisers, publishers and consumers, to an extent which makes prediction of the behavior of the mass media system possible.

Secondly, policymaking in the public sector and in business is a difficult process. Values and goals in a pluralistic society can be inconsistent and conflicting, while the interrelationships of various components of a process are defined by complex feedback loops. Ideally, having identified various policy alternatives to a specific situation, policy and industry decision-makers would like to test each option and weigh possible consequences and outcomes, before passing a new law or starting a new program. Such experimentation with real life, large-scale social systems is at best unfeasible, if not impossible. Because the real system is so complex and unavailable for observation, it is difficult to conduct replication studies, which maintain experimental controls and introduce willful manipulation of variables. Once the real system has been touched, the outcomes and consequences cannot be reversed. Also, often when a future and hypothetical event is suggested for introduction to the system, there is no possibility of studying it in the recent or distant past because it is new, and has never occurred before.

A possible solution to this two-edged problem of lack of *a priori* consideration of mass media policy alternatives is the application of systems science and computer simulation techniques. System simulation provides a problem-solving methodology to deal with complex, dynamic, interlocking multivariate relationships which describe a particular situation or environment. Grounded in synthetic philosophy, the systems approach "emphasizes the interrelationship among different parts of a complex problem and the need to take a holistic look at the problems that have been created or worsened by a piecemeal attack." (Chen, Ghausi & Sage, 1975, p. 340) By constructing a working analogy of the structure and interrelationships of a problem under study which replicates historical data, the systems designer can identify the complex internal interactions within the system model, as well as observe the effects of informational, organizational and environmental changes on system operation by altering the model. (Naylor, Balintfy, Burdick & Chu, 1968, p. 8)

While systems simulation has not been applied as yet to the mass media, it has been used successfully in analyses of industrial (Cohen, 1960; Balderston & Hoggatt, 1962) and marketing (Orcutt, Greenberger, Korbel & Rivlin, 1961; Chorafas, 1965; Amstutz, 1967; Griggs, 1970) behavior, economic predictions (Duesenberry, Eckstein & Fromm, 1960; Adams & Burmeister, 1973), urban and regional studies and policymaking (Forrester, 1969; Hamilton, Goldstone, Milliman, Pugh, Roberts & Zellner, 1969; Anundsen & Lindgren, 1972), and world forecasting (Forrester, 1971; Meadows, Meadows, Randers & Behrens, 1972; Boyd, 1972; Burnett & Dionne, 1973; Behrens, 1973; Schiesser, 1976; Hobert, 1977; Zaiser & Schiesser, 1977; Naill, 1977). One of the most well-known simulations is The Club of Rome's Limits to Growth model (Meadows et al., 1972) which was created to identify and study the dominant elements and their interactions that influence the long-term behavior of world systems.

Critics of the use of systems simulation in the social sciences are skeptical that the complex interrelationships and behaviors of components in human systems can be represented in abstract, mathematical equations and that sufficient data exist on which to base a model. Proponents of the methodology, such as Jay Forrester, use those very arguments to urge the adoption of systems simulation in studying the behavior of social systems:

> Our social systems are far more complex and harder to understand than our technological systems. Why, then, do we not use the same approach of making models of social systems and conducting laboratory experiments on those models before we try new laws and government programs in real life? The stated answer is often that our knowledge of social systems is insufficient for constructing useful models. But what justification can there be for the apparent assumption that we do not know enough to construct models but believe we do know enough to design new social systems directly by passing laws and starting new social programs? (Forrester, 1973, p. 6)

The Purpose of the Study

The present research applied systems simulation methodology to study the behavior of the mass media industry from 1945 to 1960, a period which was marked by the introduction of a new telecommunications technology--television--into the existing system. The study was divided into two parts: first, the construction and validation of the basic simulation model, MASSMOD, from existing census and industry data, incorporating the economic and structural behavior of four key components--broadcasters (AM and FM radio, VHF and UHF television), publishers (newspapers and magazines), advertisers and consumers (detailed in Chapter 3); and second, the experiments, which used the benchmark model as a control, to manipulate various policy variables to observe the effects of organizational and environmental changes on the operation of the system (Chapter 4).

The research sought to accomplish two things:

1. By stating conscious, explicit, definite and logical relationships among variables within and among the four components in the model in mathematical form, the study hoped to contribute to the theoretical base which describes mass media behavior and effects. The quantification of abstract theories about media structure and economics, as well as the integration of such theories across the boundaries of specific media, identified integral relationships among components and variables within the complex structure of the industry. The theoretical importance of this work is stated best by Kuhn: "At the level of theory, a piece of research makes a substantive contribution, as for example, by identifying certain relationships among a set of variables." (paraphrased in Krulee, 1972, p. 53)

2. By manipulating various policy variables incorporated into the model, and comparing alternative results against the benchmark model, the study sought to demonstrate the feasibility and usefulness of the application of systems simulation to the study of mass media behavior, effects, planning, and policymaking. Specifically, the policy variables which were manipulated were those which were of interest not only during the period under study, but are also being discussed today: regulation of advertising expenditures and the number and type of spectrum frequency allocations for each broadcast medium. Such experimentation using a simulation model provided answers to many "what if" questions, without altering the real-life system.

The creation of an historical model of the mass media industry and its validation against existing time-series data, provided a framework in which to identify key theoretical relationships among variables which describe the dynamics of the system and to generate and test hypotheses about the effects of certain policies and decisions. The building of a total industry system model, linking broadcaster, publisher, advertiser and consumer components, allowed for the synthesis and integration of many single medium and single effect studies which have been conducted in the field.

Television sparked a major revolution in mass communications. Its growth and development was managed and guided by businessmen who had little notion of its far-reaching effects, save as an economic gold mine. It was heralded by consumers who lived in a postwar era of relative affluence and enjoyment, and regulated by government policymakers on an *ad hoc* basis, in the best interest of the *status quo*. At no time did long-range planning, or a consideration of alternative positions, seem necessary or possible to these people.

Now in 1980, as the United States moves from an industrial to an information economy (Robinson, 1978, p. 55), revolutionary changes in information technology, involving computers and telecommunications, stand ready to cause upheavals in markets, institutions, law and politics. In order to plan and legislate effectively, decision-makers must have a method at their disposal to explore the implications of these new technologies, and to assess the merits and drawbacks of various marketing schemes, technical requirements, and industry structures. It is to this end that the present research was directed--to encourage the development of models of the mass media system, now and in the future, which are able to predict alternative outcomes and consequences of various policy and planning decisions.

Assumptions and Research Questions

Assumptions

MASSMOD, the mass media industry model developed in this study, dealt with all model components on a highly aggregate level, as AM broadcasters, FM broadcasters, VHF television broadcasters, magazine publishers, advertisers, consumers, without regard to markets, type of programming or content, demographic variables, type of product advertised, or ownership or group affiliation. The choice of aggregation level was made for two reasons: first, data was more readily available in industry-wide terms; and second, it was felt that the general structural interrelationships in the entire system could be more readily identified without the additional complexity of a more detailed, more microscopic approach.

The model assumed that broadcasters and publishers operate in such a way as to maximize profits, which is to say to maximize the difference between revenues and cost. Both broadcasters and publishers seek to establish as large an audience as possible to maximize their advertising revenue, since advertising demand is a function of audience size. Publishers can rely on an additional source of revenue from subscriptions to their periodicals, aware that the cost of the subscription can affect their circulation, while the major source of revenue for the broadcaster is advertising. Both print and broadcast managers recognize that the amount of money invested in their publishing costs (for talent, programs, stories and quality of production) can also influence the size of their audiences.

The model also made the assumption that all media in the model are substitutable in terms of advertising placement and therefore compete for the same advertising dollar. Ignored were attempts to reach special audiences with one specific medium, or to make use of a medium's unique ability to convey a message, such as newspaper or magazine coupons.

Growth within a medium was assumed to depend in part on the profitability of the medium in the previous year. High profits motivate more investors to develop stations and publications. Since profits depend on audience size, consumer use is also a factor in the growth process. The model also assumed that cross-media ownership (ownership of more than one medium by one party) was responsible for the rapid growth of television in the time period under study. Broadcast station growth was assumed to depend on the number of channels available for licensing, with growth occurring until the spectrum allocations are completely used.

Gross National Product and disposable income per capita were assumed to be major economic factors included in the model as exogenous variables. It was also assumed that the model would not always identify and include variables which were significant predictors of various dependent variables and that some variables included in the model might not always be significant predictors; simple growth functions based on a yearly index were used at these times.

Other specific assumptions about model components are detailed in Chapter 3, the description of the model.

Research Questions

The first part of this study dealt with the possibility of constructing a mathematical model of the mass media industry, from which a computer simulation could be developed. Goodness of fit tests were used to assess the validity of such a simulation against real world data.

The experimental segment of the study was concerned with the manipulation of various policy-oriented variables and a comparison of results against the benchmark model. These manipulations revolved around two basic issues:

(1) Control on Advertising Expenditures. What would be the effect of externally imposed controls of advertising expenditures on media growth? Since media depend at least in part on advertising revenues for their income, and profitability affects future growth, would limiting advertising spending ultimately curtail media growth? If such controls were deemed necessary and/or desirable, what type of control would be best--a tax on expenditures, a limit based on percentage of sales, or some form of depreciation write-off (Bloom, 1976)? Two manipulations, one involving a tax and the other a percentage of spending limit were performed to assess the effect of such controls on the system.

(2) Spectrum Allocation. What role did the FCC determination of the use of segments of the radio spectrum play in the growth of broadcast stations? Did more available channels for a medium necessarily mean more stations on the air? What effect did the assignment of two or more different band segments to one type of telecommunications (radio, television) have on revenues and growth? If television were all UHF, or radio all FM, would the media industry be different today? The benchmark model assumed that an unlimited number of channels were available for broadcast stations. This was the case in 1945-1960; the AM radio band did not become saturated until the 1970's, and VHF television continued to grow until the mid 1970's. Six manipulations were performed to address these questions: a no-freeze situation, allowing UHF television to begin development in 1945; a limit imposed on the number of channels available for the four broadcast media; a VHF television, AM radio only situation; a VHF television, FM radio only case; a UHF television, AM radio run; and a UHF television, FM radio run.

Summary

This study applied the use of systems simulation to explore the interrelationships among variables in the complex mass media industry system from 1945 to 1960. Borrowing the technique from industrial analysts, policymakers and forecasters, the research hoped to gain valuable insights into dependencies and feedback loops within the total media complex, and, by manipulating policy variables included in the model, to suggest the use of simulation in media policymaking and planning. The development of the benchmark model within an historical time period was seen as a necessary step in the eventual development of a later generation model to be used in the forecasting of the effects of new telecommunications technologies on the media industry and its consumers.

CHAPTER 2

LITERATURE REVIEW

A review of the literature relating to the mass media reveals that systems simulation methodology has not yet been applied to media problems involving policymaking or industry structure (or at least such work has not been released for publication) and that the use of simulation in general has been sparse. However, simulation studies designed to aid in policy analysis have been employed in other social science disciplines, suggesting that the technique might be appropriate to the mass media as well.

This chapter first presents in some detail three media-related simulations which are directly applicable to this study--Gensch's (1973) advertising media allocation model, called AD-ME-SIM, Block's (1975) simulation of consumer time allocation and Bloom's (1976) study of advertising policy and competition. A discussion of the use of simulation experiments in policy analysis and planning, including examples from other social science disciplines, and in the analysis of industry structures follows. The role of simulation in theory development is considered briefly. The chapter concludes with a brief description of other simulations which have dealt with the mass media, but which have little, if any, relationship to the use of systems simulation.

Media Simulations Relevant to This Study

Three media-related simulations exist which have a direct bearing on the model developed in this study. An advertising sector in the model allocated an annual advertising budget across various media which exist in the model. The technique used by Gensch (1969, 1973) in AD-ME-SIM to predict a hypothetical population's reading and viewing preferences, discussed below, was adapted to predict a hypothetical population of advertiser's buying preferences. The prediction of these advertising expenditures is a probabilistic process using appropriate probability distributions. The techniques used in Block's (1975) time allocation model, described below, were adapted for this purpose. In addition, Block's model offers an approach to the allocation of media time by consumers, which, although it was not applied to the model in this study, could be included in further, more sophisticated revisions of the model. The present model also considered the effects of policies regulating the amount of advertising in the broadcast and print media on the total system. Bloom's (1976) simulation of advertising policies and competition, also discussed below, suggested possible advertising restraints which were used in this study.

A Media Allocation Model

Gensch (1969, 1973) created a decision-making model of advertising media selection and scheduling which defines a theory of how to send a message that will reach a defined target population, use the most cost-efficient advertising forms, and reach the target population the desired number of times within a given period. The three-stage model generates output which includes the weekly and cumulative numbers and percentages of people in the target population reached by the proposed media schedule, as well as the cost, frequency, and number of exposures, adjusted accordingly to the subjective evaluation of the media and the value of exposures to different members of the target audience. (Gensch, 1969, pp. 209-210)

The first stage of the AD-ME-SIM model, the data generation stage, is of particular interest in establishing the probability of behavior of a hypothetical population. Gensch used two months of actual data from Brand Rating Research Incorporated (BRI) to establish basic weekly probabilities of viewing and reading for a year, adjusting for trend and seasonal influences by using a Monte Carlo system (1973, p. 117) A similar technique, using data for the top 100 advertisers, was used in this study to predict the media selection behavior of the advertisers. Because Gensch deals with individual, rather than aggregate data, which allows comparison of specific media schedules, his entire selection process was not applicable to this study.

A Time Allocation Model

Block (1975) developed a model called TIMMOD, which simulated human time allocations in order to assess the impact of broadband communication network technology on consumer marketing communications. A stochastic model programmed in FORTRAN, TIMMOD develops a series of probability distributions which describe a single individual's decision-making regarding the allocation of time from real-world decision processes, which in this case are derived from the 1965 U.S. Time Use Survey (1966). The model is limited by design to be a forecasting tool, not a general model for the human allocation of time.

The simulation generates the time allocations for an entire day for a single individual and then cumulates over many individuals to create a population. The time allocations to various daily activity categories are based on two probability distributions: the first describes the activity selection behavior of the hypothetical population, the second describes the duration of the selected activity. The specific probability distribution is determined from the Erlang family, with different parameters to describe different shaped distributions for different activity categories. Experiments were conducted using the model by manipulating the specification of these probability distributions, for both activity categories and duration. A modified version of Block's technique, using probability distributions, was used to create advertiser buying habits in the advertiser sector of the present model. Gensch's technique to create a hypothetical population's habits was modified to incorporate the probability distribution approach.

An Advertising Policy Model

Bloom (1976) developed a computer simulation model of an hypothetical grocery manufacturing industry to explore the competitive effects of seven proposed controls on advertising expenditures--two advertising taxes, three limits on advertising outlays, and two depreciation requirements on advertising. The model was patterned after the nutritional submarket of the cereal industry, using data available from the Harvard Business School "Life Cereal Case." The deterministic model, written in FORTRAN, contains four sub-models that interact in a yearly cycle: (1) a manufacturer's submodel, (2) a potential rival manufacturer's submodel, (3) a retailer's submodel, and (4) a consumer's submodel. The industry is assumed to have three brands belonging to three firms at the start of each run of the model which simulates eight years of the industry's behavior.

A group of structure and performance variables--number of firms and brands, market concentration, market advertising expenditures, profits, selling costs, prices and brand quality--were monitored in each computer run to give an indication of how competition in the simulated industry was affected by a control. Twenty-one computer runs representing the partial completion of an 8x2x2 factorial design were executed. The three factors controlled were (1) type of control on advertising expenditures (eight types); (2) degree of sensitivity of the industry sales response function to changes in total advertising goodwill in the industry (high or moderate); and (3) types of objectives managers would be satisfied to reach (profit streams or cash flow stream). The results revealed that the seven controls on advertising expenditures were unable to stimulate vigorous competition in the simulated industry, and suggested the possibility that controls would tend to lessen competition in some industries.

Bloom's model was able to investigate the effects of controls on advertising expenditures advocated by various economists, consumer advocates and policymakers. While he does not claim universal generalization of the model, Bloom has provided necessary data which can be considered by policymakers, such as the Federal Trade Commission, before any laws or regulations regarding advertising expenditures are actually passed.

Summary

The Gensch, Block and Bloom models had a direct impact on the structure of the model built in this study. Gensch's approach to the creation of the habits of a hypothetical population, based on limited data, combined with Block's use of theoretical probability distributions, was used to predict the media buying behavior of the advertisers in the model.

Bloom's suggestions for advertising restraints were introduced into the model during the experimental runs. The general organization of his model, with interlocking components, or building blocks, was also followed in the construction of the model.

The Use of Simulation in Policymaking

The use of systems simulation as a tool in policymaking and analysis has been debated in the literature. Proponents cite the integrative capacity of systems theory, which synthesizes bits and pieces of information from various perspectives and sources into a comprehensive whole (Pugh, 1977, p. vii), and its ability to discern the basic structure of complex and dynamic societal systems (Fitz, 1979, p. 4). Critics point to the difficulty in validating the model and the gap in philosophies between model builders who maximize the theoretical content of models, and policymakers, who pragmatically want to maximize the accuracy of information estimates relevant to policy (Pugh, 1977, p. 5). Fromm, Hamilton and Hamilton (1974), in a survey of 250 simulation models revealed that "at least one-third and perhaps as many as two-thirds of the models failed to achieve their avowed purposes in the form of direct application to policy problems." (p. 3)

Nonetheless, a major impetus behind the use of computer simulation by decision-makers and policymakers "is the possibility of testing and evaluationg alternative decision rules, strategies and policies before they are put into effect on actual business and economic systems." (Naylor, Wertz & Wonnacutt, 1967, p. 703) Because of their ability to deal with complexity, simulations can assist in policy analysis in areas of social and administrative sciences by developing a general understanding of the real world situation, by forecasting the future of a real-world system, and by simulating the impacts of alternative policies on the real-world system. (Pugh, 1977, p. 1) Sage (1979) points out that systems engineering is an appropriate combination of the mathematical theory of systems and behavioral theory in a useful setting appropriate for the resolution of real-world problems. He concludes that systems science is most effective in policy analysis when the disparate perspectives of the sponsor--who seeks information for decision-making, the client--who has real-world problems to attempt to solve, and the researcher--who seeks to build a workable model are brought into a symbiotic heterogeneous complimentary relationship one with another (p. 6).

The potential value of systems simulation as a tool in policymaking can be seen when the elements of policymaking are examined. Dror (1968) finds six interconnected phases in the pure rationality model of decision-making, often presented as the universal ideal:

> 1. Establishing a complete set of operational goals, with relative weights allocated to the different degrees to which each may be achieved.
>
> 2. Establishing a complete inventory of other values and of resources, with relative weights.
>
> 3. Preparing a complete set of alternative policies open to the policymaker.
>
> 4. Preparing a complete set of valid predictions of the costs and benefits of each alternative, including the extent to which each will achieve the various operational goals, consumer resource, and realize or impair other values.
>
> 5. Calculating the net expectation for each alternative by multiplying the probability of each benefit and cost for each alternative by the utility of each and calculating the net benefit (or cost) in utility units.
>
> 6. Comparing the net expectations and identifying the alternative (or alternatives, if two or more are equally good) with the

highest next expectation. (Dror, 1967, p. 132)

Lasswell (1971) summarizes the policymaking process in terms of five tasks: (1) goal clarification, (2) trend description, (3) analysis of conditions, (4) projection of developments, and (5) invention, evaluation and selection of alternatives. (Lasswell, 1971, p. 72) He suggests that simulation models are most helpful in inventorying and evaluation of alternative policies.

Policy-Related Simulations

Despite criticism that simulations are too theoretical or mathematical, computer models have been developed which aid policymakers in their decision process in such disciplines as urban, regional and world analysis and forecasting; industrial dynamics; and economics. Systems theory as a problem-solving methodology has proved particularly helpful in analyzing conditions which describe a system, projecting developments resulting from a policy option, and inventing and evaluating possible policy alternatives. Simulation models function as a substitute for real-world experimentation when such testing is either impossible, or too costly, or both.

Forrester (1965) pioneered the use of systems theory in the analysis of complex organization, specifically industrial management. His initial concept of "industrial dynamics" has been applied to many other fields which exhibit positive and negative feedback processes in the course of their growth and regulatory action. His models are classic examples of systems simulation.

One such application is the life cycle of an urban area described in Urban Dynamics, which uses a stochastic, non-linear, macro-model, written in DYNAMO, a computer simulation language. Forrester defines the boundary of the city in terms of its interacting components of level and rate variables, which are grouped into three subsystems: business, housing and population. The model provides a means of assessing the effects of various policies regarding housing (e.g., amount of low income housing; ratio of industrial land to residential land), job training (e.g., programs to train skilled workers) and business growth (e.g., encouragement of new business) on population, unemployment and taxes in major urban areas. Housing densities, family sizes, personnel needed in business units, taxes levied and taxes needed are major parameters defined at the start of the simulation. The model traces the urban life cycle within a period of 250 years starting with empty land, growing to full land occupancy, maturing through a realignment of internal urban balance, and emerging into an equilibrium characterized by stagnation with its unemployment, faltering industry, and increased taxes. It then alters various policies governing variables to find out and predict alternate outcomes.

Forrester (1971) applied his industrial dynamics techniques to a model of world interactions, WORLD 2, a preliminary effort in the discussions of The Club of Rome, which later generated the Limits to Growth model, WORLD 3. The world system is defined as man, his social systems, his technology, and the natural environment; these interact to produce growth, change and stress. The main objective of the Limits to Growth model was to identify and study the dominant elements and their interactions that influence the long-term behavior of world systems, in order to suggest survival policies in areas such as population, energy, food supply, pollution, natural resources, and capital investment. The model is built at a high level of aggregation, such that distinctions between developed and underdeveloped countries are not made. In determining the level of aggregation the team felt that "questions of detail, of individual nations, and of short-term pressures can be asked much more sensibly when the overall limits and behavior modes are understood." (Meadows et al., 1972, p. 96)

Several extensions of the Limits to Growth model have been developed, which add sectors, disaggregate the principal components of the model, or change model relationships based on empirical data. Boyd (1972) included a technology sector, with the assumption that increasing technology will increase available food and reduce pollution and the depletion of natural resources. The model reverses the basically pessimistic projections of the original WORLD 2 model. Burnett and Dionne's (1973) GLOBE 6 model breaks the principal components into developed and developing nations, elements of world trade, a population sector with five different age groups and greater structural detail.

Hamilton et al. (1969) applied systems simulation to regional analysis, specifically dealing with the economic growth in the Susquehanna River Basin. The model, written in DYNAMO, interrelates and projects demographic and employment variables simultaneously, and is designed to render inexpensive experiments on the effects of change in parameter values, such as increased employment opportunities, a relaxed housing market, lay-offs of workers, to determine policies which optimize the economic growth of the Basin. The model is data based, and therefore fairly disaggregated to allow for the analysis of subregions within the Basin. The use of systems analysis and computer simulation allows the model to be dynamic, incorporating explicit feedbacks and lagged relationships among sectors and variables.

The Center for Environmental Study modelled a simulation of the Grand River Basin environment in Michigan after Forrester and the

Susquehanna River Basin Project. (Anundsen & Lingren, 1972) The simulation was created to assist policymakers and planners in the Grand Rapids area to assess the effects of potential policy changes and growth in five major areas (pollution, government, health, economics, and social factors and technology) on the existing environment. Access to the simulation is provided through various terminals located throughout the governmental community, so that policy alternatives and ideas may be easily explored and assessed.

In economics, simulations have been used to predict outcomes based on various fiscal policies. Duesenberry, Eckstein and Fromm (1960) developed an econometric model of quarterly movements of the gross national product (GNP) to test fiscal policy measures. Their aggregation followed the national income accounts of the Department of Commerce, with a time interval of a quarter of a year, variables adjusted for seasonal fluctuation, and all relationships established from time series data. The recursive model is divided into two parts: first, the total GNP is built up; then, the disposable income which would be generated is computed. Several lags exist in the model: consumption depends on the preceding quarter's disposable income; inventory investment depends on past values; dividends depend on levels in the preceding quarter. The system is actually summarized by four equations: an inventory function, a consumption function, a function relating personal income to GNP, and a function tying personal income to disposable income.

Several large scale macro-econometric models have been developed for forecasting and policy analysis such as the Wharton model, the Fed-M.I.T.-Penn model, the Brookings model, and the Michigan model. As a class, these models are moderately large systems of simultaneous equations (from fifty equations to as many as several hundred), which are dynamic and non-linear. (Adams & Burmeister, 1973, p. 126) The best known of the aggregate models is the Wharton quarterly econometric model, a living model which is modified and re-estimated when data, institutional change and new economic theory suggest it. (Adams & Burmeister, 1973)

Models of Industries

Since the present study attempts to investigate the interrelationships present in the structure of the mass media as an industry, several classic computer models from the economics literature are presented here to illustrate the use of simulation in analyzing industry structure.

A classic macro-simulation of industry is Cohen's (1960) computer model of the shoe, leather and hide sequence, which describes the aggregate behavior of shoe retailers, shoe manufacturers and cattlehide tanners between 1930 and 1940. Chief exogenous variables in the model are the Bureau of Labor Statistics consumer's price index, disposable income, and the stocks of hides held by hide dealers. The major endogenous variables are divided into four components of the industry: retailers, manufacturers, tanners, and hide dealers.

The mathematical form of the model is a complex, non-linear system of lagged simultaneous difference equations with one month as the basic time period. Cohen actually built two models: one--a "one-period-change model," resembles the classic econometric model, and is intended to explain the values of the endogenous variables for only one time period ahead into the future. It assumed that the lagged endogenous variables refer to their actually observed values and that the lagged endogenous variable at one time period becomes an exogenous variable in the next. The other model, a "process model," was designed to explain the determination of the endogenous variables for an arbitrarily large number of future time periods. In this instance, the equations of the model and the observed time paths of the exogenous variables are treated as a closed dynamic system; the values of the predetermined endogenous variables are the values generated by the model, not the actually observed values.

Cohen's results show a very close correspondence between the time paths generated by the process model and the actual values on an annual comparison basis. Although the models do not present a completely acceptable monthly aggregate description of the industry (particularly on three major variables: retailers' receipts of shoes, manufacturers' production of shoes, and manufacturers' receipts of leather), Cohen concludes (1960, p. 65) that the evidence provided by the annual comparisons is consistent with the hypothesis that the models incorporate some of the mechanisms which determine the behavior of individual firms in these industries. Improvements in performances of the process model over the one-change model is ascribed to the self-equilibrating, self-correcting features incorporated into the behavioral mechanisms of the process model which insure that the generated time paths never depart too far from the observed paths in the estimation of parameters. Such features were absent from one-period-change model.

Balderston and Hoggatt's (1962) simulation study of the lumber industry was designed to examine the intimate dynamics of a market--how market information and decentralization of market decisions and institutional alignments affect and are affected by economic forces--viewed as a complex system of behavior in which information is limited and costly. The authors viewed their study not as a business analysis, but as an experiment in constructing a general system model.

Amstutz's (1967) computer simulation of competitive market response moves from a macromodel to a micromodel. He believes that "while an aggregate model may generate correct answers at a point in time, it provides little or no insight into the reasons for these answers. The micro-analytic simulation has the potential to provide the right answers for the right reasons." (Amstutz, 1967, p. 113) After construction of a macromodel of the marketing environment, he formulates detailed behavioral micromodels of the five major elements: the manufacturer, the consumer, the retailer, the distributor, and the salesperson. Amstutz validates three functional forms in the model: the effect of attitude on purchase, the effect of attitude toward appeals on noting a promotion, and the effect of display size on point-on-sale display placement. The model allows for simulating individual behavior in the marketing decision with various initial parameters.

Summary

This survey of the literature suggests that while the problem-solving methodology of systems simulation has not been applied to the analysis of policy alternatives or industry structure within the mass media field, it has been used successfully in other social science disciplines such as urban, regional and world planning; world and national economics; and industrial dynamics. The mass media, when viewed as an industry system, present a series of complex, dynamic interrelationships and feedback loops which are not easily assessed by a straightforward linear analysis. Hence, the use of simulation experiments should provide two major outputs: a better theoretical understanding of the structure of the mass media industry, including key variables and relationships; and second, a framework for decision-making, which supplies the potential effects of various policy alternatives on the existing industry structure.

The data bases used to build the industry models cited in this chapter suggest that enough historical time series data are available about the mass media industry to build a working model. The experience of other model builders further suggests that the initial mass media industry model should be macroscopic in nature, dealing with components at their most highly aggregated level. Further research can disaggregate model units and add greater structural detail.

The Use of Simulation in Theory Development

The use of simulations in the development of theory has also been debated in the literature, most forcefully around the validity of a simulated system as a representation of a real system. As an operating model of a real system, a simulation can help theory development by "raising questions, demonstrating gaps, helping discriminate between the important and the unimportant, generating testable hypotheses and serving as vehicles for the communication or comparison of theories." (Schultz & Sullivan, 1972, p. 6) Since so many real systems are complex and unavailable for observation, studies dealing with factors and relationships crucial to the system are much more easily conducted in simulation than in the real system.

Raser, Campbell and Chadwick (1970) suggest that the strategy of science should be to test a theory in all of its settings of application, and to keep it as general as possible for as long as possible (p. 185). They cite the need for inter-nation simulation (INS) in the area of international relations "because of the very great difficulty we have in observing even recent international relations as a test of theory and because of the comparatively very great power of experimental manipulations in probing the implications of theory."

For example, Brody's (1963) study of the impact of changing power relationship on communication and alliance patterns in an inter-nation simulation gradually introduced nuclear power to all of seven nations in a simulated world. He was then able to analyze the effect of this development on the international system, an impossibility in the recent or distant past, since it was a future and hypothetical event.

The problem caused by the confounding of cause and effect in the probing of theories is also one that can be overcome by simulation. Raser and Crow (1968) investigated the effects of the development of an invulnerable nuclear retaliatory force by one nation in an international system. In the real world at the time of the study, the United States was developing such a force, and major world changes were also occurring, but the determination of which changes in the international system were caused by the developing invulnerability and which were simply co-occurring was impossible. Raser and Crow created a five nation world with alliance ties, general strength levels and political characteristics designed to simulate the Cold War system of 1962. Using repeated runs with experimenter-controlled research and development of an invulnerable nuclear weapons system, measures on a cluster of independent variables following the interventions were taken while other variables were forced to fluctuate. This replication and experimental intervention allowed the researchers to rule out more alternative explanations in their attempt to establish causality than if they had simply observed the singly occurring and uncontrolled real world.

Probing theory based on observations alone raises another problem--that of degrees of freedom. Based on a statistical concept, the point is that a plausible explanation (or line or correlation), which accounts perfectly for the behavior of a single case, is possible only when the number of observations is equal to the number of explanatory concepts. If there are no observations left over, there are no degrees of freedom to use to test the goodness of fit of the theory. Simulation, according to Raser et al. "answers the degrees-of-freedom problem...through its open-ended possibility of generating new instances, new re-runs, new observation points greater in number than its explanatory or descriptive contents." (1970, p. 187)

Raser et al. (1970) also suggest that the process of building simulations can aid powerfully in theory generation for two reasons: first, as a framework or construct to guide the integration of part theories and isolated data bits, and second, as a stimulant and goad to scholars which results in the generation of theory. "We may find that the act of trying to build may be the best strategy for learning more about that which we are trying to simulate." (p. 188)

Summary

Thus, using the field of international relations as one example, the application of simulation to probe theory, by enabling an examination of causality and providing degrees of freedom in observation, and to create theory, by forcing scientists to turn vague generalizations and verbal theories into conscious, explicit, logical and definite relationships, becomes more apparent. It is hoped that the attempt to state explicit relationships among elements of the mass media and to probe those theoretical statements by experimental manipulation will yield richer theoretical insights into the mass media industry.

Simulation at least creates a certain amount of intellectual soul-searching as theories are brought into the open. As Kaplan says (1964, pp. 268-269):

> Models have this merit, that they do not allow us to comfort ourselves with the notion that we are following up an "idea" when we are only moving from one observation to the next in the hope that something will turn up. Too often the hypotheses with which we work are at home only in the twilight regions of the mind, where their wavering outlines blend into a shadowy background. There they are safe from sudden exposure, and are free to swoop down for sustenance on whatever datum comes their way. Models are at any rate conscious, explicit, and definite; there is nothing ghostly in their appearance or manner; they look healthy even up to the very moment of their death.... The model saves us from a certain self-deception. Forced into the open, our ideas may flutter hopelessly; but at least we can see what bloodless creatures they are. As inquiry proceeds, theories must be brought out into the open sooner or later; the model simply makes it sooner.

Mass Media Simulations

While there is a lack of computer simulations in the mass media literature which employ systems science to construct dynamic, stochastic models, several descriptive, deterministic simulations have been developed, particularly in the area of media allocation. Since this research deals with mass media simulations, a brief description of media-related simulations is presented below, for the sake of completeness.

The first computer simulation used in the area of mass media was the Simulmatics Media Selection Model, designed in 1962 to test advertising media allocation plans. The simulation determines probabilistically an estimate of the media audience, described by various socio-economic features, and the reach and frequency of a proposed media schedule. (Kotler & Schultz, 1972, pp. 517-518) Gensch's AD-ME-SIM model, described earlier in this chapter, is an extension and improvement of this model.

The COMCOM (Communist Communication) model developed by Popkin (1965) is an application of the Simulmatics simulation to the mass media system in the Soviet Union. The first part of the simulation generated the hypothetical descriptions of individuals in the population, based on aggregate data tables and some basic theoretical assumptions; the second run, the actual simulation, measured exposure to a series of media messages, using Monte Carlo randomization methods to introduce new variables. The output of the simulation was the exposure probabilities of an audience for a particular communist country over a given time period.

Kessler and Pool (1965) developed Crisiscom, a computer simulation of human information processing during a crisis, which represents a set of human decision-makers who process information and the exchanges of information among them. Information is generated from imbalances among cognitive elements and relations which comprise the network, while crises are characterized by high rates of generation and exchange of information. The simulation measures salience, affect and credibility of the communication processes.

Kramer (1969) simulated the United Nations public information campaign conducted in Cincinnati, Ohio, in 1947 and 1948. The simulation was designed to predict reach and frequency of message flow from known information about the population, media habits and the placement of messages in the mass media. The first stage of the simulation generates the model population from basic age, sex, geographic region and literacy data and determines probability exposure to various media. The second stage, like the COMCOM model, calculates the actual message exposure probabilities for the audience.

Little and Lodish (1969) developed a simulation of advertising media allocation called MEDIAC, an on-line computer system which selects and schedules media to maximize total market response. The user supplies various media options, a budget, and objective and subjective data about media options and the desired audience. MEDIAC selects options and schedules over time, based on a mathematical optimization routine which uses total market response as the optimization function.

Hanneman (1969) and Carroll developed a stochastic simulation model of the diffusion of innovation to cliques in any small, relatively closed system. The simulation, called SINDI I (Simulation of Innovation Diffusion) deals with opinion leadership, clique structure, channel structure and the amount of knowledge available to clique members as a new idea spreads over time through a social system.

Summary

This overview of computer simulations related to the mass media shows that although systems methodology has not been used in conjunction with the actual simulation, computer models have been built which deal with populations of people, media habits and information structures. This suggests that enough data exist to support model-building hypotheses and relationships. The overview also highlights the use of simulation as a data-generating tool for decision-making, which provides output from the model under a variety of conditions and policies, such as media schedules.

Conclusion

This review of the literature highlights the role of computer simulation and systems science in the analysis of the behavior of complex systems. While such techniques have not been applied to the mass media industry as a system, the studies discussed here support the feasability of such an application, both as an aid in policymaking and in theory-building. The complexity of the *Limits to Growth* models and the aggregate approach which the model builders used indicate that even very large systems described by minimal data can be modelled and analyzed. The structural-economic models of industry suggest a precise definition of system boundaries, either by historical time period or identified system components, in which to build such a model.

Thus, supported by the efforts of authors included in this chapter, Chapter 3 describes MASSMOD, a simulation model of the mass media industry in the historical period 1945-1960. The works of Gensch, Block and Bloom were incorporated into the model in the advertising component. The construction and analysis of the model sought to identify underlying structures within the industry. The experiments described in Chapter 4 represented an attempt to use the model in a policymaking mode by simulating the impacts of alternative policies on the real-world system represented by MASSMOD.

CHAPTER 3

THE MODEL

This study sought to explore the effects of the introduction of television on the AM radio, fledgling FM radio, daily newspaper, magazine and advertising sectors of the mass media industry. Systems simulation at the macro level was selected as the main methodological tool to build, experiment with and attempt to validate a computer model of the industry from 1945 to 1960 in order to make some tentative statements about the interrelationships of variables among the sectors and the effects of manipulating policy variables within the system. The study was, therefore, a piece of exploratory research, designed to generate some hypotheses on the effects of various policy variables on industry sectors and consumers and to formulate a richer theory about the behavior of various system components.

Indirectly, the research hoped to show the feasibility of using systems simulation to investigate the effects of the introduction of any new sommunication technology on the existing mass media industry structure under various policy alternatives. To demonstrate the applicability of systems analysis to this type of problem, the decision was made to follow the example of Cohen (1966) and Balderston and Boggatt (1962), who chose to model specific industries in specific historical time periods for which historical time-series data were readily available. The starting date of the period under study here, 1945, marks the commercial beginning of television; the closing date, 1960, the year when color and cable television both began to have an impact on the system. (The year 1960 was chosen as a cut-off date to avoid the possible confounding influence of color and cable television. In 1960, color television owners and cable subscribers were less than one percent of the population. Both began to grow significantly after 1960.)

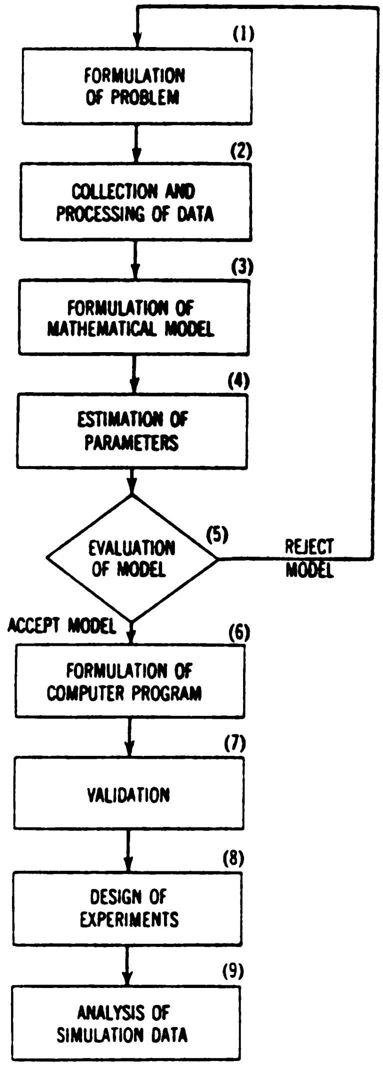
Methodology and Data Collection

Systems simulation was judged to be an appropriate methodology because, as Forrester states, it can be particularly useful for discovering the counterintuitive nature of systems. (Forrester, 1961) It was hoped that some relationship among system variables would be indentified that had not appeared elsewhere.

Naylor _et al_. (1968, p. 23) suggest that planning simulation experiments involves a procedure consisting of the following nine elements:

1. Formulation of the problem.
2. Collection and processing of real world data.
3. Formulation of mathematical model.
4. Estimation of parameters of operating characteristics from real world data.
5. Evaluation of the model and parameter estimates.
6. Formulation of a computer program.
7. Validation.
8. Design of simulation experiments.
9. Analysis of simulation data.

A flowchart of this process is given in Figure 1.



(Naylor et al., 1968, p. 24)

FIGURE 1

FLOWCHART FOR PLANNING SIMULATION EXPERIMENTS

Problem Formulation

Essentially, this study had as its objective the estimation of the effects of certain changes in policy variables, such as the number of available AM, FM and television frequencies, cross-media ownership, and advertising expenditures, on the endogenous variables in the system. It sought to simulate the effects of various alternative policy decisions on the media-consumer system in order to provide a more complete data base for decision-making.

Collection of Real World Data

The benchmark model was constructed using real world data about advertisers, broadcasters, newspaper and magazine publishers and consumers from 1945-1960. Much of the information regarding audience sizes; numbers of stations, magazines and newspapers; expenditures and profits; gross national product and disposable income were contained in Sterling and Haight's (1978) Guide to Communication Industry Trends. Population data, such as birth and death rates and household size, were obtained from U. S. Census data presented in Historical Statistics and Statistical Abstracts. Additional information about publishing costs was found in the Census of Manufactures, while advertising expenditures for the top 100 advertisers were found in annual listings in Advertising Age.

Most of these data were presented at the macro, or aggregate, level; that is, data existed which described the behavior of all AM radio stations as a group, all advertisers as a group, all magazines as a group. At times the groupings were not consistent for all variables within a sector. For example, numbers of magazines and their circulations were broken down in a grouping of consumer and farm magazines, while magazine revenues and subscription costs were given for <u>all</u> published magazines. It was assumed that consumer and farm magazines represented a bulk of total non-trade, non-business magazine volume. Additionally, no source reported the average yearly expenditure per medium for an advertiser; hence it was assumed that the behavior of the top 100 advertisers would be sufficient. Newsprint consumption was reported annually for all publishers, while circulation figures and number of newspapers were reported for daily and Sunday papers only. The number of FM households in the United States for each year in the study was impossible to locate, although scattered in-house National Association of Broadcaster publications provided some data. Hence, all data were not in perfect conformity with each other, although the decision was made to use the existing data mindful of their weaknesses.

All dollar figures were converted to constant 1972 dollars, using the Gross National Product Deflator Index, to avoid the effect of inflation. The choice of a base year within the period under study may have been desirable; however, 1972 was chosen as a base since much of the data was taken from Sterling and Haight (1978), who reported their figures in 1972 dollars, and who provided yearly deflator indices for the 1972 base.

Formulation of Mathematical Models

The formulation of a mathematical model requires the reduction of hypotheses about the operation of a system to a level of abstraction which specifies model components, variables and parameters, and functional relationships. Naylor *et al*. (1968, p. 29) declare the process an art and suggest that it draws upon previous studies in the field, a bit of intuition and trial and error approaches. A modular building-block approach was used in the model construction, which generated a set of models describing the major subsectors of the system. These subsectors were then synthesized into the general model.

Specific components and relationships among variables for each subsector are discussed in detail in the second section of this chapter. However, a word should be said about the number of variables in the model and its complexity. Since this was a first, exploratory attempt at building an intermedia model, an effort was made to limit both the number of endogenous, or output, variables which would be examined in the study and also the number of exogenous variables which determine those outcomes. The number of variables in a model and its complexity are directly related to programming time, computation time and validity.

In developing mathematical models of the various system components, the potential difficulties outlined by Naylor _et al_. (1968, p. 32) were borne in mind: first, certain types of variables which affect the system may be impossible to quantify or measure, such as the influence of the FCC or the participation of parent corporations in the operations of their subsidiaries. Second, the number of variables to be considered in a system may exceed available computer hardware. Most computers have a limit on memory storage; too many variables could put a program over this limit, although the CDC 6600 computer used for this study has a large memory available. Third, some significant exogenous variables may not be known. Fourth, some relationships between exogenous and endogenous variables may not be known and may be impossible to obtain. These difficulties were encountered in describing the FM radio and UHF television subsystems, where a simple time variable was finally used to generate the endogenous variables in the system, when no other endogenous or exogenous variables were significant predictors. Fifth, in some cases the relationships between variables affecting the system may be so complex that they are unable to be expressed in one or more mathematical equations. This might be the case in the media system in attempting to quantify cross-media ownership.

Estimation and Evaluation of Parameters

Ordinary least-squares regression routines, part of the Statistical Package for the Social Sciences (SPSS) (Nie, Hull, Jenkins, Steinbrenner & Bent, 1975) were used to estimate values of the parameters in the model from the historical data collected. Assumptions made in generating inputs to the model were tested by subjecting the parameters and equations to F-tests of statistical significance. The overall F-ratio for a regression equation was examined for its significance in expressing a relationship among variables, as was the square of the multiple regression coefficient (R-square) to determine the amount of variance accounted for by the variables in the equation. Attempts were made to choose equations which were significant at the .05 level and which explained as much variance as possible. In addition, the significance of each regression coefficient was examined to determine whether a variable contributed to the ability to predict the behavior of the system. Regression summaries for each equation in each subsector, including R-square, overall F-ratios and the probabilities for significance of individual coefficients, are presented in Appendix A.

Formulation of a Computer Program

The mathematical models describing the system were converted into computer programs using Minnesota FORTRAN for the CDC computing system. Subroutines which handled the generation of pseudorandom numbers and stochastic variates, such as the Erlang family, were included. The model used 50000 octal words of core memory and required approximately five seconds of central processing time.

Validation

The validation stage of the simulation attempted to prove the model to be true, which implies a set of criteria to differentiate "true" from "not true," and the ability to apply those criteria to the model. The multi-stage verification procedure of Naylor and Finger (1967) was used, which incorporates the methodologies of rationalism, empiricism and positive economics, and implies that each of these approaches is necessary, but not sufficient, for solving the problem of verification.

The first stage of the Naylor and Finger procedure calls for the formulation of a set of postulates or hypotheses describing the behavior of the system of interest. This set of postulates is formed from the researcher's already acquired general knowledge of the system or from her/his knowledge of other similar systems which have already been successfully simulated -- the rationalist approach. The selection of postulates includes the specification of components and the selection of variables, as well as the formulation of functional relationships.

The second stage of the multi-stage verification process--that of empiricism--calls for an attempt to verify the postulates on which the model is based subject to the limitations of existing statistical tests. Naylor and Finger suggest that postulates which cannot be falsified empirically be retained "tentatively" as there is no reason to assume they are invalid just because they cannot be tested.

The third stage of the procedure consists of testing the model's ability to predict the behavior of the system under study--the positive economics approach. Two alternatives are available to test the degree to which data generated by computer simulation models conform to observed data--historical or retrospective, prediction and forecasting, or prospective, prediction. Retrospective prediction procedures were employed to validate the model in this study.

From the many statistical techniques available to assess the goodness of fit of the model, such as chi-square or Pearson's product moment correlation coefficient, Theil's (1961) Inequality Coefficient was calculated to determine the degree of conformity of the time paths generated by the computer simulation to the historical data. The coefficient U provides an index which measures the degree to which a simulation model provides retrospective predictions of observed historical data:

$$U = \frac{\sqrt{\frac{1}{n}\Sigma\,(P_i - A_i)^2}}{\sqrt{\frac{1}{n}\,\Sigma P_i^{\,2} + \frac{1}{n}\Sigma\,A_i^{\,2}}}$$

where $P_1, \ldots, P_n$ are the predicted values

$A_1, \ldots, A_n$ the corresponding actual outcomes.

U varies between 0 and 1. If U equals 0, there are perfect predictions. If U equals 1, the predictions are no better than random.

Theil's U avoids the need to categorize data required by chi-square analysis. It is also more sensitive to the actual degree of association between the simulated and historical time series than Pearson's product moment correlation, which shows only the degree of linear relationship. Also, the Inequality Coefficient, unlike the Pearson r, is not invariant across additive transformations. The output for each endogenous variable was considered valid when U assumed a value of 0.2 or below, a limit recommended by Theil.

Description of the Model

Historical Perspective

Television was dramatically introduced to the public by David Sarnoff, president of the Radio Corporation of America (RCA), during a broadcast from the New York World's Fair on April 30, 1939. Four years earlier, FM radio had been presented to the public by its inventor, Edwin Armstrong, on April 26, 1935. These two new broadcast delivery systems were to compete head-on for the support of the public, the broadcasting industry, and the Federal Communications Commission (FCC), while at the same time causing an upheaval in the worlds of AM radio and magazines.

AM radio found itself hard hit by television, which replaced it as a major source of entertainment and national advertising dollars. To meet television's threat, radio sacrificed network advertising dollars, and turned local, factual and musical. (Wood, 1971, p. 304) FM offered competition for audiences, since it boasted clearer reception, but other events were to lessen FM's impact on its AM relative. Newspapers were not to feel the direct impact of the invasion of television, since their advertising was mostly local in nature. In fact, 1945-1960 were profitable years for newspapers, as the loss of daily newspapers in some cities was offset by the successful starts of others. Hence, the number of daily newspapers in this period remained fairly constant, although when analyzed at a more microscopic level by city size, there were significant changes in the industry. (See Sterling & Haight, 1978, p. 23) Circulation remained even with population expansion through 1960 (Emery, 1972, p. 620), although the amount of time devoted to newspaper reading dropped significantly as television gained its hold on the public. Mass magazines, once the only medium to provide advertisers with national coverage, were bitterly conscious of television's presence in the media world. To survive, they changed from a truly national mass medium to more regional fare, to a more specialized editorial content altogether, or to oblivion. Thirty-two of the 250 largest magazines between 1950 and 1960 either ceased publication or were merged into other magazines (Rucker, 1968, p. 205). According to the Magazine Publishers Association, 39 percent of its members in 1960 operated at losses and another 25 percent had profits of less than 5 percent of revenue before taxes. Most of this can be attributed to advertisers' shift to television to reach the mass audience.

In itself, the structural reorganization of the mass media industry caused by FM and television makes the period of great interest to media historians and industrial analysts. World War II postponed the normal growth of the industry until 1945, which marked a logical start to such a study. A number of policy decisions by the FCC also affected the outcome of growth in the period and are of interest to policymakers and planners facing similar decisions today.

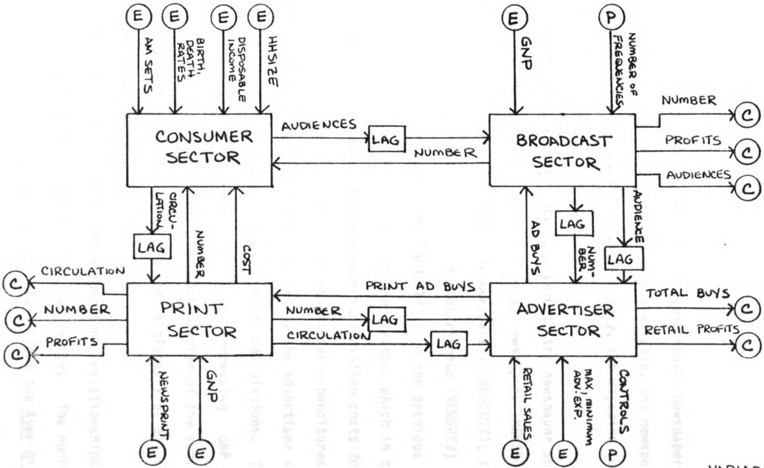
As FM radio and television developed, FCC commissioners reacted to their growth in a series of policy decisions. In 1945, the Commission issued a major spectrum frequency reallocation plan, which moved FM from its established place in the spectrum (VHF band) to make room for television. In 1948, as television applications flooded the Commission and a variety of technical improvements and developments were suggested, the FCC issued a freeze order to suspend all television licensing activity. The freeze was lifted in 1952, by an order which added ultra-high frequencies (UHF) for television use. From a policy standpoint, questions have been raised regarding the frequency reallocation itself, the number of channels actually designated for FM radio and television, and the reactionary approach typified by the freeze order. Variables in the historical model built in this study were manipulated to represent modifications in the actual FCC decision-making in order to answer some hypothetical questions asked of the period.

An Overview

MASSMOD has four principal components: (1) an advertiser sector; (2) a print sector, composed of newspaper and magazine units; (3) a consumer sector; and (4) a broadcast sector, with AM radio, FM radio, VHF television and UHF television modules. (See Figure 2.) These four sectors interact in a yearly cycle.

Key variables of interest in the system include the size of the broadcast audiences and publication circulations; the number of broadcast stations and publications; the profits of broadcasters and publishers; and the media expenditures of advertisers. Several key policy variables, manipulated during the experimental runs described in Chapter 4, were important to the system: advertisers' external media expenditure constraints and the number of broadcast frequencies available for assignment. Exogenous variables which were included were the Gross National Product (GNP), disposable income, population birth and death rates, retail sales, number of AM receivers, and newsprint consumption.

The interaction of the sectors revolves around the functional relationship among advertising expenditures on each medium, publication and broadcasting profits, number of publications and broadcasting stations and audience size. Advertiser expenditures, generated stochastically, were based on audiences and number of media during the previous year. These expenditures influence profitability, which in turn affects media growth or decline, which ultimately affects audience size. This basic



VARIABLE CODE:

E = EXOGENOUS

C = CRITERION FOR VALIDATION

P = POLICY

FIGURE 2

GENERAL SYSTEM BLOCK DIAGRAM--MASSMOD

relationship varies somewhat from submedium to submedium, but essentially describes the system and the linkages of its components. Each component is detailed in the following sections.

The Print Sector

The print sector has two parallel components--newspapers and magazines. Due to limitations on the data available, the newspaper subsector considered daily and Sunday newspapers only; the magazine subsector included consumer and farm publications.

Newspaper Subsector. For each year t, the newspaper subsector determines the number of daily and Sunday newspapers (NEWSNO); the average yearly subscription cost for newspapers (NEWCOST); the total yearly publishing costs (NPUBCST); annual revenue (NEWSREV) and earnings (NEWEARN). Circulation figures (NEWSCIR) from the previous year t-1 are passed to the subsector from the consumer sector, which in turn receives the number of newspapers and newspaper subscription costs for year t from the newspaper subsector. Total advertiser expenditures on newspapers (TNEWBUY) for year t are supplied by the advertiser sector, which uses the number of newspapers at t-1 in its calculations. The subsector uses two exogenous system variables in its processing: GNP and yearly newsprint consumption (NEWSPR). A block diagram of the subsystem is presented in Figure 3; Table 1 contains a glossary of all variables used in the subsector.

Real world data used to derive functional relationships within the subsector were gathered from a variety of sources. The number of daily and Sunday newspapers is based on data taken from the Ayer Directory of Publications (Sterling & Haight, 1978, p. 22), which includes all publications serving a general circulation. The limitation of daily and

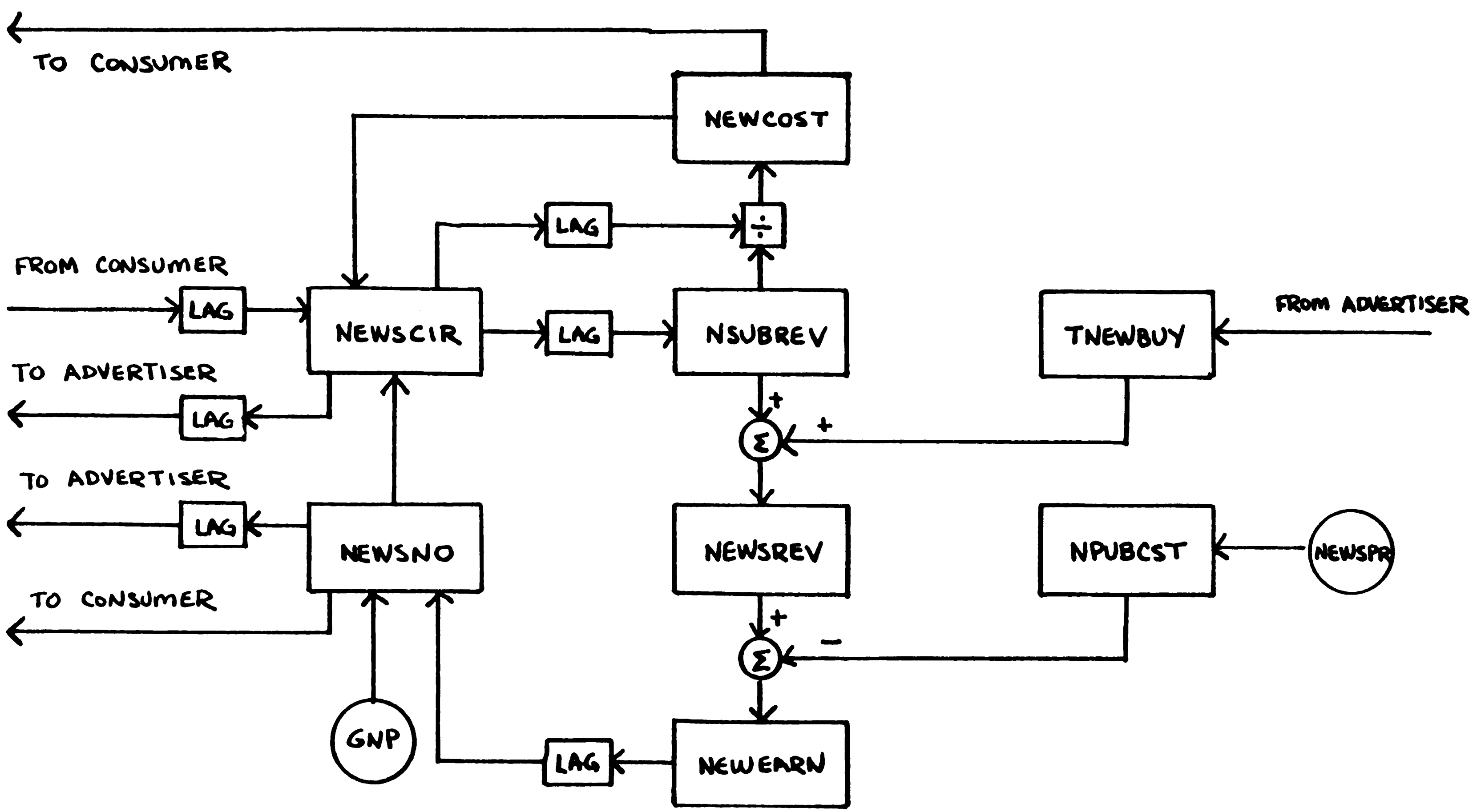


FIGURE 3

BLOCK DIAGRAM--NEWSPAPER SUBSECTOR

TABLE 1

GLOSSARY
NEWSPAPER SUBSECTOR

Variable	Description	Source
GNP	U.S. Gross National Product	Sterling & Haight, pp. 111-112
NEARNI	Total newspaper revenues for 1944; millions of 1972 dollars	Sterling & Haight, p. 157
NEWCOST	Annual average subscription cost per person for newspapers	calculated
NEWEARN	Total newspaper revenues; millions of 1972 dollars	Sterling & Haight, p. 157
NEWSCIR	Total circulation of daily newspapers (morning, evening) in thousands	Sterling & Haight, p. 20
NEWSCRI	Total circulation of newspapers for 1944	Sterling & Haight, p. 20
NEWSNO	Number of daily newspapers, morning and evening	Sterling & Haight, p. 20
NEWSPR	Newsprint consumption; in thousands of tons	Historical Statistics R 218-223
NEWSREV	Sum of advertising revenue and subscription revenue; millions of 1972 dollars	calculated
NPUBCST	Newspaper publishing costs, cost of materials; millions of 1972 dollars	Census of Manufactures 1963, 1972
NSUBREV	Total newspaper revenues from newspaper purchases; millions of 1972 dollars	Newspaper Advertising Bureau, 1972, 1978
TNEWBUY	Total advertising expenditures on newspapers; millions of 1972 dollars	Advertising Age

Sunday newspapers was imposed for two main reasons: figures were available for numbers, circulation, costs and revenues for this category; and, given the aggregate, national level of the model itself, the daily/Sunday newspaper seemed the most prominent competitor of magazine, radio and television. The newspaper audience is described in terms of circulation figures obtained from census data, realizing that circulation is a more accurate measure than individual readership, due to the unreliability of pass-along readership reports.

Publishing costs are those reported in the Census of Manufactures; it is difficult to determine from the census's categorization scheme whether these are just for daily/Sunday papers or all newspapers, and whether the costs include production and personnel expenditures or merely production. Despite these uncertainties, the figures were the only ones available. Subscription costs are based on an in-house report by the Newspaper Advertising Bureau, estimating the annual expenditure on weekday papers by consumers. Earnings are also based on Census of Manufactures and annual Survey of Manufactures data, and are those reported as total income (sale of advertising and newspapers) from newspaper products only. (Sterling & Haight, 1978, p. 157) Many valuable and more precise breakdowns of information were initiated by government and trade organizations after 1960.

Two feedback loops extend from the circulation variable. Circulation at t-1, received from the consumer subsector, determines total subscription revenue (NSUBREV) at t. In the simpler of the two loops, circulation at t is a function of this total subscription revenue (in actuality, annual subscription costs which is derived from the total subscription revenue).

In the second loop, the total subscription revenue at t, when combined with advertising revenue, determines the total newspaper revenue (NEWSREV) at t, which is related to total earning (NEWEARN) at t. Total earnings at t in part determine the number of newspapers at t+1 which influences newspaper circulation and begins the feedback loop again.

Specifically, subscription revenues are a function of the circulation at t-1:

NSUBREV(t)=540.2 + 0.018*NEWSCIR(t-1)

While this lagged relationship is indirect, it is required by the model in order to make the interconnection of subsectors possible.

From this, the average annual subscription cost can be calculated, mindful of the fact that circulations are reported in thousands in the model and revenues in millions of dollars:

NEWCOST(t)=NSUBREV(t)/NEWSCIR(t-1)*1000

Total revenues are computed as the sum of subscriptions and advertising expenses:

NEWSREV(t)=NSUBREV(t) + TNEWEUY(t)

Publishing costs are a function of the tons of newsprint consumed in the production process:

NPUBCST(t)= -14021.34 + 1797.32*ln(NEWSPR(t))

It has been suggested by Owen (1975, p. 36) that publication costs are based on the circulation of the publication and that economies of scale should exist in the production process. Since the high level of aggregation of the model does not consider individual differences in circulation and production costs, this relationship does not reach a level of significance in a regression equation. Also, it would be much more desirable to use the cost of newsprint for any given year in the relationship. Such figures for the time period under study for daily and

Sunday newspapers were not available.

Newspaper earnings are the difference between revenues and publishing costs:

NEWEARN(t)=NEWSREV(t) - NPUBCST(t)

The number of newspapers for year t is a function of the GNP and newspaper earnings at t-1:

NEWSNO(t)=1505.27 + 61.59*ln(NEWEARN(t-1))
- 0.27*GNP(t)

Since newspaper earnings depend on advertising revenue and subscription income, both of which depend on circulation, it should be noted that the number of newspapers is determined (indirectly) by the interaction of readers' (subscription income) and advertisers' (advertising revenue) demands. (Owen, 1975, p. 34) Udell (1978) suggests that paper supply is also a key determinant of number of newspapers; however, it was not significant in the regression equation.

Magazine Subsector. The following variables are computed for year t in the magazine subsector: number of general and farm magazines (MAGNO), magazine publishing costs (MPUBCST), subscription revenues (MSUBREV), total revenues (MAGREV), earnings (MAGEARN), and profits (MAGPROF). GNP is an exogenous variable to the subsystem. Circulation figures from the previous year t-1 (MAGCIRC) are passed from the consumer sector, which receives the number of magazines at year t as subsequent input. The advertiser sector supplies total media buys on magazines (TMAGBUY) in year t as input; this calculation derives in part from the number of magazines at t-1 passed from the magazine subsector. Figure 4 is a block diagram of the system; a glossary of subsector variables is presented in Table 2.

Data from which the historical model was built were accumulated

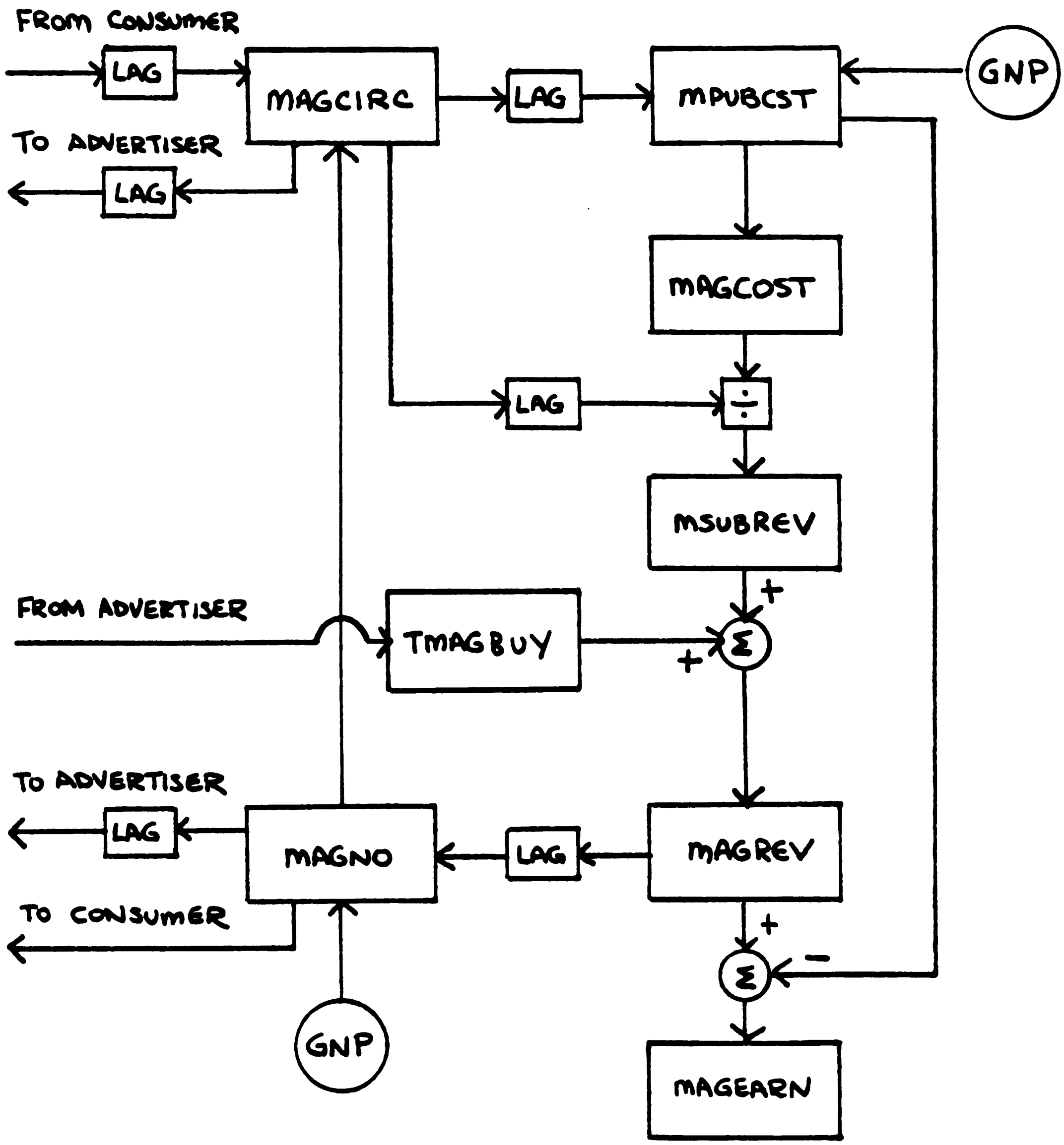


FIGURE 4

BLOCK DIAGRAM--MAGAZINE SUBSECTOR

TABLE 2

GLOSSARY
MAGAZINE SUBSECTOR

Variable	Description	Source
GNP	U.S. Gross National Product	Sterling & Haight, pp. 111-112
MAGCIRC	Magazine circulation, general and farm; in thousands	Sterling & Haight, pp. 342-343
MAGCIRI	Magazine circulation for 1944	Sterling & Haight, pp. 342-343
MAGCOST	Average subscription cost per magazine per year; 1972 dollars	Sterling & Haight, p. 177
MAGEARN	Total magazine revenues; millions of 1972 dollars	Sterling & Haight, p. 170
MAGNO	Total number of general and farm magazines	Sterling & Haight, p. 342
MAGREV	Magazine revenue, sum of advertising revenue and subscription revenue; millions of 1972 dollars	calculated
MEARNI	Total magazine earnings for 1944; millions of 1972 dollars	Sterling & Haight, p. 170
MPUBCST	Magazine publishing costs; sum of materials, payroll, wages, new capital; millions of 1972 dollars	Sterling & Haight, p. 176
MSUBREV	Total magazine revenues from subscriptions; millions of 1972 dollars	calculated
TMAGBUY	Total advertising expenditures on magazines; millions of 1972 dollars	Advertising Age

from several sources. Magazine circulation figures and number of periodicals are those of the Magazine Publishers' Association (MPA) for the total per-issue circulation of those general and farm magazines audited by the Audit Bureau of Circulations (ABC). The figures include the larger magazines of general appeal, as well as some smaller periodicals that specialize in the farm market. (Sterling & Haight, 1978, p. 34) It should be noted that membership in the ABC is voluntary, so that changes in the circulation or the number of periodicals could be a function of the periodicals audited by the ABC instead of changes in the audience's general buying behavior.

Publishing costs are taken from the Census of Manufactures and include materials, payroll, wages and new capital expenditures. Total revenues are also based on Census of Manufactures data and describe earnings from periodical products only, a distinction made by Sterling and Haight to eliminate revenues received by magazine publishers from other businesses, such as newspapers (1978, p. 170). Subscription costs are the average annual library subscription price gathered from appropriate editions of The Bowker Annual, which utilized data from the American Library Association. While the cost of magazines to libraries may not represent the actual cost to the consumer, and also includes more than general and farm magazines, these figures were the only such subscription data available for the years under study.

One feedback loop operates in the magazine subsector. Magazine circulation at t-1 influences publishing costs and subscription revenue at time t; from this, magazine revenue at t is determined, which affects the number of magazines at t+1, which in turn affects circulation.

Magazine publishing costs are a function of the GNP and lagged magazine circulation:

$$MPUBCST(t)=329.17 + 0.003*MAGCIRC(t-1) + 1.32*GNP(t)$$

Magazines use higher quality paper than newsprint, hence newsprint supply is not included in the equation as it was in the newspaper sub-sector. Paper supply and/or consumption figures for magazines are not readily available, since the production operation of magazines is often farmed out to independent printers who do not itemize nor report their paper use.

The average annual subscription cost of magazines is derived from the publishing cost:

$$MAGCOST(t)=5.56 + 0.001*MPUBCST(t)$$

From the calculation of the average subscription cost, total magazine subscription revenue can be computed by multiplying the average cost by the magazine circulation:

$$MSUBREV(t)=MAGCOST(t) * MAGCIRC(t-1)/1000$$

An adjustment is made to convert the result into millions of dollars. While the circulation at time t would be a more appropriate value in this equation, the sequence of the model requires that the preceding year's figures be used instead.

Total magazine revenue should be the sum of subscription income and advertising income:

$$MAGINC(t)=MSUBREV(t) + TMAGBUY(t)$$

However, this calculation did not correspond to revenue figures reported by the industry, possibly because the revenue figures in the Census of Manufactures are for all periodical products, while the model to this point deals with general and farm magazines. Since it was not desirable to add additional variables to the model, the revenue figure reported by the industry was regressed with the total income figure derived from the above equation to correct the anomoly:

MAGREV(t)=1073.93 + 0.58*(MSUBREV(t) + TMAGBUY(t))

Magazine earnings were computed as the difference between revenue and expenses (publishing costs):

MAGEARN(t)=MAGREV(t) - MPUBCST(t)

The number of magazines at year t is a function of magazine revenues during the previous year and the GNP at t:

MAGNO(t)=204.417 - 0.014*MAGREV(t-1) + 0.144*GNP(t)

Indirectly, the number of magazines reflects both consumer and advertiser demands, since both subscription revenue and advertising revenue are components of total magazine revenue.

The Broadcast Sector

The broadcast sector is represented by three modules in the model: a radio subsector, which has parallel AM and FM components; a VHF television subsector and a UHF television subsector. Because the model is constructed at a highly aggregate level, the distinction between network affiliated stations and independents, as well as the factor of competition between stations in a market, was not considered.

The AM Subsector. For each year t, the AM radio subsector determines the number of commercial AM radio stations (AMNO); and the annual expenses (AMEXP), revenues (AMREV) and earnings (AMEARN) for the stations. The number of households with AM radios (AMHH) from the previous year t-1 are passed to the subsector from the consumer sector; this sector receives the number of AM stations at year t as input. Advertising expenditures on AM radio (AMBUY) for year t are delivered from the advertising sector, which uses the number of stations at t-1 in its calculations. GNP is the only exogenous variable in the module;

one policy variable--channels available for AM radio use (AMCHAN)--was manipulated during experimental runs described in Chapter 4. A block diagram for this subsector is presented in Figure 5; Table 3 contains a glossary of variables used in the module.

The model concerns itself only with commercial (i.e., those which sell advertising time) AM radio stations; the number of stations for each year is that reported by the Federal Communications Commission. Expenses, revenues and pre-tax earnings are also FCC figures as given in annual financial reports on the radio industry. The figures include not only AM stations, but AM-FM combinations--those FM stations which are owned by AM stations. The FCC did not require separate reporting of AM and FM revenues for these jointly owned stations until 1969 (Sterling & Haight, 1978, p. 204), which made the analysis of FM stations particularly difficult in this model.

In detail, the equations in the submodel are as follows:

The number of AM radio stations in year t is a function of the GNP for that year and the earnings of the stations during the previous year t-1:

$$\begin{aligned} AMNO(t) = 2727.41 - 3.13*GNP(t) &- 1.78*AMEARN(t-1) \\ &+ 213.46*RNYR \end{aligned}$$

RNYR can be considered a growth variable; it represents the number of the year and makes more of a contribution as the model progresses through time, and the industry becomes more well-established. The use of RNYR could also indicate that a significant variable has not been identified and included in the model. Since earnings are derived from expenses, which are affected by audience size, the number of stations is indirectly determined by audience. (Blau, Johnson & Ksobiech, 1976, p. 199)

The number of stations in year t is a factor in the total expenses

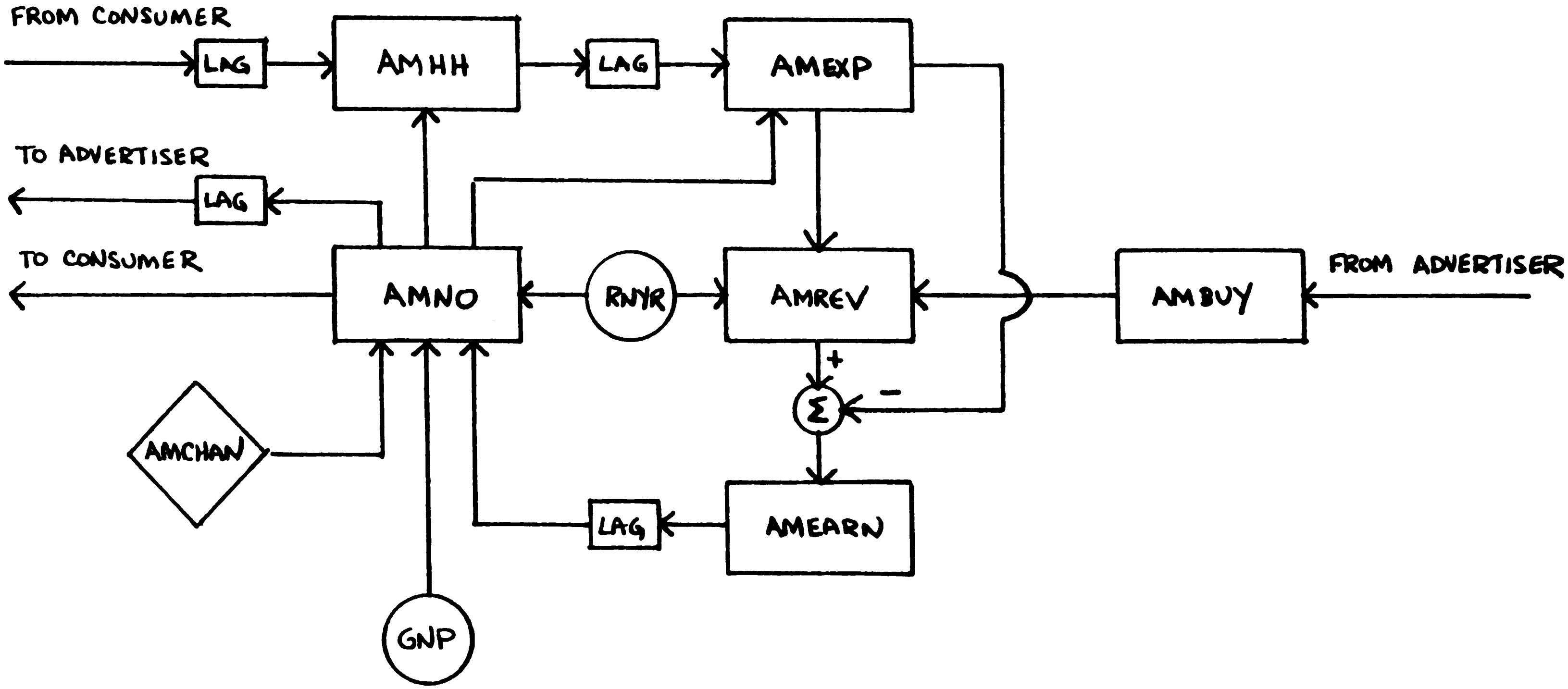


FIGURE 5

BLOCK DIAGRAM--AM RADIO SUBSECTOR

TABLE 3

GLOSSARY
AM RADIO SUBSECTOR

Variable	Description	Source
AINCOME	Difference between AM station revenues and expenses; millions of 1972 dollars	calculated
AMBUY	Total advertising expenditures on AM radio; millions of 1972 dollars	*Advertising Age*, calculated
AMCHAN	Number of channels available for AM commercial use	*FCC Reports*, manipulated
AMEARN	Total pre-tax earnings for all AM radio stations (includes AM and FM combinations); millions of 1972 dollars	Sterling & Haight, p. 203
AMEXP	Total expenses for all AM radio stations (includes AM and FM combinations); millions of 1972 dollars	Sterling & Haight, p. 203
AMHH	U.S. households with AM radio receivers; in thousands	Sterling & Haight, p. 367
AMNO	Number of commercial AM radio stations	Sterling & Haight, p. 43
AMREV	Total revenues of AM radio stations (includes AM and FM combinations); millions of 1972 dollars	Sterling & Haight, p. 203
GNP	U.S. Gross National Product	Sterling & Haight, pp. 111-112
RNYR	Time index: NYR-1	calculated

of stations in that year. The number of AM households at t-1 is also a determinant:

AMEXP(t)=513.04 + 0.00002*AMHH(t-1) + 0.07*AMNO(t)

Since broadcasters attempt to maximize audience size in order to attract maximum advertising dollars and hence profits, this equation is quite expected.

AM station revenues are determined mainly by advertiser expenditures, although these do not totally account for reported AM station income. The growth variable RNYR is also included in the equation. Part of this anomoly could be due to the inclusion of the FM revenues of AM-FM station combinations.

AMREV(t)=118.423 + 0.760*AMBUY(t)
+ 0.689*(RNYR**2)

AM station income is computed as the difference between revenue and expenses:

AINCOME=AMREV(t) - AMEXP(t)

This computation is not equivalent to the pre-tax earnings reported for AM stations in the FCC Annual Reports, although the components of the regression equations for AM revenues and AM expenses are significant and the predicted values validate with the historical data. AM earnings are therefore calculated as follows in the model:

AMEARN(t)=59.059 + 0.49*AINCOME

The FM Subsector. The FM radio subsector determines for each year t the number of FM stations in operation (FMNO), and their annual revenues (FMREV), expenses (FMEXP) and pre-tax earnings (FMEARN). Advertising expenditures on FM stations (FMBUY) for the year under consideration are passed to the subsector by the advertising sector; this sector uses the number of FM stations in the previous year t-1 to arrive at the expenditures for year t. GNP is the only exogenous variable in the subsystem, although calculations also depend on the growth variable RNYR. One policy variable, representing the number of FM channels available for commercial use (FMCHAN), was included for experimentation in Chapter 4. A block diagram of the FM subsector is given in Figure 6; Table 4 contains a glossary of variables.

This subsector was, by far, the most difficult to model due to lack of data, or lack of data available in the desired categories. Data on the number of FM stations were derived from annual FCC Reports and refer to commercial stations actually on the air, regardless of license status. Figures for expenses, revenues and earnings are also taken from FCC Reports, but include only independent FM stations (stations not owned by an AM station company). As previously mentioned, the FCC did not require AM-FM station combinations to provide a detailed breakdown of their financial affairs until 1969. Hence, the monetary figures used in this subsector most likely underestimate actual expenses, revenues and profits, but there is no data available to quantify this underestimation.

The number of households with FM radio receivers does not enter into the calculation of any variables in the subsector. This could be due, at least in part, to the scarcity of data used in the regression estimating equations. Neither the FCC nor the National Association of Broadcasters (NAB) nor the National Association of FM Broadcasters nor the Electronics Industries Association nor audience measurement services such as Hooper or A. C. Nielsen maintained any separate data on FM households or the number of radio receivers capable of FM reception during the time period involved in this study. Four scattered data points were gleaned from in-house publications in the NAB library produced by NAB's Broadcast Measurement Bureau (1949) and <u>FM-phasis</u> (1959),

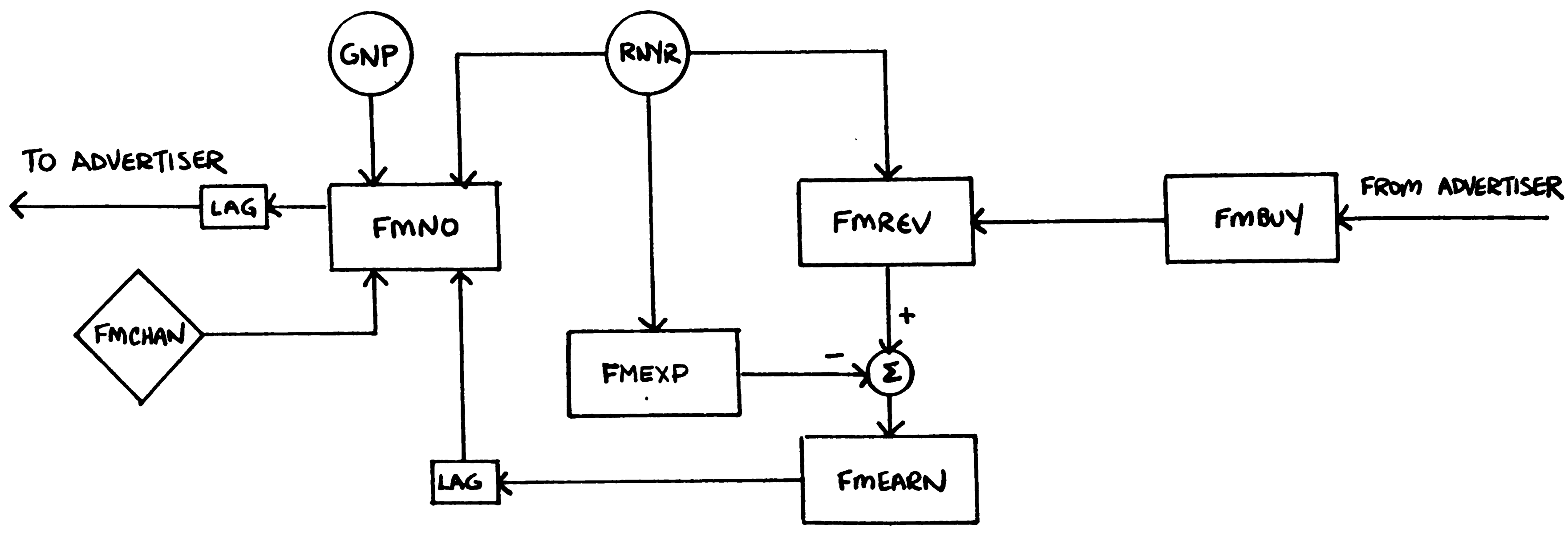


FIGURE 6

BLOCK DIAGRAM--FM RADIO SUBSECTOR

TABLE 4

GLOSSARY
FM RADIO SUBSECTOR

Variable	Description	Source
FMBUY	Total advertising expenditures	Advertising Age
FMCHAN	Number of channels available for FM commercial use	FCC Reports, manipulated
FMEARN	Total pre-tax earnings for commercial FM radio stations; millions of 1972 dollars	Sterling & Haight, p. 205
FMEXP	Total expenses for commercial FM radio stations; millions of 1972 dollars	Sterling & Haight, p. 205
FMHH	U.S. households with FM radio receivers; in thousands	NAB, 1959; NARTB, 1952
FMNO	Number of commercial FM radio stations	Sterling & Haight, p. 205
FMREV	Total revenues of commercial FM radio stations (excludes combinations); millions of 1972 dollars	Sterling & Haight, p. 205
GNP	U.S. Gross National Product	Sterling & Haight, p. 157
GROWTH	Constant to describe growth of FM radio stations	calculated
RNYR	Time index: NYR-1	calculated

and the National Association of Radio and Television Broadcasters (1952, 1954).

The number of FM stations for year t is determined by an exponential relationship with FM station earnings during the previous year t-1 and the GNP:

$$FMNO(t)=\exp(7.208 - 0.096*FMEARN(t-1) \\ -0.006*GNP(t))$$

Station earnings are calculated as the difference between revenues and expenses:

$$FMEARN(t)=FMREV(t) - FMEXP(t)$$

where revenues are a function of the advertisers' expenditures on FM commercial time and the cube of the growth factor RNYR:

$$FMREV(t)= -16.518 + 0.086*FMBUY(t) \\ + 0.0023*(RNYR**3)$$

FM station expenses are calculated using only the time variable RNYR in its cubed and squared form. As with most of the other equations ultimately used in the broadcasting submodels, many other variables suggested by theory, such as number of FM households, number of FM stations, earnings, GNP, were included in regression equations, only to discover that they were not significant predictors of the variable under consideration. Therefore, the only significant equation derived for FM expenses was as follows:

$$FMEXP(t)=11.42 + 0.019*(RNYR**3) - 0.28*(RNYR**2)$$

<u>The VHF Subsector.</u> This subsector determines the number of commercial VHF television stations (VHFNO) at year t. It also computes the revenues (VHFREV), expenses (VHFEXP) and earnings (VHFEARN) for those stations during the same year. The consumer subsector provides this module with the number of households with VHF television receivers (VHFHH) during the previous year t-1. The advertising sector delivers

advertiser expenditures on VHF television (VHFBUY) for year t, and uses number of VHF television households at t-1 in its computations. As in the other broadcast subsectors, GNP is the only exogenous variable; one policy variable--number of channels in the VHF band of the spectrum allocated for commercial television use (VHFCHAN)--were manipulated during experimental runs. Figure 7 is a block diagram of the VHF subsystem; a glossary of variables is given in Table 5.

The number of commercial VHF stations for each year is that reported by the FCC (Sterling & Haight, 1978, p. 49). Regular television station operation was approved by the FCC in 1941, but was interrupted by World War II. After the war, growth was still slow, due to high station construction and operation costs, the limited number of VHF-only channels, and allocation problems. The FCC froze the processing of station applications in 1948; the freeze was lifted in 1952. Increase in station numbers during this period is the result of stations which had approved applications prior to 1948 actually going on the air. Revenues, expenses and earnings for VHF commercial stations are drawn from official FCC data on television station economics (Sterling & Haight, 1978, p. 206).

One feedback loop is involved in the model, with the number of VHF stations as the keystone. VHF expenses are a function of VHF households, the number of VHF stations and advertiser expenditures for VHF commercial time. VHF revenue is based on advertiser expenditures, which depend in part on the number of VHF stations during the previous year. The difference between revenues and expenses is pre-tax earnings for year t, which after a two-year delay, affects the number of VHF stations at t. Hence, number of stations influences earnings which in turn determines number of stations.

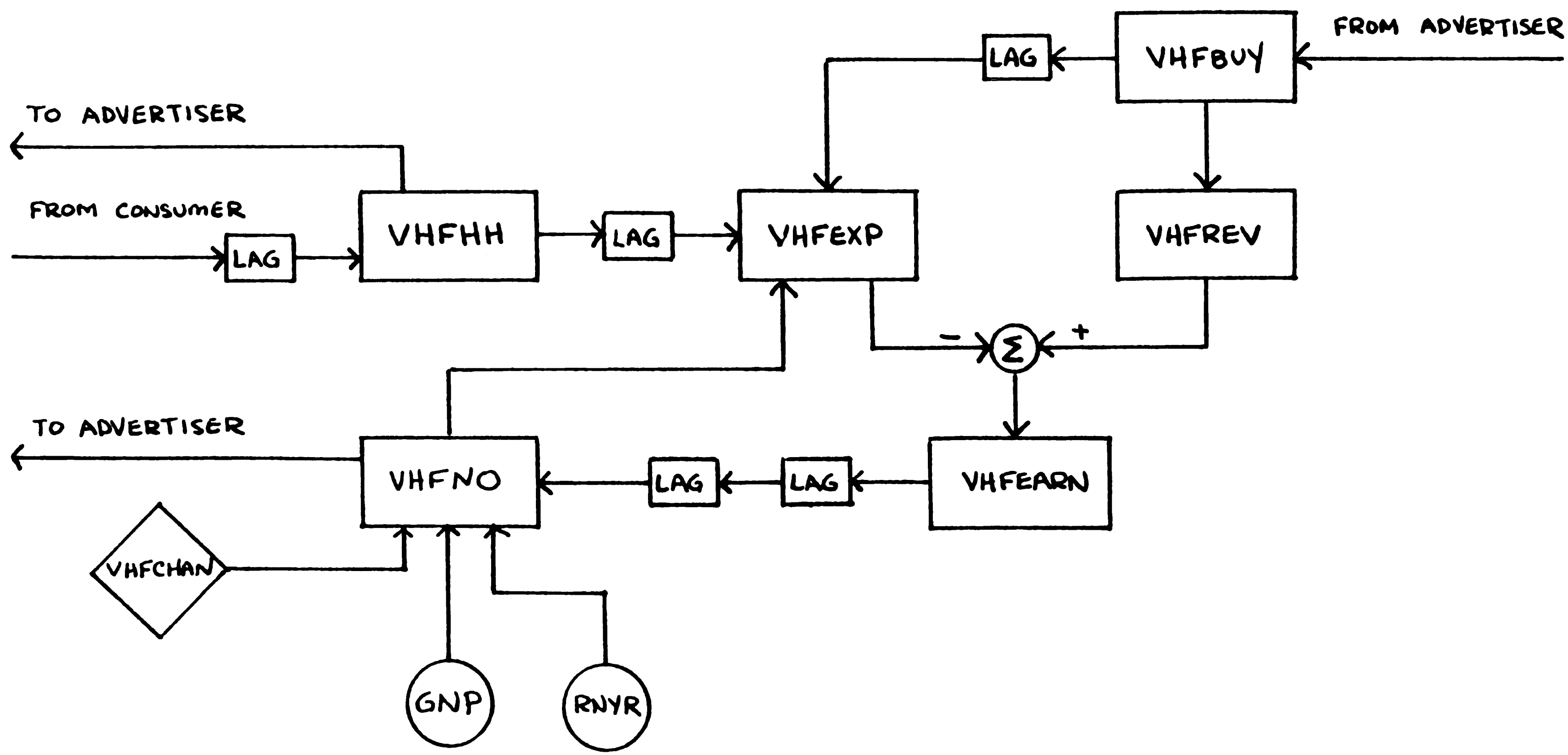


FIGURE 7

BLOCK DIAGRAM--VHF TELEVISION SUBSECTOR

TABLE 5

GLOSSARY
VHF TELEVISION SUBSECTOR

Variable	Description	Source
GNP	U.S. Gross National Product	Sterling & Haight, pp. 111-112
RNYR	Time index; NYR-1	calculated
VHFBUY	Total advertising expenditures on VHF television; millions of 1972 dollars	Advertising Age
VHFCHAN	Number of channels available for commercial VHF stations	FCC Reports, manipulated
VHFEARN	Earnings before taxes for commercial VHF television stations; millions of 1972 dollars	Sterling & Haight, pp. 208-209
VHFEXP	Expenses for commercial VHF television stations; millions of 1972 dollars	Sterling & Haight, pp. 208-209
VHFHH	Number of U.S. households with VHF television receivers; in thousands	Sterling & Haight, p. 372
VHFNO	Number of commercial VHF television stations	Sterling & Haight, p. 49
VHFREV	Revenue of VHF commercial television stations; millions of 1972 dollars	Sterling & Haight, pp. 208-209

Specifically, VHF station revenue is related to advertising expenditures as follows:

VHFREV(t)= -24.63 + 0.48*VHFBUY(t)

It might be expected that VHF station revenue would be accounted for in full by advertising revenue. This, however, is not the case, at least according to the data used in the regression equations. Stations do have other sources of income, such as promotional fees, use of talent, use of facilities. However, advertiser expenditures are not broken down according to VHF and UHF stations, and the assumptions made as to the proportional breakdown may be incorrect.

Station expenses are computed according to the following relationship:

VHFEXP(t)= -32.78 + 0.489*VHFBUY(t)
- 0.00533*VHFHH(t-1)

Stations base their expenditures on the number of households to be served, as well as the revenue they derive from advertisers. This result is consistent with real life data on a market by market basis. Stations in larger markets, determined by number of households, tend to invest more money in programming and personnel expenses than stations in smaller markets. Of course, their revenue is also increased due to larger advertiser buys, so the increased expense is offset by increased revenues.

Earnings are the difference between revenue and expenses:

VHFEARN(t)=VHFREV(t) - VHFEXP(t)

The submodel acknowledges the slow growth of television stations and the subsequent freeze in the granting of applications by using two separate equations:

VHFNO(t)= -149.156 + 0.343*GNP(t)

The second equation takes into account earnings after a two year delay and adds the growth variable, RNYR, not unexpected due to the freeze:

$$
\begin{aligned}
VHFNO(t) = -177.29 &+ 0.303*GNP(t) \\
&+ 0.6*VHFEARN(t-2) \\
&+ 20.42*RNYR
\end{aligned}
$$

Since no FCC financial data were available for the years 1945-1947, the subsector reports values of 0 for expenses, revenues and earnings for these three years.

The UHF Subsector. This subsector begins operation in the model in 1953, the first year the FCC authorized the use of frequencies in the ultra high band for commercial television. It determines the number of UHF television stations (UHFNO) at year t as well as the revenues (UHFREV), expenses (UHFEXP) and earnings (UHFEARN) for those stations. The subsector receives the number of households with UHF television receivers (UHFHH) at t-1 from the consumer sector and the revenue from advertising on UHF stations (UHFBUY) from the advertiser sector. Number of UHF stations at t-1 is used by the advertiser sector to determine all buys. UNYR is a growth variable comparable to RNYR in the AM, FM and VHF subsectors; in 1953, UNYR equals 0. The number of channels available for commercial UHF stations (UHFCHAN) was a policy variable manipulated in experiments in Chapter 4. A block diagram of the subsystem is shown in Figure 8; Table 6 is a glossary of variables in the subsector.

Figures for number of commercial UHF stations are taken from FCC Annual Reports. The number of households with UHF receivers is a derived value based on UHF penetration percentages reported by the Advertising Research Foundation and the U.S. Census Bureau and the number of homes with television receivers, gathered from NBC Corporate Planning data (Sterling & Haight, 1978, p. 373). Revenues, expenses

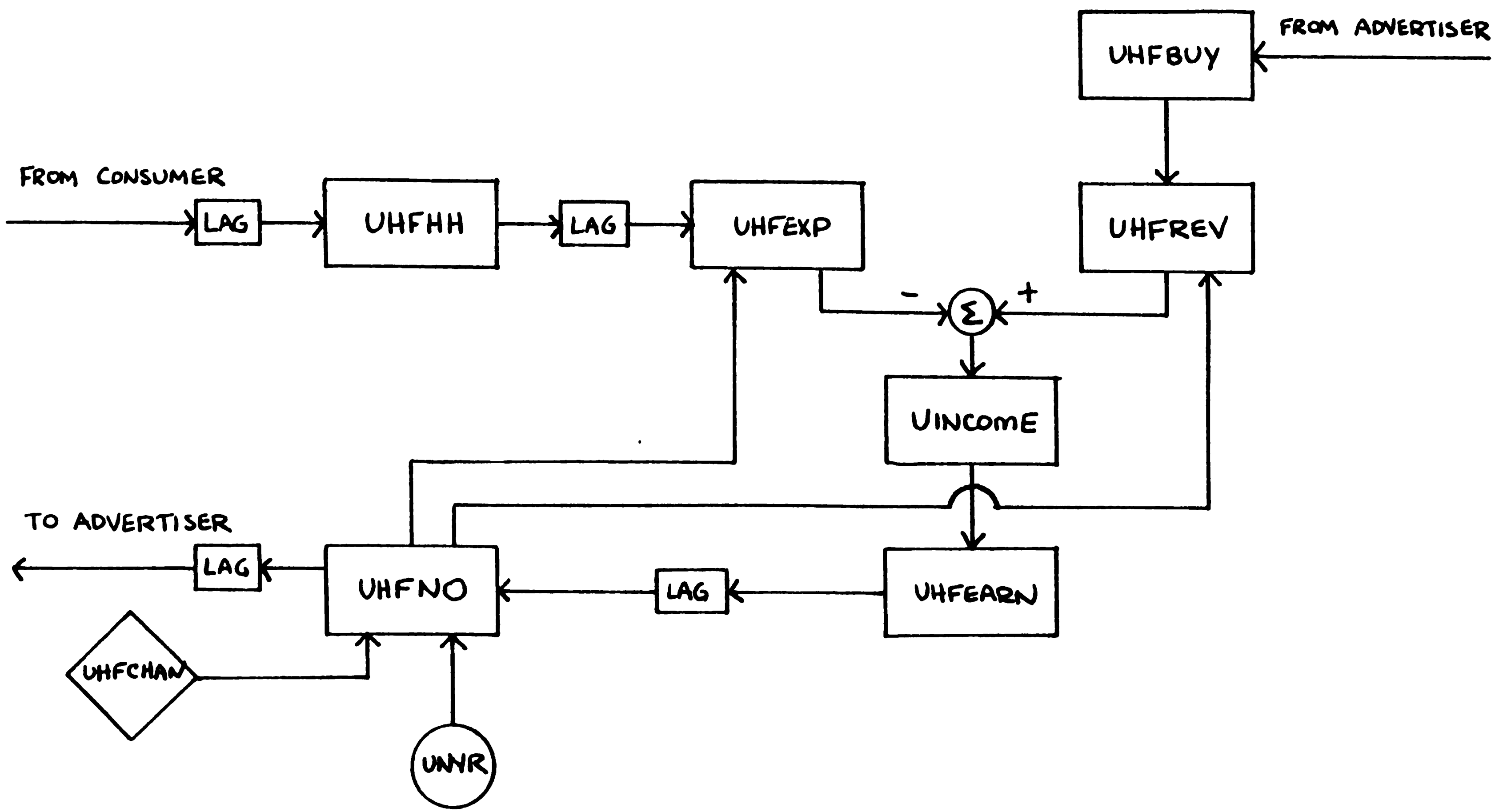


FIGURE 8

BLOCK DIAGRAM--UHF TELEVISION SUBSECTOR

TABLE 6

GLOSSARY
UHF TELEVISION SUBSECTOR

Variable	Description	Source
UHFBUY	Total advertising expenditures on UHF television stations; millions of 1972 dollars	Advertising Age, calculated
UHFCHAN	Number of channels available for UHF commercial use	FCC Reports, manipulated
UHFEARN	Total earning before taxes for UHF television stations; millions of 1972 dollars	Sterling & Haight, pp. 208-209
UHFEXP	Total expenses for UHF television stations; millions of 1972 dollars	Sterling & Haight, pp. 208-209
UHFHH	Number of households in U.S. with UHF receivers; in thousands	Sterling & Haight, p. 372
UHFNO	Number of commercial UHF television stations	Sterling & Haight, p. 49
UHFREV	Revenue of commercial UHF television stations; millions of 1972 dollars	Sterling & Haight, pp. 208-209
UINCOME	Difference between UHF station revenue and expenses; millions of 1972 dollars	calculated
UNYR	Time index; NYR-9; 1953=0	calculated

and pre-tax earnings for commercial UHF stations are those reported by the National Association of Broadcasters in their Television Financial Reports (Sterling & Haight, 1978, p. 209).

Feedback in this subsector revolves around number of UHF stations, determined by station earnings after a one-year delay, but which in turn contributes to the determination of both expenses and revenues, which generate earnings. The number of UHF stations at t-1 is used by the advertiser sector to calculate UHF advertising expenditures, which also contribute to the prediction of UHF revenue, thus adding to the complexity of the feedback loop.

Specifically, the number of UHF stations is determined by the following equation:

```
UHFNO(t)=128.21 - 0.55*UHFEARN(t-1)
                + 0.87*(UNYR**2) - 13.86*UNYR
```

UNYR functions as a growth variable, negative in this case, since the number of UHF stations decreases from 1953 to 1960. This is partially due to the fact that television sets were not required to receive UHF signals until the 1962 All-Channel Receiver Act was passed. Hence, without a guarantee that audiences would be capable of receiving their signals, station profitability was in jeopardy. Number of UHF receivers was tested in this equation, but was not a significant variable. Number of UHF households reflects indirectly in the equation, as it affects expenses which in turn affect earnings.

The equation for expenses is:

```
UHFEXP(t)=26.68 - 0.001*UHFHH(t-1) + 0.26*UHFNO(t)
```

Revenue is based on advertiser expenditures and the number of stations:

```
UHFREV(t)=34.32 - 0.02*UHFBUY(t) + 0.27*UHFNO(t)
```

Station income is calculated as the difference between revenue and expenses:

UINCOME=UHFREV(t) - UHFEXP(t)

However, this income figure, like that in the AM subsector, does not equal the reported pre-tax earnings for UHF stations, even though the predicted values for both revenue and expenses validate with historical data. Therefore, another regression equation was inserted in the model to accomodate the discrepancy:

UHFEARN(t)= -5.380 - 2.395*(UINCOME**2)
- 6.030*UINCOME

The Advertising Sector

This sector computes the total advertising expenditures by advertisers for each media subsector in the model at t (NEWSBUY, MAGBUY, AMBUY, FMBUY, VHFBUY, UHFBUY) based on input from the media subsectors regarding the medium's circulation or audience, and the number of publications or stations in operation during the previous year t-1. Operating as a media planning-buying function, it first calculates the amount of money spent on local, national spot and network advertising before allocating expenditures to the particular media. It also monitors retail profits (RETPROF) as the difference between retail sales (SALES), supplied to the model as an exogenous variable, and advertising expenditures. For reasons to be discussed below, this sector is stochastic--i.e., the results are based on probabilistic rather than completely determined outcomes. Minimum and maximum values for one advertiser's expenditures on a particular medium are provided to the sector as exogenous variables, as is a parameter for each medium used by the random number generator (the PARAM array). A policy variable which controls the amount of advertising expenditures (ADEXPOL) was included in the model for manipulation during the experiments described in Chapter 4. A basic diagram of the sector is presented in Figure 9; a glossary of variables is given in Table 7.

Generally, annual advertiser expenditures are reported by medium, without regard for VHF/UHF or AM/FM distinctions, and by the type of advertising--network, national spot and local. Figures used in the model, reported by Robert J. Coen of McCann-Erickson, Inc. (Sterling & Haight, 1978, p. 124), are estimates, which vary greatly in validity depending on the medium. Broadcast figures are taken from FCC annual financial reports; newspaper data are for daily and Sunday papers only. Retail sales figures for each year were taken from appropriate volumes of Statistical Abstracts. In order to locate minimum and maximum expenditures by advertisers by medium, it was assumed that the advertising buys of the top 100 advertisers represented a major portion of all buys in a particular medium; hence, annual Advertising Age reports of the top 100 Advertisers by medium were used to provide the necessary minima and maxima, and also to determine estimates of the average annual advertiser expenditure by medium.

The selection of a media schedule by an advertiser is a multi-faceted problem, which includes at the least such variables as the distribution system of the product, the target population, the firm's budget size, and the characteristics of the product (Gensch, 1973, p. 75). Other considerations include the availability of time or space in the media, the quality of the advertising copy and the viewing or reading habits of the population. While a number of mathematical methods exist, such as the optimizing approach of linear, non-linear and dynamic programming, and the non-optimizing approach of iteration or marginal analysis, heuristic programming and simulation, Gensch maintains that

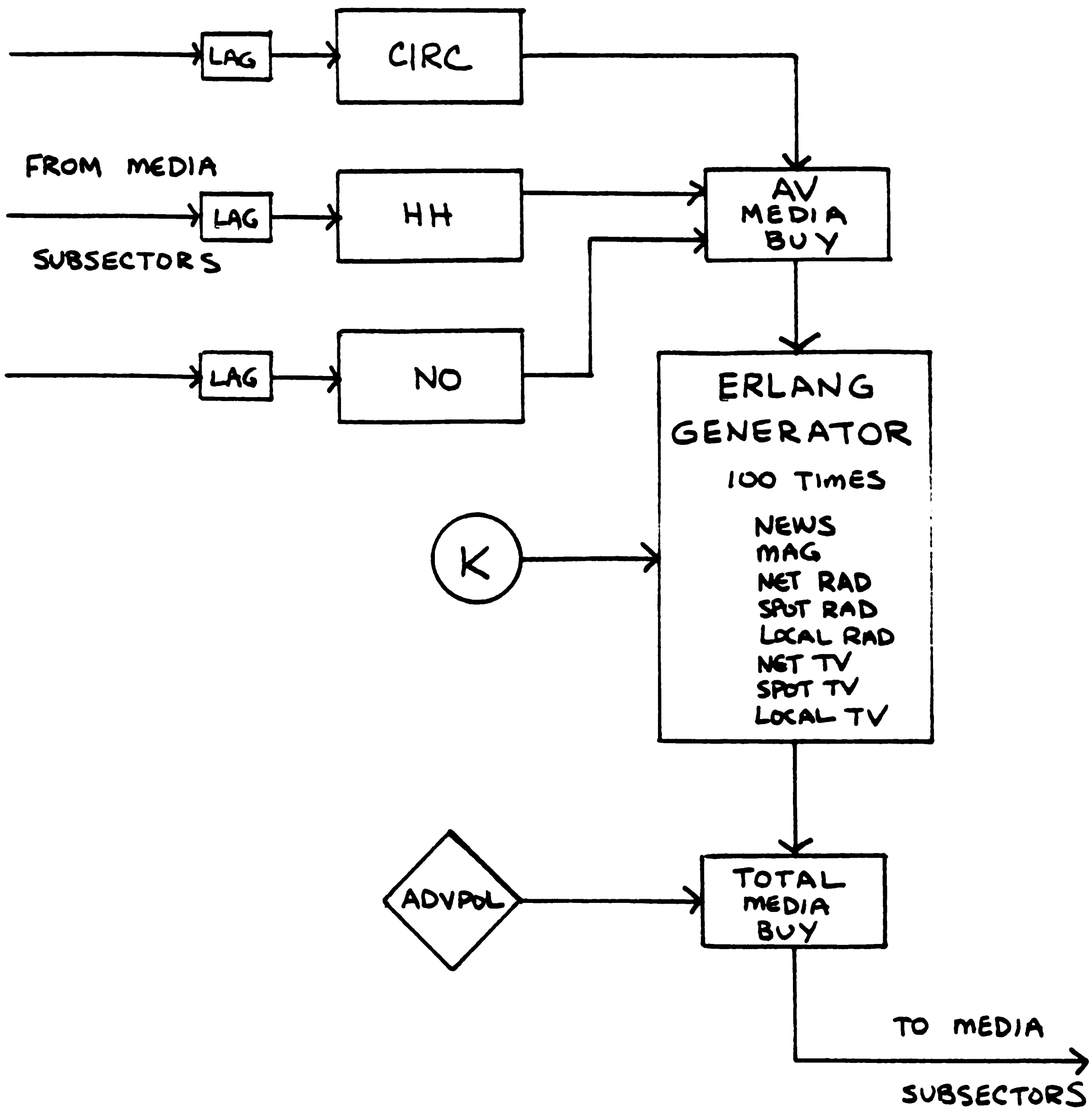


FIGURE 9

BLOCK DIAGRAM--ADVERTISER SECTOR

TABLE 7

GLOSSARY
ADVERTISER SECTOR

Variable	Description	Source
AMBUY	Total advertising expenditures on AM radio; millions of 1972 dollars	*Advertising Age*, calculated
AMHH	U.S. households with AM radio receivers; in thousands	Sterling & Haight, p. 367
AMNO	Number of commercial AM radio stations	Sterling & Haight, p. 43
AVLRD	Average expenditure per advertiser on local radio spots; millions of 1972 dollars	Sterling & Haight, pp. 122-129
AVLTV	Average expenditure per advertiser on local television spots; millions of 1972 dollars	Sterling & Haight, pp. 122-129
AVMAG	Average expenditure per advertiser on magazines; millions of 1972 dollars	Sterling & Haight, pp. 122-129
AVNEW	Average expenditure per advertiser on newspapers; millions of 1972 dollars	Sterling & Haight, pp. 122-129
AVNRD	Average expenditure per advertiser on network radio spots; millions of 1972 dollars	Sterling & Haight, pp. 122-129
AVNTV	Average expenditure per advertiser on network television spots; millions of 1972 dollars	Sterling & Haight, pp. 122-129
AVSRD	Average expenditure per advertiser on spot radio; millions of 1972 dollars	Sterling & Haight, pp. 122-129
AVSTV	Average expenditure per advertiser on spot television; millions of 1972 dollars	Sterling & Haight, pp. 122-129

TABLE 7 (cont'd)

BUDGET	Advertising budget for all media; millions of 1972 dollars	Sterling & Haight, pp. 122-129
FMBUY	Total advertising expenditures on FM radio; millions of 1972 dollars	<u>Advertising Age</u>, calculated
ISEED	Externally determined seed for random number generator	
MAGCIRC	Magazine circulation for general and farm magazines; in thousands	Sterling & Haight, pp. 342-343
MAGNO	Total number of general and farm magazines	Sterling & Haight, p. 342
NEWSCIR	Total circulation of daily newspapers (morning, evening); in thousands	Sterling & Haight, p. 20
NEWSNO	Number of daily newspapers, morning and evening	Sterling & Haight, p. 20
NYRLRD	Index for local radio ad expenditures in PARAM array	
NYRLTV	Index for local television ad expenditures in PARAM array	
NYRMAG	Index for magazine ad expenditures in PARAM array	
NYRNEW	Index for newspaper ad expenditures in PARAM array	
NYRNRD	Index for network radio ad expenditures in PARAM array	
NYRNTV	Index for network television ad expenditures in PARAM array	
NYRSRD	Index for spot radio ad expenditures in PARAM array	
NYRSTV	Index for spot television ad expenditures in PARAM array	

TABLE 7 (cont'd)

OBDGT	Over-budget indicator used to monitor difference between advertising budget and actual expenditures	calculated
PARAM	Array of average advertising expenditures for each medium, minimum and maximum values, and k values	_Advertising Age_
RADNO	Total number of commercial radio stations (sum of AMNO and FMNO)	calculated
RADTOT	Total advertising expenditures on radio (both AM and FM); (sum of local, spot and network radio expenditures); millions of 1972 dollars	calculated
RETPROF	Total retail profits; difference between retail sales and advertising expenditures; millions of 1972 dollars	calculated
SALES	Total annual retail sales; millions of 1972 dollars	_Census of Manufactures_
TBUY	Total advertising expenditures across all media; millions of 1972 dollars	Sterling & Haight, pp. 122-129
TLRDBUY	Total advertising expenditures on local radio; millions of 1972 dollars	Sterling & Haight, pp. 122-129
TLTVBUY	Total advertising expenditures on local television; millions of 1972 dollars	Sterling & Haight, pp. 122-129
TMAGBUY	Total advertising expenditures on magazines; millions of 1972 dollars	Sterling & Haight, pp. 122-129
TNEWBUY	Total advertising expenditures on newspapers; millions of 1972 dollars	Sterling & Haight, pp. 122-129

TABLE 7 (cont'd)

TNRDBUY	Total advertising expenditures on network radio; millions of 1972 dollars	Sterling & Haight, pp. 122-129
TNTVBUY	Total advertising expenditures on network television; millions of 1972 dollars	Sterling & Haight, pp. 122-129
TSRDBUY	Total advertising expenditures on spot radio; millions of 1972 dollars	Sterling & Haight, pp. 122-129
TSTVBUY	Total advertising expenditures on spot television; millions of 1972 dollars	Sterling & Haight, pp. 122-129
TVNO	Total number of television stations (sum of VHFNO and UHFNO)	calculated
UHFBUY	Total advertising expenditures on UHF television; millions of 1972 dollars	Advertising Age, calculated
UHFNO	Number of commercial UHF television stations	Sterling & Haight, p. 49
VHFBUY	Total advertising expenditures on VHF television; millions of 1972 dollars	Advertising Age, calculated
VHFHH	Number of U.S. households with VHF television receivers; in thousands	Sterling & Haight, p. 372
VHFNO	Number of commercial VHF television stations	Sterling & Haight, p. 49

"...there is no single acceptable, unified theory of making media selection decisions." (1973, p. 17)

The lack of a unified theory of media selection is compounded in this model by the highly aggregate nature of the variables. No time/space availabilities are offered, nor is it possible to define selected target audiences from the population, which is assumed to be homogeneous. The concept of market segmentation as a tool in planning advertising expenditures was to come later. (Kotler, 1972, pp. 165-166) In addition, no single product decisions are involved, only total expenditures. Therefore it was decided to make the selection of media by advertisers stochastic, selecting annual advertiser expenditures by medium from probability distributions instead of completely determined equations.

Probability Distributions. A stochastic simulation involves the replacement of an actual statistical universe of elements (such as advertiser media selection behavior) by its theoretical counterpart, described by some probability distribution, and then sampling by means of some type of random number generation from the theoretical population, according to Naylor *et al*. (1968, p. 69). The task becomes one of selecting an appropriate probability distribution to replace the actual statistical universe.

A probability distribution represents the distribution of the relative frequency of the occurrence of all possible events under consideration. The shape of such a distribution is determined by the behavior of events within the system. Distributions can be divided into two general types, theoretical and empirically derived. An empirically derived probability distribution assumes that data are available to generate the distribution, while the theoretical distribution is represented by a mathematical function or rule. Theoretical distributions are preferred for use in computer simulations.

The gamma family of probability distributions was selected for use in the advertising sector of the model. As Zehna points out, the gamma family is so extensive that it "is a fairly safe assumption to make as a model for an experiment described by almost any nonnegative random variable." (1970, p. 148) The gamma distribution has two parameters, k which is the number of successes per interval or unit space, and α which is the reciprocal of the average number of successes per interval. One of the most powerful properties of the distribution is its ability to change shape from an extremely skewed exponential distribution to a near normal distribution by changing only the k parameter. Figure 10 shows the effect of changes in k on the shape of the distribution.

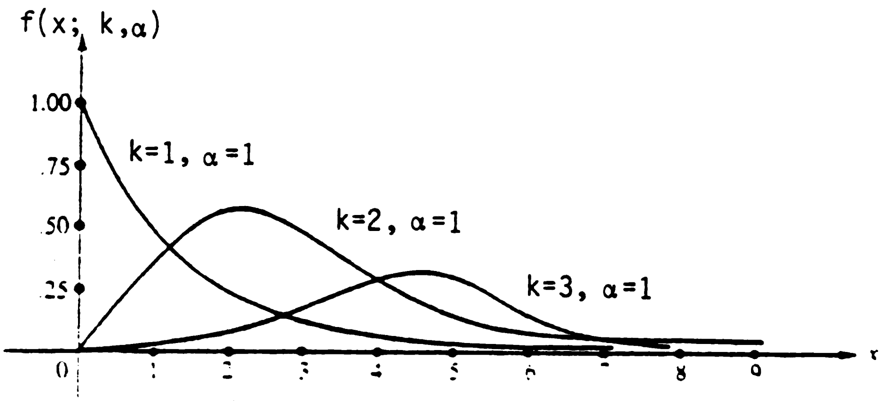


FIGURE 10

THE GAMMA DISTRIBUTION

The computer function for generating deviates from a gamma distribution developed by Pritsker and Kiviat (1969, p. 99) was employed in the model. Actually, because the cumulative distribution function for a gamma distribution cannot be formulated explicitly (Naylor et al., 1973, p. 88), the k parameter is limited only to integer values and an Erlang distribution results. The equation for the Erlang distribution used by Pritsker and Kiviat is:

$$f_X(x) = \frac{1}{(k-1)!}\mu(\mu x)^{k-1}\ \exp(-\mu x) \qquad x>0$$

$$= 0 \qquad \text{otherwise}$$

The function itself, called ERLNG, with its FORTRAN source code, is contained in Appendix B. It employs the inverse-transformation method to calculate the random deviates and the CDC Minnesota FORTRAN pseudorandom number generator function RANF.

The PARAM Array. The ERLNG function of Pritsker and Kiviat requires the establishment of a two-dimensional array PARAM which defines parameter values for each probability distribution to be generated. For the MASSMOD simulation, this required 128 rows of information to accomodate eight different media buying behaviors (newspapers, magazines, network radio, spot radio, local radio, network television, spot television, local television) for 16 different years. For each medium for each year, a row contained the mean of the distribution, i.e., the average media buy per advertiser among the top 100 advertisers, divided by k; the minimum value of the distribution; the maximum value of the distribution; and the desired value of k.

The need to examine advertising expenditures at three different levels for broadcasters was suggested by Stuart (1976) who found that television's effect on radio was most profound at the network sales level, since network radio was the principal medium for which advertisers substituted television. Spot and local sales continued to rise, but at growth rates lower than pre-television rates. (Stuart, 1976, p. 136) Newspaper advertising was considered at the local level only, since 85 percent of newspaper advertising is local or regional. (Udell, 1978, p. 28) The Federal Communications Commission's policy of localism, manifested both in its assignment of UHF frequencies for television stations (Noll, Peck & McGowan, 1973, p. 103) and its limitation on the power of FM radio stations (FCC Docket #6051, 1945) suggests that these media would be used to a greater degree for local advertising than for national spot or network advertising.

Minimum and maximum values, as well as the mean of the distribution, were obtained from appropriate annual Advertising Age top 100 listings. Estimates for the value of k for each medium were made by examining output from the runs of the function using various k values, and comparing them to actual historical data. Values of k used in the model for each medium are given in Table 8.

Means for each distribution for each medium were estimated with regression equations using appropriate variables from the print, broadcast and consumer sectors of the model.

Average advertising expenditures on newspapers at time t (AVNEW) are a function of newspaper circulation and the number of newspapers in the previous year (t-1):

$$\begin{aligned} AVNEW = 24.285 &+ 0.0026*NEWSCIR(t-1) \\ &- 0.067*NEWSNO(t-1) \end{aligned}$$

Average expenditures on magazines (AVMAG) also depend on circulation and number of publications but are responsive to the number of households with VHF television receivers during the previous year. This is not unexpected since general circulation magazines competed with television for the mass audience advertising dollar:

$$\begin{aligned} AVMAG = 9.194 &+ 0.000018*MAGCIRC(t-1) \\ &+ 0.000070*VHFHH(t-1) \\ &- 0.011*MAGNO(t-1) \end{aligned}$$

Advertising behavior for radio buys is broken down by the industry

TABLE 8

PARAMETERS AND VARIABLES USED TO CALCULATE AVERAGE ADVERTISER EXPENDITURE BY MEDIA

Media Buy	Variables	k
AVNEW	NEWSCIR(t-1), NEWSNO(t-1)	9
AVMAG	MAGCIRC(t-1), VHFHH(t-1), MAGNO(t-1)	3
AVNRD	AMHH(t-1), VHFHH(t-1)	2
AVSRD	AMHH(t-1), VHFHH(t-1), RNYR**2	5
AVLRD	SQRT(RADNO(t-1))	5
AVNTV	VHFHH(t-1), RNYR**2	3
AVSTV	VHFHH(t-1), RNYR**2	6
AVLTV	TVNO(t-1), RNYR**2	6

into network buys (which decreased in size as television took over as the mass advertising medium), spot buys (made by national and regional advertisers on a station by station basis) and local buys (made by local advertisers and merchants).

Average network radio advertising expenditures (AVNRD) at time t are determined by the number of households with AM radio receivers at t-1 and also by the number of households with VHF television receivers:

```
AVNRD=5.39 - 0.000043*AMHH(t-1)
           - 0.000068*VHFHH(t-1)
```

Average spot radio expenditures (AVSRD) also are determined by the number of AM and VHF households during the previous year. In addition, the square of the growth variable RNYR appears in the significant equation:

```
AVSRD=2.45 - 0.0000077*AMHH(t-1)
           - 0.0000035*VHFHH(t-1)
           + 0.012* (RNYR**2)
```

Average local radio expenditures (AVLRD) at t are a function only of the total number of radio stations, both AM and FM (RADNO), at t-1:

```
AVLRD=2.881 + 0.046*SQRT(RADNO(t-1))
```

Average expenditures for television advertising are similar to those of radio, both in their categories and their computations. Network (AVNTV) and spot (AVSTV) purchases in year t are functions of the number of VHF households during the previous year and the square of the growth variable RNYR. When UHF households was added as an additional variable in the equations, the regression was not significant.

```
AVNTV=2.95 + 0.0044*VHFHH(t-1) - 0.044*(RNYR**2)

AVSTV=1.20 + 0.00011*VHFHH(t-1) + 0.0095*(RNYR**2)
```

Average local television advertising expenditures (AVLTV) are determined by the total number of television stations, VHF and UHF, (TVNO) at t-1 and the squared growth variable:

AVLTV=1.56 + 0.009*TVNO(t-1) - 0.0080*(RNYR**2)

Calculation of Advertising Expenditures. Once values are stored in the PARAM array, the actual calculation of advertising expenditures can occur. Since all assumptions in this sector are based on the behavior of the top 100 advertisers, the total expenditures per medium for each year are computed by summing the results of a call to the ERLNG function 100 times. The total available budget for advertising expenditures on newspaper, magazine, radio and television space and time is computed as a function of retail profits (RETPROF) during the previous year and the year index RNYR:

BUDGET=4474.8948 - 0.0013*RETPROF(t-1)
+ 413.43*RNYR

Expenditures are checked after each call to ERLNG, and if the expenditures exceed the budget, the buying process stops before 100. Once the total buys are calculated, network, spot, and local categories are combined for radio and television to produce a dollar total for all advertising, regardless of type, on the particular medium:

RADTOT=TNRDBUY + TSRDBUY + TLRDBUY

TVTOT=TNTVBUY + TSTVBUY + TLTVBUY

Since no industry figures exist which split the advertising revenues between AM and FM radio stations or VHF and UHF television stations, two assumptions were made. AM radio was assigned 80 percent of all radio advertising expenditures; FM radio was assigned 20 percent. All television advertising expenditures were assigned to VHF television until 1952; after 1952, 75 percent of all buys were attributed to VHF and 25 percent to UHF. Since determining this division of expenditures was not a main purpose of the model, these constant assumptions were used across all years of the model. Obviously, a more responsive non-linear function could be determined and included in future models to make this estimation more precise.

The Consumer Sector

This sector generates the percentage of U.S. households having AM (AMHHPC) and FM (FMHHPC) radio receivers and VHF (VHFHHPC) and UHF (UHFHHPC) television receivers for year t, as well as the percentage of the adult population subscribing to newspapers (NEWSPC) and magazines (MAGPC). Percentages are converted to households and persons using calculations of the number of U.S. households (POPHH) and the total population (POP) for each year and output to the media subsectors and the advertising sector. Annual birth (BIRTHR) and death (DEATHR) rates and the average annual household size (HHSIZE) are exogenous variables to the subsystem. Audience percentage calculations are based on information input to the sector by the media subsectors, such as number of magazines, newspaper cost or number of AM radio stations, or on the exogenous variables disposable income (DISINC) or number of AM sets available (AMSETS). No policy variables operate in the sector. A block diagram of the subsystem is given in Figure 11. Table 9 presents a glossary of variables used in the sector.

Population data was obtained from Historical Statistics, which provided annual estimates of the population, annual estimates by age (adult was defined as 18 and over), households by number of persons, and the number of births and deaths per thousand population. (Both birth rates and death rates for a given year were based on the population in that same year; data were modified to use the previous year's population as a base for each of calculations in the model.) Newspaper circulations

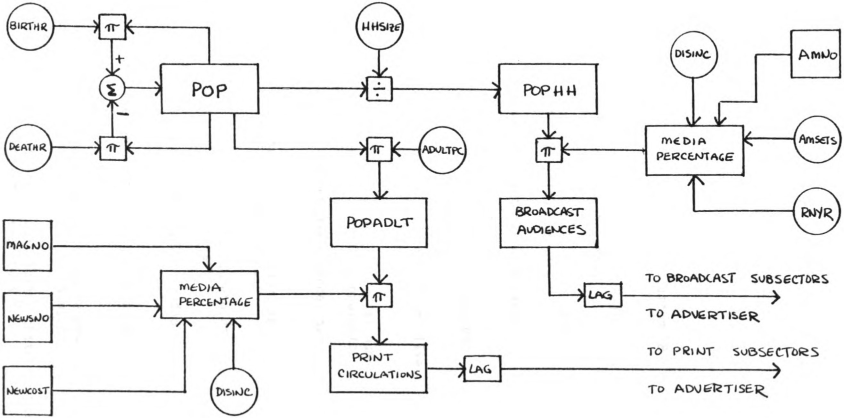


FIGURE 11

BLOCK DIAGRAM--CONSUMER SECTOR

TABLE 9

GLOSSARY
CONSUMER SECTOR

Variable	Description	Source
ADULTPC	Percentage of U.S. population 18 years and older	calculated
AMHH	U.S. households with AM radio receivers; in thousands	Sterling & Haight, p. 367
AMHHPC	Percent of all U.S. households with AM radio receivers	Sterling & Haight, p. 367
AMNO	Number of commercial AM radio stations	Sterling & Haight, p. 43
AMSETS	Number of AM receivers produced annually; in thousands	*Electrical Merchandising*
BIRTHR	Annual U.S. birth rate; total live births per 1000 population	*Historical Statistics* B5-10
DEATHR	Annual U.S. death rate; total number of deaths per 1000 population	*Historical Statistics* B167-180
DISINC	Disposable personal income, per capita	Sterling & Haight, p. 114
FMHH	U.S. households with FM radio receivers; in thousands	
FMHHPC	Percent of all U.S. households with FM radio receivers	calculated
FMNO	Number of commercial FM radio stations	Sterling & Haight, p. 205
HHSIZE	Average size of U.S. households	*Statistical Abstracts* No. 35
MAGCIRC	Magazine circulation for general and farm magazines; in thousands	Sterling & Haight, pp. 342-343
NEWCOST	Annual average subscription costs per person for newspapers	calculated

TABLE 9 (cont'd)

NEWSNO	Number of daily newspapers, morning and evening	Sterling & Haight, p. 20
NEWSPC	Percent of adult population purchasing daily newspapers	calculated
POP	Annual population of the U.S.; in thousands	Historical Statistics A23-28
POPADLT	Population of persons 18 years and older in U.S.; in thousands	Historical Statistics A29-42
POPHH	Number of households in U.S.; in thousands	Historical Statistics A335-349
UHFHH	Number of households in U.S. with UHF receivers; in thousands	Sterling & Haight, p. 372
UHFHHPC	Percent of U.S. households with UHF receivers	Sterling & Haight, p. 372
UHFNO	Number of commercial UHF television stations	Sterling & Haight, p. 49
VHFHH	Number of U.S. households with VHF television receivers; in thousands	Sterling & Haight, p. 372
VHFHHPC	Percent of U.S. households with VHF receivers	Sterling & Haight, p. 372
VHFNO	Number of commercial VHF television stations	Sterling & Haight, p. 49

are those listed in Historical Statistics for all daily newspapers (Sterling & Haight, 1978, p. 333); magazine circulation figures are those for the total number of copies sold of general and farm magazines, reported by the Magazine Publishers Association (Sterling & Haight, 1978, p. 342). Percentages for both magazines and newspapers were calculated as the number of single copies purchased per 100 adults.

The number of households with AM radio receivers are drawn from U.S. Bureau of the Census figures, reissued by the Radio Advertising Bureau (Sterling & Haight, 1978, p. 368). No such figures were available from similar sources for FM receiver households. Scattered in-house publications from the National Association of Broadcasters library provided FM figures for 1948, 1952, 1954, and 1959. Percentage figures for VHF receivers are those of NBC Corporate Planning as reprinted annually in Television Factbook (Sterling & Haight, 1978, p. 372). UHF percentage figures are those reported by the Advertising Research Foundation (Sterling & Haight, 1978, p. 372).

Disposable personal income statistics are based on Bureau of Economic Analysis calculations appearing in Historical Statistics. Disposable income is personal income that remains after all tax and other obligatory payments to government (Sterling & Haight, 1978, p. 114). Number of AM sets produced annually is data drawn from annual tables in Electrical Merchandising.

Population calculations for the sector are as follows, with all figures in thousands of persons or households. Total U.S. population for each year is the population of the previous year minus the deaths in that year, plus the live births in that year:

```
POP(t)=POP(t-1) + (BIRTHR (t)*POP(t-1)
                - DEATHR(t)*POP(t-1))/1000.
```

Birth and death rates are given as number of births or deaths per thousand persons. Since population figures in the model are already in thousands, a simple multiplication produces numbers of persons born and dead. These numbers must then be divided by 1000 to maintain the reporting base.

The number of U.S. households for any year is calculated by dividing the total population by the average household size for that year:

POPHH(t)=POP(t)/HHSIZE(t)

To derive the number of adults in the population from the total population, without employing a sophisticated time delay function with population maturation rates for various age groups, which was judged too sophisticated and computer-time and space consuming for this model, adult population percentage data was regressed with the year of reporting (1945 equals 0; 1960 equals 16) to yield the following relationship:

ADULTPC(t)=0.709 - 0.0045*RNYR

This percentage was then used to compute the number of adults:

POPADLT(t)=ADULTPC(t)*POP(t)

Household percentages for the various broadcast media are based on the following equations:

AMHHPC(t)=1.039 - 0.000013*AMNO(t)
- 0.0000086*AMSETS(t)

Hence, the percentage of households with AM radio receivers is determined by the number of AM stations in operation and the number of AM receivers produced during that year. Number of households with AM receivers is a simple calculation:

AMHH(t)=AMHHPC(t)*POPHH(t)

Percentage of households with FM receivers was a more difficult relationship to express, since so little data about FM households were available. The best regression equation used disposable income and the natural log of the year index RNYR as predictor variables:

$$\text{FMHHPC}(t)=0.043 + 0.093*\ln(\text{RNYR}) - 0.000018*\text{DISINC}(t)$$

Number of households with FM receivers was reached as:

$$\text{FMHH}(t)=\text{FMHHPC}(t)*\text{POP}(t)$$

Percentage of households with VHF receivers was best predicted by disposable income and the cube and square of the growth index RNYR. Other variables, such as number of VHF stations, number of television receivers produced and cost of receivers were entered in the equation, but were not significant or produced a singular matrix, from which no unique solution could be derived.

$$\text{VHFFHPC}(t)= -1.058 - 0.004*(\text{RNYR}**3) + 0.00045*\text{DISINC}(t) + 0.0097*(\text{RNYR}**2)$$

Number of VHF households follows:

$$\text{VHFHH}(t)=\text{VHFHHPC}(t)*\text{POP}(t)$$

UHF household percentages begin to be calculated in 1954. The growth curve for UHF receivers could not be fit by one regression equation. A growth factor, based on the UHF year index, is added to the UHFHHPC equation from 1957 onward:

$$\text{GROWTH}= -0.039 - 0.0014*\text{UNYR} + 0.00144*(\text{UNYR}**2)$$

The complete equation for UHF television household percentages is:

$$\text{UHFHHPC}(t)=0.0081 + 0.042*\ln(\text{UNYR}) - \text{GROWTH}$$

UHF households:

$$\text{UHFHH}(t)=\text{UHFHHPC}(t)*\text{POP}(t)$$

The percentages of newspapers and magazines sold when compared to the total U.S. population are based on disposable income, number of publications, and in the case of newspapers, cost.

$$NEWSPC(t)=0.463 + 0.000050*NEWSNO(t) - 0.0033*NEWCOST(t) + 0.000018*DISINC(t)$$

Circulation for daily and Sunday newspapers is calculated as follows:

$$NEWSCIR(t)=NEWSPC(t)*POPADLT(t)$$

Magazine percentages were derived from this equation:

$$MAGPC(t)= -0.536 + 0.0058*MAGNO(t) + 0.00022*DISINC(t)$$

The circulation for magazines follows:

$$MAGCIRC(t)=MAGPC(t)*POPADLT(t)$$

Calculations in the sector are based on historical data in all cases and hence are deterministic. Initially, a stochastic sector dealing with the allocation of consumers' discretionary time on media and the media expenses of consumers was envisioned. Robinson and Converse (1972, p. 198) found that areas of greater television set ownership showed greater amounts of primary activity time devoted to television, and greater amounts of secondary viewing as well. However, they suggest no quantitative relationships, nor the interrelationships among other media and their time allocation. Block (1975) developed a stochastic computer simulation called TIMMOD which allocated discretionary time among a variety of activities, including media use. Two key problems kept a consumer time allocation subsystem from inclusion in the model. First, the highly aggregate level of the model deals with the total U. S. population as if it were one entity and does not allow for a categorization of media users into heavy or light, in the manner of TGI, or high and low, reader/non-reader. To accomplish this type of approach, habits of a hypothetical population would have to be created, in a manner similar to that of Gensch (1973) or Block (1975). This would add greatly to the complexity of the model.

However, even if such a simulation like TIMMOD were added to MASSMOD, the other key problem still remains: the conversion of amount of minutes allocated to media to number of persons and number of households for advertiser and media financial calculations. The complexity of this conversion is created in part by the aggregation level. Perhaps in future models which are run at a more microscopic level, such considerations can be taken into account. The decision was made to use a completely deterministic calculation of population media behavior in the initial version of MASSMOD.

Validation of the Benchmark Model

As mentioned previously in this chapter, the final step in creating a simulation model is the validation. Since this was a model created from historical data to describe a specific time period, postdictive validation procedures were used. A goodness of fit test, Theil's U (discussed earlier in this chapter in the Methodology and Data Collection section), was used to determine how well the data generated by the equations and relationships contained in the model corresponded to actual historical data. A Theil's U value of 0 indicates perfect agreement between predicted and actual data; a value of 1 indicates the results are no better than chance. A cut-off value of 0.2, suggested by Theil as adequate for predictive ability, was used to evaluate the results.

The creation and validation of a simulation model is a cyclical process. Regression equations are derived from historical data to predict values for both the time period under study and future periods for each subsystem. Variables are selected as predictor variables for the endogenous variables under consideration and regressed. The overall correlation coefficient (R-square) and the F-ratio for the equation are examined for significance, as are the individual coefficients. When the results are not acceptable, variables are removed, added, or presented in another non-linear form until a satisfactory equation is developed. The values generated for endogenous variables by those equations is then compared to the historical data and subjected to a goodness of fit test. If the results are not acceptable, a new regression equation is sought which meets the tolerance level of the validation test. Once each subsystem has been validated individually, they are combined into one model, and all data generated by each subsystem are passed as input and output to the various sectors. Again, the values generated by the model for various variables under study are matched with their historical actualities to determine validity. If a variable fails to validate, further modifications are made on the prediction equations, and the validation procedure begins again.

Hence, the results presented in this section are the products of a fair amount of trial and error and refinement, seeking equations and parameters which not only satisfy explicit and intuitive theory, but also the quantitative rigor of the goodness of fit test. The MASSMOD benchmark model validates on all endogenous variables, and is thus assumed to be a valid description of the mass media industry from 1945-1960. It is this benchmark model that was manipulated in experimental runs described in Chapter 4.

Tables 10 through 17 display the validation data for key variables on a subsector by subsector basis. Table 10 contains results for the newspaper subsector. The model's prediction of number of newspapers compared to the historical data yields a U of 0.006; annual newspaper

TABLE 10

BENCHMARK VALIDATION DATA
NEWSPAPER SUBSECTOR

Year	NEWSNO Predicted	NEWSNO Actual	NEWCOST Predicted	NEWCOST Actual	NEWSREV Predicted	NEWSREV Actual
1945	1851	1850	30.120	33.650	3397.965	0000.000
1946	1869	1872	29.300	29.560	4020.792	0000.000
1947	1876	1873	29.120	27.390	4305.649	3650.300
1948	1873	1887	29.040	26.250	4413.495	0000.000
1949	1871	1894	28.920	27.240	4577.898	4243.900
1950	1861	1890	28.840	27.320	4753.505	4362.500
1951	1850	1873	28.710	25.640	4836.569	4362.800
1952	1846	1887	28.610	28.990	5023.204	4607.600
1953	1843	1875	28.510	29.470	5157.520	4809.200
1954	1846	1860	28.400	30.220	5408.691	4902.000
1955	1839	1841	28.300	29.310	5879.381	5262.600
1956	1841	1824	28.170	27.220	5814.554	5399.700
1957	1836	1824	28.050	26.660	5945.294	5239.800
1958	1838	1855	27.960	27.910	5983.992	5239.800
1959	1829	1854	27.880	29.200	6104.894	5581.200
1960	1824	1850	27.790	28.890	6227.250	5706.300
THEIL'S U	.00561643		.03065998		.05000903	

TABLE 10 (cont'd)

	NPUBCST	
Year	Predicted	Actual
1945	505.328	0000.000
1946	883.478	0000.000
1947	1065.180	1041.941
1948	1206.288	0000.000
1949	1337.119	1379.348
1950	1464.939	1360.933
1951	1476.620	1383.613
1952	1480.497	1459.109
1953	1526.381	1550.049
1954	1532.348	1585.955
1955	1665.567	1682.110
1956	1707.865	1747.900
1957	1702.168	1706.674
1958	1632.064	1680.476
1959	1779.779	1736.796
1960	1839.435	1764.999
THEIL'S U	.01714346	

subscription costs a U of 0.03; newspaper revenue 0.05 and newspaper publication costs 0.02.

In the magazine subsector (Table 11), comparisons of model predictions with actual time-series data for number of magazines produce a U of 0.02; for annual subscription costs 0.01; and for magazine revenue and publishing costs, 0.02 and 0.02, respectively.

Broadcast subsector validations are presented in Tables 12-15. AM radio data (Table 12) yields a U of 0.03 for number of AM radio stations; a U of 0.02 for revenue, 0.02 for expenses and 0.13 for earnings. FM model data (Table 13) produces the following values of U: for number of FM stations, 0.11; for FM station revenue, 0.12; for FM expenses, 0.06; and for earnings 0.14. In the VHF television subsystem (Table 14), Theil's U calculations generated a 0.06 for number of stations, 0.11 for revenue, 0.11 for expenses and 0.13 for earnings. Table 15 contains data for the UHF sybsystem, which began predicting values for variables in 1953. Number of UHF stations validates with a U of 0.01; revenue, 0.09; expenses 0.02; and earnings 0.13.

Table 16 contains data for total buys by the top 100 advertisers by medium as generated by the stochastic advertiser sector and as reported by Advertising Age. Total advertising buys for newspapers predicted by the model produced a U of 0.08 when compared to actual data. For magazine buys, U was 0.04. For the broadcast media, AM buys yielded a U of 0.03; FM buys 0.03; VHF buys 0.12; and UHF buys 0.09.

Consumer sector data is presented in Table 17 for both population data and various media audiences. The Theil's U for total population figures is 0.01; for household populations, 0.005; and for the adult population, 0.01. For newspaper circulation, U is 0.01, while for magazines it is 0.02. Number of households with AM radio receivers produced

TABLE 11

BENCHMARK VALIDATION DATA
MAGAZINE SUBSECTOR

	MAGNO		MAGCOST		MAGREV	
Year	Predicted	Actual	Predicted	Actual	Predicted	Actual
1945	257	219	7.040	0.000	2049.264	1993.330
1946	245	239	7.010	0.000	2171.239	0000.000
1947	242	243	6.980	7.370	2203.864	2076.370
1948	244	239	7.000	6.820	2097.175	0000.000
1949	246	246	7.020	6.880	2194.692	0000.000
1950	251	250	7.080	7.290	2134.995	2269.220
1951	258	247	7.160	6.960	2270.762	0000.000
1952	259	252	7.210	7.100	2280.588	0000.000
1953	262	258	7.250	7.200	2476.546	0000.000
1954	259	259	7.260	7.270	2412.484	2367.000
1955	265	272	7.310	7.280	2449.762	0000.000
1956	267	282	7.350	7.250	2506.024	0000.000
1957	268	278	7.380	7.230	2545.677	0000.000
1958	267	270	7.390	7.450	2484.595	2483.480
1959	274	274	7.450	7.600	2658.795	2555.360
1960	274	273	7.490	7.740	2616.806	2627.240
THEIL'S U	.02209353		.01202328		.01793420	

TABLE 11 (cont'd)

Year	MPUBCST Predicted	MPUBCST Actual
1945	1425.599	1164.450
1946	1399.235	0000.000
1947	1371.175	1337.470
1948	1386.470	1383.590
1949	1403.376	1429.710
1950	1464.510	1475.830
1951	1542.619	1521.940
1952	1590.098	1568.060
1953	1629.308	1614.180
1954	1632.975	1660.300
1955	1683.479	1694.660
1956	1726.612	1729.020
1957	1755.044	1763.370
1958	1760.235	1797.760
1959	1816.074	1844.050
1960	1859.691	1890.370

THEIL'S U .02205017

TABLE 12

BENCHMARK VALIDATION DATA
AM RADIO SUBSECTOR

	AMNO		AMREV		AMEXP	
Year	Predicted	Actual	Predicted	Actual	Predicted	Actual
1945	920	919	758.851	796.000	585.984	573.700
1946	1190	948	713.775	734.900	599.838	560.600
1947	1485	1062	774.258	750.900	621.055	594.500
1948	1603	1621	811.320	766.500	629.651	645.800
1949	1782	1921	791.376	786.700	642.637	679.700
1950	1891	2086	825.571	829.300	650.518	702.100
1951	1946	2232	782.713	786.000	654.565	685.700
1952	2132	2331	815.526	809.800	668.018	706.200
1953	2256	2391	772.856	807.000	676.984	713.600
1954	2540	2521	756.172	687.600	697.520	682.900
1955	2657	2669	764.357	743.300	706.023	667.900
1956	2827	2824	763.660	764.100	718.332	685.900
1957	3014	3008	744.502	796.800	731.863	712.800
1958	3260	3196	746.842	792.600	749.683	736.100
1959	3359	3326	806.093	829.600	756.830	766.800
1960	3476	3456	820.957	870.000	765.292	803.200
THEIL'S U	.03450364		.02177253		.02261227	

TABLE 12 (cont'd)

	AMEARN	
Year	Predicted	Actual
1945	143.764	222.300
1946	114.888	174.300
1947	134.128	144.500
1948	148.077	120.700
1949	131.941	107.000
1950	144.835	127.200
1951	121.852	100.300
1952	131.338	103.600
1953	106.036	93.400
1954	87.799	70.000
1955	87.643	75.400
1956	81.270	78.200
1957	65.252	84.000
1958	57.667	56.500
1959	83.198	62.800
1960	86.335	66.800

THEIL'S U .13347551

TABLE 13

BENCHMARK VALIDATION DATA
FM RADIO SUBSECTOR

	FMNO		FMREV		FMEXP	
Year	Predicted	Actual	Predicted	Actual	Predicted	Actual
1945	61	46	1.599	0.000	11.425	0.000
1946	169	48	0.307	0.000	11.162	0.000
1947	511	140	1.976	0.000	10.448	0.000
1948	625	458	2.970	2.100	9.397	7.900
1949	746	700	2.355	3.000	8.124	9.700
1950	724	733	3.287	2.600	6.742	7.500
1951	566	676	2.070	2.100	5.366	5.200
1952	599	637	3.036	1.900	4.108	3.600
1953	501	580	1.926	1.400	3.084	2.700
1954	624	560	1.621	1.300	2.406	2.300
1955	536	552	2.106	1.600	2.190	2.300
1956	523	540	2.438	2.200	2.548	2.900
1957	547	530	2.361	3.100	3.595	3.800
1958	686	537	3.019	3.800	5.446	4.800
1959	657	578	5.427	6.400	8.212	8.700
1960	673	688	6.733	8.400	12.010	11.900
THEIL'S U	.10841261		.11550053		.05574877	

TABLE 13 (cont'd)

Year	FMEARN Predicted	Actual
1945	-9.825	0.000
1946	-10.855	0.000
1947	-8.472	0.000
1948	-6.427	-5.800
1949	-5.769	-6.700
1950	-3.455	-4.900
1951	-3.296	-3.100
1952	-1.072	-1.700
1953	-1.158	-1.300
1954	-0.785	-1.000
1955	-0.084	-0.700
1956	-0.110	-0.700
1957	-1.234	-0.700
1958	-2.427	-1.000
1959	-2.786	-2.300
1960	-5.277	-3.500
THEIL'S U	.13515436	

TABLE 14

BENCHMARK VALIDATION DATA
VHF TELEVISION SUBSECTOR

	VHFNO		VHFREV		VHFEXP	
Year	Predicted	Actual	Predicted	Actual	Predicted	Actual
1945	0	8	0.000	0.000	0.000	0.000
1946	15	6	0.000	0.000	0.000	0.000
1947	11	12	0.000	0.000	0.000	0.000
1948	32	16	117.958	16.400	110.798	44.400
1949	53	51	259.916	65.200	247.503	113.300
1950	91	98	308.075	197.600	287.853	214.700
1951	128	107	459.268	411.300	413.189	338.700
1952	160	108	399.084	559.000	331.820	463.300
1953	203	120	446.009	323.600	357.727	228.000
1954	235	233	537.405	437.000	423.913	330.200
1955	281	297	643.435	561.000	513.121	418.900
1956	321	344	768.453	671.100	605.589	502.400
1957	356	381	889.110	690.200	698.993	547.400
1958	396	411	906.989	738.200	696.509	591.100
1959	446	433	894.214	829.300	670.589	629.500
1960	484	440	984.676	869.100	733.714	652.800
THEIL'S U	.05883884		.10688429		.10954187	

TABLE 14 (cont'd)

Year	VHFEARN Predicted	VHFEARN Actual
1945	0.000	00.000
1946	0.000	00.000
1947	0.000	00.000
1948	7.160	-28.000
1949	12.412	-48.100
1950	20.222	-17.100
1951	46.079	72.600
1952	67.262	95.700
1953	88.282	95.600
1954	113.492	106.800
1955	130.313	142.100
1956	162.864	168.700
1957	190.117	142.800
1958	210.480	147.100
1959	223.625	199.800
1960	150.962	216.300

THEIL'S U .12958355

TABLE 15

BENCHMARK VALIDATION DATA
UHF TELEVISION SECTOR

	UHFNO		UHFREV		UHFEXP	
Year	Predicted	Actual	Predicted	Actual	Predicted	Actual
1953	6	6	28.901	17.700	28.220	28.400
1954	121	121	59.069	42.500	57.691	59.300
1955	114	114	55.559	46.700	55.503	54.100
1956	98	97	49.183	51.700	49.823	54.700
1957	88	90	44.761	41.100	46.476	46.500
1958	82	84	42.786	39.500	43.057	42.900
1959	79	77	42.091	41.500	42.339	42.200
1960	76	75	40.065	44.800	41.890	44.400
THEIL'S U	.00740802		.09273828		.02219440	

	UHFEARN	
Year	Predicted	Actual
1953	-10.602	-10.700
1954	-18.235	-16.800
1955	-5.726	-7.400
1956	-2.501	-3.000
1957	-2.081	-5.400
1958	-3.919	-3.400
1959	-4.034	-0.700
1960	-2.351	0.400
THEIL'S U	.13069146	

TABLE 16

BENCHMARK VALIDATION DATA
ADVERTISER SECTOR

	TNEWBUY		TMAGBUY		AMBUY	
Year	Predicted	Actual	Predicted	Actual	Predicted	Actual
1945	2014.	2444.	867.	915.	843.0	900.0
1946	2573.	2631.	879.	923.	782.0	829.6
1947	2842.	2960.	975.	934.	859.0	813.6
1948	2944.	3286.	813.	898.	904.0	846.4
1949	3097.	3631.	949.	871.	871.0	868.8
1950	3265.	3862.	826.	892.	908.0	903.2
1951	3337.	3928.	998.	934.	841.0	846.4
1952	3514.	4248.	964.	991.	873.0	860.0
1953	3639.	4469.	1276.	1065.	803.0	829.6
1954	3879.	4497.	1130.	1054.	766.0	748.8
1955	4340.	5044.	1195.	1133.	759.0	715.2
1956	4262.	5124.	1225.	1205.	739.0	720.8
1957	4380.	5028.	1258.	1195.	693.0	760.8
1958	4409.	4812.	1135.	1112.	674.0	752.0
1959	4521.	5224.	1420.	1233.	727.0	776.8
1960	4634.	5358.	1286.	1323.	720.0	807.2
THEIL'S U	.07553567		.04106710		.02903063	

TABLE 16 (cont'd)

Year	FMBUY Predicted	FMBUY Actual	VHFBUY Predicted	VHFBUY Actual	UHFBUY Predicted	UHFBUY Actual
1945	211.0	225.0	000.000	000.000		
1946	196.0	207.4	000.000	000.000		
1947	215.0	203.4	000.000	000.000		
1948	226.0	211.6	297.000	000.000		
1949	217.0	217.2	593.000	110.000		
1950	226.0	225.8	693.000	316.600		
1951	210.0	211.6	1008.000	579.000		
1952	218.0	215.0	883.000	586.500	294.00	195.50
1953	201.0	207.4	980.000	771.000	327.00	257.00
1954	191.0	187.2	1171.000	1017.000	390.00	339.00
1955	190.0	178.8	1392.000	1272.750	464.00	424.25
1956	185.0	180.2	1652.000	1460.250	551.00	486.75
1957	174.0	190.2	1904.000	1510.500	635.00	503.50
1958	169.0	188.0	1941.000	1576.500	647.00	525.50
1959	183.0	194.2	1914.000	1702.500	638.00	567.50
1960	181.0	201.8	2103.000	1776.750	701.00	592.25
THEIL'S U	.02814202		.12015303		.09039118	

TABLE 17

BENCHMARK VALIDATION DATA
CONSUMER SECTOR

Year	POP Predicted	POP Actual	HHPOP Predicted	HHPOP Actual	POPADLT Predicted	POPADLT Actual
1945	139769	139928	41108	00000	99096	98372
1946	141760	141389	39269	00000	99870	99501
1947	144145	144126	39709	00000	100901	100724
1948	146344	146631	41108	00000	101782	102066
1949	148548	149188	42442	00000	102647	103445
1950	150738	151684	43440	43468	103482	104624
1951	153068	154287	44497	44564	104393	105678
1952	155481	156954	45198	45464	105338	106683
1953	157915	159565	46039	46828	106277	107673
1954	160504	162391	46523	46893	107297	108739
1955	163067	165275	47961	47788	108276	109803
1956	165689	168221	48876	48785	109272	110956
1957	168338	171274	49657	49543	110262	112108
1958	170906	174141	49682	50432	111174	113139
1959	173442	177073	51774	51302	112043	114356
1960	175915	177830	53470	52610	112849	114780
THEIL'S U	.00604577		.00487422		.00660434	

TABLE 17 (cont'd)

	NEWSCIR		MAGCIRC		AMHH	
Year	Predicted	Actual	Predicted	Actual	Predicted	Actual
1945	49427	48384	144771	121240	37263	33100
1946	50246	50928	139579	130898	35304	33998
1947	50613	51673	136201	135567	36927	35900
1948	51202	52285	140458	140999	38462	37623
1949	51607	52846	142008	143713	40956	39300
1950	52242	53829	149051	147260	41030	40700
1951	52730	54018	155124	151504	42840	41900
1952	53265	53951	157917	159369	44161	42800
1953	53867	54472	162631	163035	44769	44800
1954	54414	55072	161425	164967	45606	45100
1955	55101	56147	169535	179965	46810	45900
1956	55789	57102	173637	185731	47552	46800
1957	56320	57805	175950	181410	47938	47600
1958	56805	57418	176583	183325	47378	48500
1959	57346	58300	183813	185589	48862	49450
1960	57788	58882	185402	190432	49876	50193
THEIL'S U	.00987801		.02481235		.01574088	

TABLE 17 (cont'd)

	FMHH		VHFHH		UHFHH	
Year	Predicted	Actual	Predicted	Actual	Predicted	Actual
1945	411	000	8	0		
1946	393	000	8	8		
1947	2693	000	318	14		
1948	4281	771	1811	172		
1949	5583	000	345	940		
1950	6511	000	8868	3875		
1951	7407	000	12653	10320		
1952	8150	8500	16784	15300		
1953	8826	0000	21864	20400		
1954	9441	9760	25413	26000	377	0000
1955	10117	0000	31997	30700	1785	0000
1956	10684	0000	37566	34900	2651	0000
1957	11252	0000	41471	38900	4392	3579
1958	11640	0000	43906	41925	4287	3396
1959	12431	12000	49384	43950	4119	3516
1960	13170	00000	52836	45750	3676	3203
THEIL'S U	.09969080		.05367532		.09458828	

a U of 0.02; for households with FM receivers, 0.10. Households with VHF receivers had a U of 0.05, while those with UHF receivers yielded a U of 0.09.

CHAPTER 4

THE EXPERIMENTS

One of the major benefits of constructing a simulation model of a real-life system is the ability to alter conditions within the model in order to evaluate various alternative policy options or different courses of action. As previously stated, this opportunity to experiment with the system is useful both in theory-building, to evaluate various hypotheses about the system and to provide more observation points, and in decision-making, to offer probable outcomes of several alternative policy parameters. This chapter describes eight experimental manipulations performed with MASSMOD, which sought to explore the results of different operating parameters on the mass media industry. The experiments were groups around two policy issues: external controls on advertising expenditures and allocation of radio spectrum space for different types of broadcasting. Other potential experiments are discussed in suggestions for further research in Chapter 5.

The endogenous variables generated in each of the four subsystems in MASSMOD were viewed as structure and performance criterion variables and were monitored in each experiment to study the effect of the policy manipulation on the simulated mass media industry. These variables included number of boradcast stations and number of publications; audience size and circulation; revenues, expenses and earnings for each medium; advertising expenditures and retail profits. The following discussion of the experimental runs includes a rationale for each experiment and an analysis of output from the experimental run compared to the benchmark model output using Theil's goodness of fit test.

Controls on Advertising Expenditures

Rationale

Proponents of external controls on advertising expenditures fall into two main groups: those who argue that unlimited advertising can reduce competition in a multi-brand, multi-firm industry (Kaldor, 1949; Bain, 1956; Comanor & Wilson, 1967; Greer, 1971), and those who maintain that too many commercial interruptions in broadcast programs destroy the programming itself. (Doan, 1975; Dominick, 1976) While the first group specifically proposes a control on the amount of money a firm is able to spend on advertising, the second group deals with a reduction in the number of commercial minutes available to advertisers seeking to buy broadcast time. Nonetheless, this reduction could result in a decrease in advertising revenues received by broadcast stations, which constitute a major share of station incomes.

In a study addressing the first concern dealing with advertising and competition, Bloom (1976) applied constraints which represented proposed controls on advertising expenditures posed by critics, in his study of advertising and competition:

(1) a five percent straight tax on current-year advertising subtracted from after-tax profits;

(2) a progressive tax on advertising of 2 percent per million computed as follows:

rate = .02 x (advertising expenditures/1,000,000)

(3) a 10 percent limit on the advertising/sales ratio, accomplished by adjusting the profit equation to subtract 100 percent of advertising spending that exceeds 10 percent of sales;

(4) a 20 percent limit on the advertising/sales ratio;

(5) a depreciation requirement, with a fast write-off of advertising outlays:

current advertising expense = .6A(t) + .15A(t-1) + .15A(t-2) + .1A(t-3)

(6) a depreciation requirement, with a slower write-off of advertising outlays:

current advertising expense = .3A(t) + .3A(t-1) + .2A(t-2) + .2A(t-3)

This study used two of Bloom's suggestions:

(1) a straight tax of 5, 10 or 20 percent on current year advertising, subtracted from after-tax profits;

(2) a 10 percent limit on the advertising/sales ratio, accomplished by adjusting the profit equation to subtract 100 percent of advertising spending that exceeded 10 percent of sales.

Results--Experiment 1

This experiment actually consisted of three runs, each with a different percentage value for the tax on advertising expenditures (TBUY). The tax was deducted from retail profits in the following manner, using 5 percent as an example. Taxes of 10 and 20 percent were imposed similarly:

RETPROF(t) = SALES(t) - TBUY(t) - (.05*TBUY(t))

Since the budget for advertising expenditures for a given year is a function of the retail profits of the previous year, it was assumed that this reduction in profits should have an effect on subsequent media buys, which in turn would affect the revenues of the media in the system. However, all criterion variables in the experimental run were identical to those in the benchmark model, except, obviously, retail profits.

Bloom's (1976) experimental runs with such a tax tended to make the advertising expenditures of all brands lower (p. 81), which eventually diminished competition in the industry. It is possible that the highly aggregate nature of MASSMOD, several levels above consideration of a brand or firm, masked this effect, since a decrease in retail profits of one million dollars brought about by the tax was still only an overall reduction of 0.3 percent. Moreover, the equation in the model which generated the annual advertising budget displayed a negative relationship between retail profits and the budget, such that a decrease in the total retail profits resulted in an increase in the advertising spending budget. Given this structural relationship in the model, the tax on advertising expenditures indirectly causes an increase in the advertising budget for the next year, rather than a disincentive as was the case in the Bloom experiments. This problem is addressed in more detail in the summary section of the advertising control experiments.

Results--Experiment 2

This experiment levied a 100 percent tax on all advertising expenditures in excess of 10 percent of sales revenues. This was accomplished using the following equation, applied when advertising expenditures (TBUY) exceeded the 10 percent limit (LIMIT):

RETPROF(t) = SALES(t) - TBUY(t) - (TBUY(t) - LIMIT))

where LIMIT = .10*SALES(t).

When expenditures did not exceed the limit, retail profits were computed as:

RETPROF(t) = SALES(t) - TBUY(t)

Table 18 presents values of Theil's U for criterion variables in the experimental run when compared to those variables in the benchmark run. In this case, a U with the value of 0 indicated perfect agreement between the runs (i.e., no change), whereas a value approaching 1 indicated a more radical change caused by the experimental manipulation. The largest U value (only .0393) is for retail profits, an expected result since it was the variable being manipulated. This small change from the benchmark supports the lack of changed output in Experiment 1 in this section, as the limit which was deducted from profits here was greater than the straight tax imposed there. Some broadcasting revenues changed slightly, reflecting a very small increase in advertising buys for each medium.

Summary

Manipulations of external advertising controls did not produce substantive changes in the criterion variables when compared to the benchmark model, eliminating a discussion of the relative merits and demerits of each policy alternative. The manipulations did, however, highlight two structural relationships in the model. The first is the inverse relation between retail profits and advertising budgets, which means that a decrease in profits actually produced an increase in the budget for advertising expenditures. Secondly, the components of the model are insensitive to changes introduced in the advertising sector.

TABLE 18

ADVERTISING EXPERIMENT TWO
THEIL'S U

Variable	Theil's U
NEWSNO	.0002
NEWSCIR	.00002
NEWCOST	0
NEWSREV	0
NEWEARN	.0038
NPUBCST	0
MAGNO	0
MAGCOST	0
MAGCIRC	.0001
MAGREV	.0011
MPUBCST	.00004
MAGEARN	.0035
AMNO	.0007
AMHH	0
AMREV	.0038
AMEXP	.0002
AMEARN	.0123
FMNO	.0054
FMHH	0
FMREV	.0237
FMEXP	0
FMEARN	.0182
VHFNO	0
VHFHH	0
VHFREV	.0033
VHFEXP	.0042
VHFEARN	.0003
UHFNO	0
UHFHH	0
UHFREV	0
UHFEXP	.0006
UHFEARN	.0314
TBUY	.0032
TNEWBUY	.0038
TMAGBUY	.0041
AMBUY	.0048
FMBUY	.0049
VHFBUY	.0032
UHFBUY	.0031
RETPROF	.0393

While the former relationship seems intuitively correct and can be supported by actual industry behavior, the insensitivity of the model's components to changes in advertiser buying behavior seems incorrect, since advertising revenues are a major source of income for both print and broadcast media, and revenues affect the behavior of the entire media subsystems.

While the original benchmark model validates on all criterion variables using Theil's goodness-of-fit test, it is at this point in the simulation modelling process that Naylor and Finger's (1967) multi-stage verification procedure is best employed. The two-edged question faced by the researcher is whether the relationships expressed in the model are in fact correct, and the media sectors are insensitive to changes in advertiser behavior, or whether some statement of relationship and/or selection of relevant variables is not correctly stated or used. If, upon examination, all structural relationships seem to be rational and correspond with reality, then the model's results should be accepted, and interpreted accordingly. On the other hand, if some underlying assumptions or equations seem less than obvious or realistic, a reexamination of those components for possible structural misstatements and data problems is in order, before accepting the model's output as correct.

In the case at hand, a false assumption resulting in a misstatement of the relationship between profits and advertising budgets, could explain the model's insensitivity to changes in the advertising budget. What the model computes as retail profits are not retail profits at all, but the difference between retail sales and advertising expenditures. The equation fails to include production or personnel costs, as well as any other marketing costs not considered advertising. Another exogenous variable, retail production costs or retail expenses, should be included in the equation to make it accurate.

The difference between retail sales and advertising expenditures was the figure used in determining the regression equation which predicted the annual advertising budget. It is this equation which shows an inverse relationship between budget and "retail profits," (i.e., as profits decrease, the advertising budget increases.) While this relationship in itself can be easily rationalized, and in fact, is probably correct, since a drop in sales might precipitate a more vigorous advertising campaign, the parameters and coefficients do not reflect the actual mathematical relationship since an incorrect assumption, and therefore incorrect data, were used to derive the equation. If the direction of this relationship is correct, however, the placement of the tax, whether a direct tax on all expenditures as in Experiment 1, or a tax on excess expenditures as in Experiment 2, is incorrect, as the tax should serve as a deterrent to advertising expenditures, not an incentive as is the case when a decrease in profits results in an increase in budget. The advertising budget should be the first value calculated for each run of the subsector each year. Then, on the basis of that proposed budget, the tax should be imposed, so that the actual amount of advertising expenditures for the year have been reduced by taxation.

Additionally, data used to derive the relationships for this sector may have been mismatched. Retail sales figures supplied to the model as exogenous were used for all sales made at the retail level across the country. The behavior of advertisers in each buying category (newspapers, local radio, network television, etc.) was based on the transactions of the top 100 advertisers in that category, which obviously does not include all retailers. However, data describing the retail sales, production costs and other expenses which were suggested for inclusion earlier for the top 100 advertisers are not readily available and data on the behavior of all retail advertisers, whatever their size, are also not available.

Hence, the experiments conducted to investigate the effect of external advertising control policies on the model system did not yield output which could be analyzed and compared to determine the optimum policy option and its impact on the media system. Instead, the attempted experimental runs with their lack of differences in output, highlighted a structural flaw in the model itself, which might have gone undetected if the experiments had not been undertaken. This discovery highlights the role of experimentation in simulation not only for investigation of various experimental states imposed on the system, but also for the refinement and correction of the basic model specifications themselves.

Spectrum Allocation

Rationale

These experiments dealt with the impact of the FCC's determination of how various segments of the electromagnetic spectrum are used on the growth of the broadcast industry. They manipulated only the amount of the spectrum assigned to a particular medium, and assumed that the width of a channel within that assignment was fixed, according to FCC standards. In other words, the number of available channels was increased or decreased by increasing or decreasing the size of the assigned band and not by using a given band more or less efficiently in terms of channel size.

This spectrum allocation policy variable was crucial to the model in representing the regulated nature of the broadcast sector. Determining the uses to which portions of the electromagnetic spectrum may be put, as well as licensing the use of the frequencies, constitutes the essential regulatory power given to the FCC by the Communications Act of 1934. (Noll, Peck & McGowan, 1973, p. 97)

At first, AM radio stations simply applied to the FCC for a license in whatever community and on whatever channel they chose, as long as they could prove non-interference with other stations in the area. This same policy has remained in effect for AM radio, although the FCC determines at what power and during what hours stations may broadcast in a three-tiered structure of powerful, regional clear-channel stations; strong metro stations; and local stations.

The same type of allocation process was used initially for FM radio stations and VHF television stations, which chose a community and a channel on which they would provide service. Facing both a monstrous number of applications and potential interference problems, in 1945 the FCC issued an allocation plan which determined in advance where stations could be built and which was based, not on a definite demand for stations, but rather on control of interference. In addition, the FCC shifted FM radio from its 1940 assignment in the VHF band to a new location in the UHF portion of the spectrum. This policy was to have a profound effect on the development of the industries. (Webbink, 1969, p. 537)

The 1945 allocation plan moved FM radio from its assignment in the VHF band at 42-50 MHz to the UHF band at 88-108 MHz to allow for 13 VHF television channels to be used in the top 140 markets of the country. (FCC, 1945) The television assignment was criticized at the time as too meager; members of the Radio and Television Planning Board (RTPB) commissioned by the FCC from the industry had recommended 25 or 30 channels. (Sterling & Kitross, 1978, p. 233) While the assignment gave FM more channels, it also required the manufacture and consumer purchase of all-new FM transmitters and receivers to pick up the signals at the new frequencies, setting the development of FM radio back at least a decade.

Inundated by the postwar flood of applications for television licenses, the FCC issued a "freeze order" in 1948 to suspend all licensing activity until a study had been made of the channel-allocation problem. (13 Federal Reg. 5860 (1948)) Realizing that 12[1] television channels were not adequate for a nationwide system, in 1952 the Commission issued its Sixth Report and Order (FCC, 1953) which lifted the freeze and provided for the use both of the VHF channels and 70 UHF channels (470-890 MHz) set aside in 1945 for television experimentation and future broadcasting. The Order provided for the intermixture of VHF and UHF stations within the same markets, a policy which critics said would create for UHF a serious competitive disadvantage with the VHF stations. (CBS, 1956, p. 792; DuMont Laboratories, 1949, p. X-87) They suggested a policy of deintermixture, or reassignment of channels by rulemaking to make a given community either all VHF or all UHF.

The deintermixture debate, along with a debate on the concept of VHF drop-ins and a change in AM channel width from 10 to 9 kHz, continues today. A more radical proposal calls for a complete deregulation of broadcasting (Levin, 1970, p. 209; Webbink, 1969, p. 537) which would allow the economics of the market place to determine the value of

[1]Channel 1 (44-50 MHz) had been turned over to safety and special services in 1948 in return for the exclusive assignment of the remaining 12 stations to television. (Sterling & Kitross, 1978, p. 298)

broadcast licenses and earnings and the division of spectrum. (Levin, 1964, p. 153; Owen, 1975, p. 92) Hence, the manipulations of the spectrum allocation policy variable have implications not only within the historical time period of the model, but also on policy debates today.

The benchmark model assumed that an unlimited number of channels were available for broadcast stations. This was effectively the case during the period. Six manipulations were run to address questions raised by FCC actions.

(1) Earlier development of VHF television. To investigate the effect of the 1948-1952 freeze on VHF television license applications and the effect of the late introduction of UHF use for television, the model was run under the assumption that both VHF and UHF channels were available for use in 1945.

(2) Limit on number of channels available for commercial use. As stated before, the benchmark model was run assuming an unlimited number of channels were available for use by AM, FM, VHF television and UHF television. This experiment set a limit on the number of channels which was reflected in the number of licensed stations.

The 1952 Report and Order made available 2,053 frequency assignments for television in 1,291 communities; over two-thirds of the assignments were UHF channels; 252 frequencies were reserved for educational use. The previous VHF-only assignment table had made available 405 assignments in 140 metro areas. (Webbink, 1969) On the radio side, the 1945 spectrum reallocation established 100 available channels for FM, 20 of which were for educational use, which created 3,623 frequency assignments across the country. Prior to the reassignment, only 40 channels were available. AM spectrum use was never governed by a table of assignments; the 107 channels set aside for AM radio were used in 1977 by a total of 4,497 stations. (Sterling & Haight, 1978, p. 44)

This experiment placed the following limits on frequency assignments for each medium:

AM radio: 50 channels, allowing 2,100 stations;

FM radio: 40 channels, as allocated prior to 1945, permitting 1,450 stations;

VHF television: 12 channels, with 400 frequency assignments;

UHF television: 30 channels, with 600 frequency assignments.

Thus, in this experiment FM radio and VHF television retained their assignments before the 1945 reallocation and the 1952 Report and Order respectively. AM radio frequencies and UHF television assignments were cut in half.

(3) A VHF television, AM radio broadcasting system. All television stations were assumed to transmit on VHF frequencies, which were unlimited in number. All commercial radio stations used amplitude modulation. No UHF or FM sectors were included.

(4) A VHF television, FM radio broadcasting system. In this experiment, no AM radio broadcasting was included.

(5) A UHF television, AM radio broadcasting system. All television was of the UHF variety, beginning in 1945, with all radio using amplitude modulation.

(6) A UHF television, FM radio broadcasting system. As before, this experimental run operated only with UHF television and FM radio components.

Results--Experiment 1

In this experiment, the calculation of UHF variables was begun in 1945, instead of 1953, when UHF commercial television began historically. Two additional modifications were made in the model. First, the GROWTH variable was removed from the new calculation of UHF household percentages in the consumer sector:

GROWTH = -0.0394 - 0.00144*UNYR + 0.00144*(UNYR**2)

UHFHHPC(t) = 0.0081 + 0.042*ln(UNYR) - GROWTH

GROWTH was included in the original equation to adjust for the curvilinear function representing the rapid growth in the number of UHF households. Its presence under the experimental adjustments made the number of households nonexistent.

Secondly, UHF earnings, which in the benchmark model were calculated as:

UHFEARN(t) = -5.380 - 2.395*(UINCOME**2) - 6.030*INCOME

where INCOME = UHFREV(t) - UHFEXP(t)

were allowed to be the difference between revenues and expenses (in other words, equal to UINCOME above). In the equation in the benchmark model, when UINCOME was historically negative, the negative coefficient of INCOME served to make the final term of the equation positive, which increased the value of UHFEARN (i.e., made it less negative than it might otherwise have been.) However, in this experimental run, the negative coefficient caused an overall decrease in earnings when income was positive, a result which does not correspond with reality. Positive income should produce positive earnings.

Table 19 contains values of Theil's U for all model variables when values from the experimental runs were compared to the benchmark. No variables outside the UHF subsector seemed to be affected greatly by the early addition of UHF television. Media revenues were most sensitive to the entry, mainly because of a slight increase in advertiser expenditures for each medium, but the U's are small (.0127 to .1132). The additional years of UHF service resulted in an overall increase in the number of UHF stations and UHF households in 1960. Revenues and expenses were about 25 percent greater, while UHF station earnings were positive, instead of negative, but showed a downward trend. Table 20 presents UHF subsector output for the experimental run compared to the basic model.

The results of this experiment indicated that the earlier addition of UHF television into the media system had little effect on the more established media, making fears of a competing medium drawing advertising revenue from other media unfounded in this system.

Results--Experiment 2

In this experimental run, a maximum number of stations for AM, FM, UHF and VHF was established using the CHAN variable. In the radio sector

TABLE 19

FREQUENCY ALLOCATION EXPERIMENTS
THEIL'S U

Variable	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6
NEWSNO	.0004	0	0	.0076	.0005	.0064
NEWSCIR	0	0	0	.0066	.0001	.0065
NEWCOST	0	0	0	.0005	.0001	.0004
NEWSREV	.0127	0	0	.1510	.1032	.1270
NPUBCST	0	0	0	0	0	0
NEWEARN	.0176	0	0	.2207	.0184	.1842
MAGNO	.0022	0	0	.0064	.0035	.0072
MAGCIRC	.0020	0	0	.0064	.0034	.0072
MAGCOST	0	0	0	.0005	.0002	.0005
MAGREV	.0166	0	0	.0547	.0287	.0618
MPUBCST	0	0	0	.0050	.0048	.0051
MAGEARN	.0522	0	0	.1912	.0937	.2192
AMNO	.0044	.1511	.0251		.0547	
AMHH	.0001	.0048	.0008		.0863	
AMREV	.0157	.0089	.0772		.1608	
AMEXP	.0011	.0352	.0063		.0134	
AMEARN	.0547	.0704	.2349		.4241	
FMNO	.0338	.0180		*		*
FMHH	0	0		0		0
FMREV	.1132	.0664		.9805		.9830
FMEXP	0	0		0		0
FMEARN	.0654	.0370		.9914		.9922
VHFNO	.0013	.0481	.0320	.0033		
VHFHH	0	0	0	.0107		
VHFREV	.0372	.0033	.1275	.1446		
VHFEXP	.0485	.0043	.1599	.1959		
VHFEARN	.0031	.0003	.0125	.0108		
UHFNO	.4254	0			.4326	
UHFHH	.4333	0			.4333	.4314
UHFREV	.4620	.0009			.4394	.4476
UHFEXP	.4217	0			.4253	.4249
UHFEARN	.8166	.0109			.8682	.8918
TBUY	.0219	.0020	.0054	.0235	.0984	.0222
TNEWBUY	.0178	0	0	.2247	.0186	.1872
TMAGBUY	.0633	0	0	.2426	.1159	.2801
AMBUY	.0202	.0113	.0966		.1983	
FMBUY	.0204	.0114		.8996		.9126
VHFBUY	.0360	.0032	.1238	.1393		
UHFBUY	.1189	.0034			.3680	.3969
RETPROF	.0003	.0001	.0123	.0662	.0049	.0006

TABLE 20

SPECTRUM ALLOCATION EXPERIMENT ONE OUTPUT
COMPARED TO BENCHMARK MODEL

	UHFNO		UHFHH		UHFREV	
Year	MASSMOD	Exp 1	MASSMOD	Exp 2	MASSMOD	Exp 3
1945	0	6	0	333	0	35.961
1946	0	111	0	318	0	64.713
1947	0	98	0	1478	0	61.295
1948	0	89	0	2230	0	57.084
1949	0	82	0	2815	0	52.951
1950	0	76	0	3288	0	51.317
1951	0	72	0	3709	0	48.275
1952	0	70	0	4060	0	46.787
1953	6	70	0	4394	28.901	45.637
1954	121	71	377	4670	59.069	44.743
1955	114	75	1785	5027	55.559	45.371
1956	98	79	2651	5318	49.183	44.600
1957	88	86	4392	5585	44.761	44.771
1958	82	95	4287	5755	42.786	46.817
1959	76	104	4119	6158	42.091	49.240
1960	76	116	3676	6515	40.065	51.136

TABLE 20 (cont'd)

	UHFEXP		UHFEARN	
Year	MASSMOD	Exp 1	MASSMOD	Exp 1
1945	0	28.220	0	7.741
1946	0	54.739	0	9.974
1947	0	51.561	0	9.735
1948	0	47.950	0	9.134
1949	0	45.265	0	7.686
1950	0	43.322	0	7.995
1951	0	41.694	0	6.581
1952	0	40.813	0	5.975
1953	28.220	40.337	-10.602	5.300
1954	57.691	40.335	-18.235	4.408
1955	55.503	40.872	- 5.726	4.449
1956	49.823	41.633	- 2.501	2.967
1957	46.476	43.139	- 2.081	1.632
1958	43.057	45.090	- 3.919	1.727
1959	42.339	47.387	- 4.034	1.852
1960	41.890	49.882	- 2.351	1.434

if the limit on the number of AM stations was reached, the overflow of new stations was added to the FM total, under the assumption that a broadcaster seeking an AM station would prefer an FM station to no station at all. In the television subsectors, if the limit on stations was reached, no further stations were allowed for that year. Unlike the radio case where AM and FM stations were assumed to be substitutable, the interchangeability of VHF and UHF stations did not seem to be supported by historical data. A broadcaster might well have preferred no station at all to owning an UHF television station.

Theil's U values for variables in this run are given in Table 19. No changes at all occurred in the print sector; differences were minimal in the advertiser, VHF and UHF sectors. AM stations reached their limit in 1952 (U = .1511), which caused the number of FM stations to increase somewhat (U = .0180). The increase in FM stations was not as great as the absolute difference between the number of AM stations in the benchmark model and the limit, however, since the number of AM stations for a year is part of a feedback loop which determines earnings and number of stations.

When the limit of 2,100 stations was reached in the AM subsector, AM expenses declined, which brought about an increase in AM earnings. This increase in earnings was inversely related to number of stations; thus, as expenses declined and earnings increased each year, the number of AM stations in the following year decreased. At first, this seems contrary to industry behavior; one would expect that as earnings/profits in an industry increased, investors would be attracted to the industry, and more corporations (in this case, stations) would result. On the other hand, what seems to be occurring is that revenues tend to be distributed over a smaller number of stations which record high earnings.

Holding the number of AM stations available constant at 2,100 highlights this effect--stations which can earn high revenues exist, while those that don't are forced to go off the air. This relationship has implications for those who propose to decrease the AM channel width from 10 kHz to 9 kHz, thus providing more channels and ultimately more stations. Either total AM earnings will decrease with the increase in stations, causing earnings per station to decline, or the newly established stations will quickly go off the air, because the earnings will remain concentrated in the hands of the most profitable stations. More analysis at the micro (station) level is needed to pursue these questions.

In the FM subsector, the decrease in total number of radio stations (AM plus FM) caused a decrease in local radio advertising expenditures, which were based on number of radio stations on the air. This ultimately resulted in a decrease in FM revenue and earnings. These results are presented in Table 21.

Results--Experiment 3

This Experiment set the maximum number of FM and UHF stations at 0 throughout the run of the model to study the results of an all AM, all VHF broadcasting system. All other conditions in the model remained constant.

There was no change in the print sector. Since all radio and television advertising expenditures were assigned to AM and VHF respectively, these variables showed an expected increase (U values of .0966 and .1238). Number of AM stations decreased (.0251), as revenue (.0772) and earnings (.2343) increased, due to the inverse relationship discussed in the summary of Experiment 2. Number of AM households showed little change, an anticipated result, even with the deletion of FM broadcasting,

TABLE 21

SPECTRUM ALLOCATION EXPERIMENT TWO OUTPUT
COMPARED TO BENCHMARK MODEL

	AMNO		AMEXP		AMEARN	
Year	MASSMOD	Exp 2	MASSMOD	Exp 2	MASSMOD	Exp 2
1945	920	920	585.984	585.984	143.764	143.764
1946	1190	1190	599.838	599.838	114.888	114.888
1947	1485	1485	621.055	621.055	134.128	134.128
1948	1603	1603	629.651	629.651	148.077	148.077
1949	1782	1782	642.637	642.637	131.941	131.941
1950	1891	1891	650.518	650.518	144.835	144.835
1951	1946	1946	654.565	654.565	121.852	121.852
1952	2132	2100	668.018	665.698	131.338	132.474
1953	2256	2100	676.984	665.725	106.036	111.117
1954	2540	2100	697.520	665.739	87.799	101.220
1955	2657	2100	706.023	665.759	87.643	101.693
1956	2827	2100	718.332	665.784	81.217	99.365
1957	3014	2100	731.863	665.801	65.252	88.305
1958	3260	2100	749.683	665.811	57.667	88.083
1959	3359	2100	756.830	665.803	83.198	113.181
1960	3476	2100	756.830	665.803	86.335	120.470

TABLE 21 (cont'd)

	FMNO		FMREV		FMEARN	
Year	MASSMOD	Exp 2	MASSMOD	Exp 2	MASSMOD	Exp 2
1945	61	61	1.599	1.599	- 9.825	- 9.825
1946	169	169	0.307	0.307	-10.855	-10.855
1947	511	511	1.976	1.976	- 8.472	- 8.472
1948	625	625	2.970	2.970	- 6.427	- 6.427
1949	746	746	2.355	2.355	- 5.769	- 5.769
1950	724	724	3.287	3.287	- 3.455	- 3.455
1951	566	566	2.070	2.070	- 3.296	- 3.296
1952	599	599	3.036	3.036	- 1.072	- 1.072
1953	501	501	1.926	1.901	- 1.158	- 1.183
1954	624	626	1.621	1.497	- 0.785	- 0.909
1955	536	543	2.106	1.778	- 0.084	- 0.412
1956	523	539	2.438	1.996	- 0.110	- 0.552
1957	547	570	2.361	1.823	- 1.234	- 1.772
1958	686	722	3.019	2.402	- 2.427	- 3.044
1959	657	697	5.427	4.583	- 2.786	- 3.630
1960	673	730	6.733	5.890	- 5.277	- 6.119

since AM and FM audiences tend to be duplicated.

The number of VHF television stations declined slightly (U = .0320) due to a small decrease in earnings (.0125) brought about by increases in expenses (.1599) and revenues (.1275), which are both directly related to advertising revenues in an inverse relationship. Television stations rely almost exclusively on advertising expenditures for their revenue, so an increase in expenditures translates into an increase in revenue. Increased revenue from advertising, generated by a large television audience, encourages stations to invest more money in programming and personnel expenses, knowing that the additional expenditures will result in larger audiences and higher revenues. As the model is constructed, this is the stated direction of the relationship due to time lags; i.e., advertising buys for the year under consideration are calculated first, using audience data from the previous year. It could be that the sequence begins with a larger investment in programming expenses, which attracts a larger audience, which in turn attracts more advertising dollars.

Table 22 contains summary results for this Experiment.

Results--Experiment 4

This Experiment maintained the all-VHF television broadcasting condition from Experiment 3, but shifted radio to an all-FM state. Hence, the UHF and AM radio subsectors were eliminated from the run.

One modification was made in a model equation, which, in the end, did not prove satisfactory. The number of FM stations in the benchmark model had been calculated using this equation:

$$FMNO(t) = \exp(7.2081 - 0.09624*FMEARN(t-1) + 1.3663*\ln(RNYR))$$

The equation worked well when FMEARN was negative or minimal, the

TABLE 22

SPECTRUM ALLOCATION EXPERIMENT THREE OUTPUT
COMPARED TO BENCHMARK MODEL

	AMNO		AMREV		AMEARN	
Year	MASSMOD	Exp 3	MASSMOD	Exp 3	MASSMOD	Exp 3
1945	920	920	758.851	918.958	143.764	222.216
1946	1190	1051	713.775	859.001	114.888	191.003
1947	1485	1349	774.258	922.562	134.128	211.603
1948	1603	1465	811.320	953.999	148.077	222.881
1949	1782	1649	791.376	923.669	131.941	210.487
1950	1891	1767	825.571	963.529	144.835	216.825
1951	1946	1818	782.713	908.683	121.851	188.122
1952	2132	2014	815.526	953.935	131.338	201.195
1953	2256	2128	772.856	900.168	106.036	172.956
1954	2540	2420	756.172	879.598	87.799	152.502
1955	2657	2542	764.357	884.812	87.643	150.750
1956	2827	2715	763.660	881.893	81.270	143.188
1957	3014	2904	744.502	856.251	65.252	123.918
1958	3260	3156	746.842	856.519	57.667	115.112
1959	3359	3257	806.093	920.293	83.198	142.782
1960	3476	3370	820.957	935.705	86.335	146.323

TABLE 22 (cont'd)

	VHFNO		VHFEXP		VHFREV	
Year	MASSMOD	Exp 3	MASSMOD	Exp 3	MASSMOD	Exp 3
1945	0	0	0	0	0	0
1946	15	15	0	0	0	0
1947	11	11	0	0	0	0
1948	32	32	110.798	110.798	117.958	117.958
1949	53	53	247.503	247.503	259.916	259.916
1950	91	91	287.853	287.853	308.075	308.075
1951	128	129	413.189	413.189	459.268	459.268
1952	160	162	331.820	475.706	339.084	540.322
1953	203	203	357.727	517.548	446.009	602.888
1954	235	233	423.913	611.965	537.405	721.995
1955	281	279	513.121	687.223	643.435	814.332
1956	321	319	605.589	822.565	768.453	981.436
1957	356	354	698.993	967.306	889.110	1152.485
1958	396	394	696.509	973.415	906.989	1178.799
1959	446	443	670.589	945.946	894.214	1164.504
1960	484	481	733.714	1039.082	984.676	1284.424

TABLE 22 (cont'd)

	VHFEARN	
Year	MASSMOD	Exp 3
1945	0	0
1946	0	0
1947	0	0
1948	7.160	7.160
1949	12.412	12.412
1950	20.222	20.222
1951	46.079	46.079
1952	67.264	64.616
1953	88.282	85.340
1954	113.492	110.031
1955	130.313	127.109
1956	162.864	158.871
1957	190.117	185.179
1958	210.480	205.384
1959	223.625	218.557
1960	250.962	245.342

historical case. However, in this experiment, FM earnings increased substantially, since all radio advertising expenditures were channelled into this subsector. Before a change in the equation, this resulted in no FM radio stations and forced the program to find the exponential of a negative number. The sign of the FMEARN coefficient was changed from negative to positive. However, after the modification, the argument of the exponential became so large that the number of FM stations had to be reported in scientific notation (maximum value: .32E+19). No attempt was made to make further modifications in the equation to bring it into sensible range. It seems safe to say, however, that under the conditions which existed between 1945-1960, the growth of FM radio was contained, and that given a free rein, it would have developed faster, though not as fast as the benchmark equation would suggest.

The enormous values for number of FM stations affected the entire run of this Experiment. Local radio advertising expenditures depended on the total number of radio stations the previous year. This resulted in a major share of each year's advertising budget being allocated to FM radio, with smaller allocations to the remaining media. Thus, newspaper advertising buys (U = .2247), revenue (.1510) and earnings (.2207) decreased as did magazine advertising buys (.2426), revenues (.0547) and earnings (.1912). Other variables in the print sector had U's below .01. In the VHF subsector, advertiser expenditures also decreased (.1393), affecting revenue (.1446), expenses (.1959) and earnings (.0108). FM revenues (.9805) and earnings (.9914) were radically affected. Table 23 contains summary data for these variables.

TABLE 23

SPECTRUM ALLOCATION EXPERIMENT FOUR OUTPUT
COMPARED TO BENCHMARK MODEL

	TNEWBUY		NEWSREV		NEWEARN	
Year	MASSMOD	Exp 4	MASSMOD	Exp 4	MASSMOD	Exp 4
1945	2014	2014	3397.965	3397.065	2892.637	2892.637
1946	2573	2573	4020.792	4020.792	3137.313	3137.313
1947	2842	2543	4305.649	3997.118	3240.468	2931.938
1948	2944	2402	4413.495	3872.050	3207.207	2665.763
1949	3097	1676	4577.898	3155.989	3240.779	1818.870
1950	3265	1706	4753.505	3192.759	3288.566	1727.820
1951	3337	1969	4836.569	3465.112	3359.948	1988.492
1952	3514	1950	5023.204	3455.027	3542.707	1974.530
1953	3639	2139	5157.520	3653.917	3631.139	2127.536
1954	3879	2261	5408.691	3787.043	3876.343	2254.694
1955	4340	2427	5879.381	3962.915	4213.815	2297.349
1956	4262	2656	5814.554	4205.155	4106.688	2497.290
1957	4380	2825	5945.294	4385.743	4243.126	2683.574
1958	4409	2763	5983.992	4334.122	4351.928	2702.058
1959	4521	2987	6104.894	4567.109	4325.115	2787.330
1960	4634	3123	6227.250	4713.399	4387.815	2873.964

TABLE 23 (cont'd)

	TMAGBUY		MAGREV		MAGEARN	
Year	MASSMOD	Exp 4	MASSMOD	Exp 4	MASSMOD	Exp 4
1945	867	867	2049.264	2049.264	623.664	623.664
1946	879	879	2171.239	2171.239	772.003	772.003
1947	975	878	2203.864	2147.361	832.689	776.185
1948	813	854	2097.175	2121.229	710.706	734.760
1949	949	491	2194.692	1931.461	791.316	526.679
1950	826	542	2134.995	1970.017	670.486	506.111
1951	998	488	2270.762	1984.923	728.143	435.647
1952	964	518	2280.588	2028.320	690.490	434.013
1953	1276	544	2476.546	2063.801	847.237	427.124
1954	1130	667	2412.484	2153.813	779.509	514.285
1955	1195	782	2449.762	2226.550	766.283	532.247
1956	1225	726	2506.024	2227.381	779.412	493.924
1957	1258	671	2545.677	2214.297	790.632	453.292
1958	1135	769	2484.595	2283.827	724.360	516.083
1959	1420	784	2658.795	2303.544	842.721	478.466
1960	1286	776	2616.806	2329.883	757.115	464.694

TABLE 23 (cont'd)

	VHFBUY		VHFREV		VHFEXP	
Year	MASSMOD	Exp 4	MASSMOD	Exp 4	MASSMOD	Exp 4
1945	0	0	0	0	0	0
1946	0	0	0	0	0	0
1947	0	0	0	0	0	0
1948	297	261	117.958	100.877	110.798	93.396
1949	593	315	259.916	126.804	247.503	111.896
1950	693	380	308.075	157.741	287.853	134.700
1951	1008	508	459.268	219.372	413.189	168.794
1952	883	618	399.084	271.854	331.820	202.204
1953	980	735	446.009	328.253	357.727	237.764
1954	1171	894	537.405	404.683	423.913	288.703
1955	1392	977	643.435	444.128	513.121	310.078
1956	1652	1203	768.453	552.745	605.589	385.837
1957	1904	1381	889.110	638.194	698.993	443.372
1958	1941	1628	906.989	756.891	696.509	543.596
1959	1914	1596	894.214	741.573	670.589	515.086
1960	2103	1850	984.676	863.229	733.714	609.989

TABLE 23 (cont'd)

Year	VHFEARN MASSMOD	VHFEARN Exp 4	FMBUY MASSMOD	FMBUY Exp 4	FMNO MASSMOD	FMNO Exp 4
1945	0	0	211	1053	61	23
1946	0	0	196	1029	169	27276
1947	0	0	215	1621	511	62626
1948	7.160	7.480	226	1948	625	13849779
1949	12.412	14.908	218	3424	746	.33E+09
1950	20.222	23.041	227	3679	724	.80E+14
1951	46.079	50.577	210	3696	566	.74E+15
1952	67.264	69.650	218	3991	599	.10E+16
1953	88.282	90.490	201	4152	501	.14E+17
1954	113.492	115.980	191	4106	624	.79E+17
1955	130.313	134.050	190	4105	536	.54E+17
1956	162.864	166.909	185	4121	523	.60E+17
1957	190.117	194.822	173	4194	547	.75E+17
1958	210.480	213.294	168	4370	686	.15E+18
1959	223.625	226.487	182	4610	657	.52E+18
1960	250.962	253.239	180	4603	673	.32E+19

TABLE 23 (cont'd)

Year	FMREV MASSMOD	FMREV Exp 4	FMEARN MASSMOD	FMEARN Exp 4
1945	1.599	74.069	- 9.825	62.644
1946	0.307	71.990	-10.855	60.828
1947	1.976	122.894	- 8.472	112.446
1948	2.970	151.024	- 6.427	141.644
1949	2.355	178.110	- 5.769	269.986
1950	3.287	300.177	- 3.455	293.435
1951	2.070	301.801	- 3.296	296.435
1952	2.036	327.502	- 1.072	323.394
1953	1.926	341.702	- 1.158	338.619
1954	1.621	338.300	- 0.785	335.894
1955	2.106	338.807	- 0.084	336.618
1956	2.438	340.988	- 0.110	338.440
1957	2.361	348.175	- 1.234	344.579
1958	3.019	364.352	- 2.427	358.907
1959	5.427	386.242	- 2.786	378.029
1960	6.733	387.091	- 5.277	375.081

Results--Experiment 5

This Experiment imposed an all AM, all UHF system on the broadcasting industry for the time period under study. The UHF subsector was adjusted in a manner similar to Experiment 1, so that it could operate from 1945, instead of beginning in 1953.

In the model, magazine advertising expenditures were determined in part by the number of VHF television households. Therefore, eliminating the VHF sector which set the number of VHF households to 0, caused a drop in magazine advertising expenditures (U = .1159). Since earnings were dependent on advertising buys, this contributed to a decrease in overall magazine earnings (.0937). The UHF television audience generated in this experiment should most probably have been substituted for the VHF audience in the equation. Including both UHF and VHF households in the equation did not prove to be significant--possibly because they are duplicated audiences. Other variables in the print sector were not substantially changed, with U values of .01 or less.

The elimination of VHF households led to an increase in radio advertising expenditures, all of which were assigned to AM radio (.1983). This increase resulted in increased AM revenues (.1608) and earnings (.4241). Since earnings and number of AM stations are inversely related, the number of AM stations decreased (.0547). This relationship was considered earlier in this chapter. The decrease in stations caused an increase in AM households (.0863), due to the inverse relationship between those two.

The macro level at which the model is constructed does not allow for an analysis of station preference types by AM households. However, the increase in AM households which occurred when there were fewer AM stations might be explained by the higher profitability of those stations (recalling that a decrease in stations brought about an increase in earnings), which might suggest better quality programming. On the other hand, the directionality of the relationships in the feedback loop could be reversed. A larger audience will attract more advertising dollars, which in turn increases revenues and earnings, which are distributed to those AM stations which remain in existence to share the profits. Higher earnings due to larger audiences tend to reduce the number of AM stations on the air.

The assignment of all television advertising expenditures to UHF television brought about a substantial change in values for that variable (.3680). Number of stations increased (.4326), mainly as a result of the growth function built into the equation, but this increase helped both expenses (.4253) and revenues (.4394) to increase also, with a resulting increase in earnings (.8682). UHF households (.4333) increased, also as a result of a growth function. Results for this Experiment are found in Table 24.

Results--Experiment 6

This Experiment maintained an FM radio, UHF television broadcasting system, with results similar to those of Experiment 4, with its FM subsector, and Experiment 5, with its UHF system. Again, the exponential relationship which determined number of FM stations resulted in very large values for this variable, which in turn increased advertising expenditures for FM (.9126), while decreasing advertising buys for the rest of the media. This increase in advertising expenditures for FM in this Experiment was even greater than that in Experiment 4 (compare Tables 23 and 25), since the variable of VHF households, which kept radio ad expenditures in check, had been removed.

TABLE 24

SPECTRUM ALLOCATION EXPERIMENT FIVE OUTPUT
COMPARED WITH BENCHMARK MODEL

	TMAGBUY		MAGEARN		AMBUY	
Year	MASSMOD	Exp 5	MASSMOD	Exp 5	MASSMOD	Exp 5
1945	867	919	623.664	654.002	843	1023
1946	8792	976	772.003	828.283	782	1014
1947	975	790	832.689	725.017	859	1004
1948	813	887	710.706	753.374	904	1083
1949	949	947	791.316	791.470	871	1038
1950	826	939	670.486	735.673	908	1100
1951	998	853	728.143	644.175	841	1066
1952	964	849	690.490	623.296	873	1096
1953	1276	888	847.237	623.615	803	1140
1954	1130	967	779.509	685.667	766	1131
1955	1195	913	766.283	605.648	759	1231
1956	1225	1128	779.412	724.183	739	1167
1957	1258	920	790.632	597.127	693	1274
1958	1135	971	724.360	630.040	674	1251
1959	1420	896	842.721	541.711	727	1339
1960	1286	976	757.115	579.195	720	1345

TABLE 24 (cont'd)

	AMNO		AMHH		AMREV	
Year	MASSMOD	Exp 5	MASSMOD	Exp 5	MASSMOD	Exp 5
1945	920	920	37263	37263	758.851	896.025
1946	1190	1071	35304	35363	713.775	889.985
1947	1485	1323	36927	37008	774.258	884.086
1948	1603	1497	38462	38517	811.320	947.652
1949	1782	1656	40956	41024	791.376	918.366
1950	1891	1772	41030	41096	825.571	971.787
1951	1946	1811	42840	42917	782.713	953.257
1952	2132	1975	44161	44252	815.526	985.405
1953	2256	2097	44769	44861	772.856	1028.647
1954	2540	2306	45606	45744	756.172	1033.728
1955	2657	2400	46810	46966	764.357	1122.844
1956	2827	2498	47552	47757	763.660	1088.421
1957	3014	2710	47938	48130	744.502	1186.205
1958	3260	2855	47378	47634	746.842	1185.907
1959	3359	2950	48862	49131	806.093	1271.327
1960	3476	3044	49876	50169	820.957	1295.333

TABLE 24 (cont'd)

	AMEARN		UHFBUY		UHFNO	
Year	MASSMOD	Exp 5	MASSMOD	Exp 5	MASSMOD	Exp 5
1945	143.764	210.979	0	0	0	6
1946	114.888	205.475	0	0	0	111
1947	134.128	193.664	0	0	0	98
1948	148.077	218.638	0	303	0	89
1949	131.941	198.621	0	597	0	84
1950	144.835	220.691	0	508	0	84
1951	121.852	210.208	0	504	0	76
1952	131.338	220.157	294	446	0	73
1953	106.036	236.981	327	378	6	71
1954	87.799	232.068	390	377	121	71
1955	87.643	272.410	464	362	114	74
1956	81.270	252.068	551	372	98	78
1957	65.252	292.469	635	372	88	84
1958	57.667	287.154	647	365	82	92
1959	83.198	325.650	638	404	79	101
1960	86.335	334.086	701	398	76	113

TABLE 24 (cont'd)

	UHFHH		UHFREV		UHFEXP	
Year	MASSMOD	Exp 5	MASSMOD	Exp 5	MASSMOD	Exp 5
1945	0	333	0	35.961	0	28.220
1946	0	318	0	64.713	0	54.739
1947	0	1478	0	61.295	0	51.561
1948	0	2230	0	52.185	0	47.950
1949	0	2815	0	44.555	0	45.961
1950	0	3288	0	45.692	0	44.612
1951	0	3709	0	44.234	0	42.676
1952	0	4060	0	44.729	0	41.525
1953	0	4394	28.901	45.727	28.220	40.730
1954	377	4670	59.069	45.756	57.691	40.378
1955	1785	5027	55.559	46.778	55.503	40.735
1956	2651	5318	49.183	47.669	49.823	41.414
1957	4392	5585	44.761	49.351	46.476	42.672
1958	4287	5755	42.786	51.619	43.057	44.374
1959	4119	6158	42.091	53.356	42.339	46.604
1960	3676	6515	40.065	56.695	41.890	49.187

TABLE 24 (cont'd)

	UHFEARN	
Year	MASSMOD	Exp 5
1945	0	7.741
1946	0	9.074
1947	0	9.735
1948	0	4.235
1949	0	-1.405
1950	0	1.079
1951	0	1.559
1952	0	3.204
1953	-10.602	4.997
1954	-18.235	5.378
1955	- 5.726	6.043
1956	- 2.501	6.255
1957	- 2.081	6.679
1958	- 3.919	7.245
1959	- 4.034	6.752
1960	- 2.351	7.508

TABLE 25

SPECTRUM ALLOCATION EXPERIMENT SIX OUTPUT
COMPARED TO BENCHMARK MODEL

	TNEWBUY		NEWSREV		NEWEARN	
Year	MASSMOD	Exp 6	MASSMOD	Exp 6	MASSMOD	Exp 6
1945	2014	2009	3397.965	3393.846	2892.637	2888.518
1946	2573	2568	4020.792	4016.469	3137.313	3132.991
1947	2842	2672	4305.649	4134.906	3240.468	3069.725
1948	2944	2414	4413.495	3883.823	3207.207	2677.535
1949	3097	1661	4577.898	3141.875	3240.779	1804.756
1950	3265	1862	4753.505	3349.620	3288.566	1884.681
1951	3337	1978	4836.569	3474.191	3359.948	1997.571
1952	3514	2106	5023.204	3611.380	3542.707	2130.883
1953	3639	2311	5157.520	3826.191	3631.139	2299.810
1954	3879	2543	5408.691	4069.713	3876.343	2537.364
1955	4340	2794	5879.381	4330.790	4213.815	2665.224
1956	4262	2819	5814.554	4368.562	4106.688	2660.697
1957	4380	3142	5945.294	4704.323	4243.126	3002.154
1958	4409	3048	5983.992	4620.059	4351.928	2987.995
1959	4521	3348	6104.894	4929.709	4325.115	3149.930
1960	4634	3533	6227.250	5123.700	4387.815	3284.265

TABLE 25 (cont'd)

	TMAGBUY		MAGREV		MAGEARN	
Year	MASSMOD	Exp 6	MASSMOD	Exp 6	MASSMOD	Exp 6
1945	867	919	2049.264	2079.601	623.664	654.002
1946	879	970	2171.239	2224.139	772.003	824.903
1947	975	765	2203.864	2081.114	832.689	710.679
1948	813	716	2097.175	2039.251	710.706	654.086
1949	949	472	2194.692	1923.116	791.316	516.687
1950	826	464	2134.995	1927.651	670.486	461.688
1951	998	573	2270.762	2034.601	728.143	485.114
1952	964	491	2280.588	2014.136	690.490	418.749
1953	1276	547	2476.546	2063.197	847.237	427.808
1954	1130	529	2412.484	2074.378	779.509	434.482
1955	1195	566	2449.762	2101.798	766.283	407.480
1956	1225	589	2506.024	2151.237	779.412	415.678
1957	1258	643	2545.677	2203.053	790.632	438.716
1958	1135	706	2484.595	2250.555	724.360	480.759
1959	1420	691	2658.795	2250.281	842.721	424.898
1960	1286	773	2616.806	2329.634	757.115	463.534

TABLE 25 (cont'd)

Year	FMNO MASSMOD	FMNO Exp 6	FMREV MASSMOD	FMREV Exp 6	FMEARN MASSMOD	FMEARN Exp 6
1945	61	23	1.599	71.474	- 9.825	60.049
1946	169	27276	0.307	77.233	-10.855	66.071
1947	511	62626	1.976	120.281	- 8.472	109.833
1948	625	13849779	2.970	161.085	- 6.427	151.688
1949	746	.33E+09	2.355	280.157	- 5.769	272.033
1950	724	.80E+14	3.287	296.682	- 3.455	289.940
1951	566	.74E+15	2.070	313.782	- 3.296	308.416
1952	599	.10E+16	3.036	354.816	- 1.072	350.708
1953	501	.14E+17	1.926	361.308	- 1.158	358.224
1954	624	.79E+17	1.621	377.702	- 0.785	375.296
1955	536	.54E+17	2.106	397.402	- 0.084	395.212
1956	523	.60E+17	2.438	416.303	- 0.110	413.755
1957	547	.75E+17	2.361	429.078	- 1.234	425.483
1958	686	.15E+18	3.019	455.070	- 2.427	449.625
1959	657	.52E+18	5.427	468.885	- 2.786	460.673
1960	673	.32E+19	6.733	484.905	- 5.277	472.895

TABLE 25 (cont'd)

Year	UHFNO MASSMOD	UHFNO Exp 6	UHFHH MASSMOD	UHFHH Exp 6	UHFREV MASSMOD	UHFREV Exp 6
1945	0	6	0	333	0	35.961
1946	0	111	0	318	0	64.713
1947	0	98	0	1478	0	61.295
1948	0	89	0	2230	0	53.322
1949	0	84	0	2815	0	50.281
1950	0	78	0	3288	0	49.568
1951	0	73	0	3709	0	48.628
1952	0	70	0	4060	0	48.666
1953	6	69	0	4394	28.901	48.609
1954	121	69	377	4670	59.069	48.570
1955	114	72	1785	5027	55.559	49.190
1956	98	76	2651	5318	49.183	49.843
1957	88	83	4392	5585	44.761	51.238
1958	82	91	4287	5755	42.786	52.697
1959	79	101	4119	6158	42.091	55.579
1960	76	112	3676	6515	40.065	58.124

TABLE 25 (cont'd)

Year	UHFEXP MASSMOD	UHFEXP Exp 6	UHFEARN MASSMOD	UHFEARN Exp 6
1945	0	28.220	0	7.741
1946	0	54.739	0	9.974
1947	0	51.561	0	9.735
1948	0	47.950	0	5.372
1949	0	45.799	0	4.482
1950	0	43.777	0	5.791
1951	0	42.007	0	6.621
1952	0	40.807	0	7.859
1953	28.220	40.069	-10.602	8.539
1954	57.691	39.876	-18.235	8.695
1955	55.503	40.264	- 5.726	8.926
1956	49.823	41.004	- 2.501	8.838
1957	46.476	42.306	- 2.081	8.932
1958	43.057	44.054	- 3.919	8.643
1959	42.339	46.405	- 4.034	9.174
1960	41.890	48.843	- 2.351	9.281

The decrease in ad buys forced newspaper revenues (.1270) and earnings (.1842) down, as well as magazine revenues (.0618) and earnings (.2191). The increased revenues from advertising increased FM revenues (.9830) and earnings (.9922). UHF subsystem variables increased as they did in Experiment 5; number of stations (.4314) and households (.4334) on the basis of yearly growth functions, revenue (.4476) and expenses (.4249) as a result of increased number of stations, and earnings (.8918) as the resultant difference between the latter two. Speculating on reasons for system behavior in this experiment is difficult, since so many of the structural equations for FM and UHF use only time indices as predictor variables.

Summary

Manipulations of the use of the electromagnetic spectrum by various broadcast media in various combinations resulted in little disturbance of the print media. Since most changes in the broadcast sector were relatively small in themselves, this result is not unexpected. When variables in the print sector were affected, it tended to be the result of changes in the allocation of advertising dollars which caused the difference. Several relationships within the broadcast sector were highlighted by these experiments: the inverse relationships between AM earnings and number of stations, which suggested that as the AM industry became more profitable, high-earning stations kept other stations from sharing in the industry profits; and between number of AM stations and number of AM households, another link in the earning/number chain, since number of households is a predictor of earnings.

The very large values for number of FM stations in Experiments 4 and 6 caused changes within the entire subsystem, but still only yielded values for Theil's U around 0.3. This either suggests a problem of sensitivity within the model structure, or the remarkable stability of the industry system in the midst of an uncontrolled addition of FM radio. Historically, the AM radio industry was stable, and prepared to make substantial investments in VHF television. The indifference of radio broadcasters to the FM system, in addition to the FCC's reallocation of spectrum space to FM forcing the manufacture of new receivers, could well have made the effect of FM on the system so minimal. Even with different channel availability parameters, the model functioned from initial conditions from the historical period under study.

Another structural problem was highlighted when the UHF subsector was manipulated. Changes in values of the criterion variables occurred not because of changes in variable values within the subsystem, but solely because of the growth function built in by the presence of UNYR. When UNYR equals 0 in 1945 instead of 1953, values change dramatically, but only because of a time index.

Postscript

Thus, a basic simulation model such as MASSMOD can be manipulated to reflect changes in the conditions under which the model operates to accomplish two things: the evaluation of various policy options and their effect on the system, such as comparing results across all six spectrum allocation manipulations; and the identification, or at least the emphasis, of structural relationship within the model which run counter to assumed behavior: for example, the inverse relationships between number of AM stations and AM earnings, and between number of AM stations and AM households, suggest that the subsector stations may tend to operate as an oligopoly, instead of as competitors.

One other comment should be made about the Experiments. Every manipulation made here assumed that the initial conditions in the system in 1945 were exactly the same as they were in the benchmark. Also, the modified models for the most part retained equations for criterion variables that were established using the historical data. Thus, for example, in Experiments 5 and 6, the pattern for number of UHF stations across all 16 years is parabolic, reflecting the initial function in the benchmark model.

Chapter 5 contains a summary of conclusions to be drawn from examination of both the benchmark model and the experimental manipulations. It also discusses the weaknesses of the present MASSMOD version and makes suggestions for further research and future directions.

CHAPTER 5

CONCLUSIONS AND FUTURE DIRECTIONS

This research applied systems simulation methodology to the study of the economic and structural behavior of the mass media industry from 1945 to 1960. Using historical data from a time period marked by the introduction of a new communications technology--television, the study had two major purposes: (1) the quantification of abstract theories about media structure and economics and the identification of integral relationships among media components, accomplished by the construction and validation of a computer simulation model; and (2) the demonstration of the feasibility and usefulness of systems simulation to the study of media behavior, planning and policymaking, shown by a series of experiments manipulating two policy variables in the model.

Because of a shortage of past research that has applied systems simulation to the mass media as an industry, or to decision-making and planning within that industry, the research was designed to be exploratory. This chapter contains conclusions about the application of systems methodology to the study of the media, as well as some necessarily tentative conclusions about the structure and performance of the media industry during the introduction of television. The chapter concludes with some suggestions of areas where future research could be conducted that would build upon the work of this study.

Conclusions

Methodology

The creation of MASSMOD, a simulation model of the industry which validates against historical data for the time period, suggests that enough information about the behavior and economics of the mass media industry is available to construct a mathematical model of the system. Further, the data acquisition problems discussed in Chapter 3 should only lessen as the model is expanded and modified to deal with decades beyond the time frame of the original MASSMOD. While the data are still distributed among multiple sources, industry has realized the importance of quantitative information reported in a variety of ways to its development, and is therefore collecting more information than it did in 1945-1960.

Secondly, the manipulation of conditions in MASSMOD to conform to various hypothetical situations with alternative outcomes indicates that a simulation model can be of use in systematically testing the impact of proposed policy actions on the mass media system without actually implementing such actions in the real world. The spectrum allocation experiments performed as part of this study altered the availability of channels for four different broadcasting systems to investigate the effect of alternative policy choices. The model showed remarkable stability across the experiments, and suggested that even unfettered FM and UHF systems would not have been financial successes on the scale of AM radio and VHF television. Policymakers looking back to history in the midst of current decisions could use such a simulation model to answer "what if" questions that previously relied only on speculation for answers.

The search of the literature dealing with systems analysis of the structure and economics of other industries detailed in Chapter 2 implied that the methodology might be appropriate to the analysis of the mass media as a multi-component industry. The construction, validation and manipulations with MASSMOD confirmed this, if only on a first-attempt, exploratory basis.

Theory

Since MASSMOD is an exploratory effort in the construction of a valid simulation model of the mass media industry, conclusions drawn from the model are necessarily tentative. Nonetheless, it is felt that the model has sufficient validity to make these conclusions of interest.

First, the media system was able to be represented in quantitative mathematical form by just four components: print, broadcast, advertising and consumer, and at a high aggregation level, chosen to identify overall structure with the least complexity. Initial attempts to include a manufacturing sector for broadcasting equipment which would provide receiver supply and costs did not yield significant equations, and was therefore dismissed as unnecessary to the development of broadcast audiences. The consumer's choice to be a viewer or listener seems to be independent of the supply and/or price of the receiver, or can be explained as well by available disposable income. This may have relevance to the developing field of video recording technology and its acceptance by the public.

At the same time, some model subcomponents, such as FM radio and UHF television, were more dependent on simple time variables as predictors than on structural variables determined within the system. When system variables were used as predictors for UHF and FM variables such as number of stations, households, revenues, expenses and earnings, the regression equations were not significant. Without searching beyond the system for other predictor variables, a simple time variable, which indexed the year in the series, was used. Hence, even when values for structural variables in the system changed, the UHF and FM sectors for the most part remained unchanged. Incomplete data and/or a real lack of structural equations to predict the early years of these two media could be responsible for this deficiency, which affected the overall sensitivity of the model.

Secondly, what seemed on first inspection to be a potentially complex system was able to be modelled with relatively few endogenous variables with simple linkages among and between them. In the model development stage, complex relationships were proposed to predict most variables, only to discover that some of the predictor variables did not make a significant contribution to the equation. These variables were therefore eliminated. For example, variables from other subsectors were included as predictors within a subsector to acknowledge a possible overlap among subsectors--television affecting magazines and newspapers, FM radio affecting AM radio--but most of these cross-sector variables were not significant in the regression equations. Variables from the newspaper subsector, such as circulation and cost, were included in early equations for the magazine subsector, and vice versa, in an attempt to determine how much effect the publishers have on each other. The results were not significant, and therefore the variables were not included in the final equations.

In the time period of this study--1945 to 1960, the print sector was largely insensitive to changes in the broadcast sector, even though magazine circulation was a function of television households. Only when a shift in advertising expenditures occurred, as it did when an all UHF sector was imposed on the system, did revenues change slightly. Newspapers and consumer publications do not compete with the broadcast media for the exclusive claim to each consumer; rather, the consumer reads such publications in addition to his/her radio listening and television watching. Newspapers and magazines were not radically affected by the other's behavior either, as the lack of linkages between the two subsystems suggested. The often expressed fear that a new medium will siphon off advertiser dollars from existing media was not supported in MASSMOD; rather, newspaper and magazine advertising expenditures increased during the period.

The demise of mass circulation magazines in the 1960's, attributed to television, did not occur in this time period. Further, since television won over advertisers from magazines on the basis of audience demographics and not mere audience size, the model may not have reflected such an effect, since it deals with audiences at a high level of aggregation which ignores demographic differences. A more microscopic approach would be required to detect such an effect.

In the broadcast sector, each medium was isolated from the other, again indicated by the lack of broadcast variables passed from subsector to subsector. Attempts were made to include, for example, AM variables in FM and television equations, but the results were not significant. Several relationships existed in the AM subsector, which were contrary to expected behavior. It was assumed that lagged AM earnings would influence the number of AM stations in operation directly; that is, as earnings increased more investors would be willing to establish AM stations and the number of such stations would increase. However, as stations increased in number, the total AM earnings decreased, and vice versa, as number of stations decreased, earnings increased. This suggests that AM stations may function, not as competitors, but in an oligopoly, where strong, financially sound stations can ward off the attempts of newer stations to enter the broadcasting market and generate higher earnings for themselves.

Additionally, it was assumed that a greater number of stations would attract a larger audience, but the opposite held true--an increase in the number of stations caused a decrease in audience. The audience variable is linked to advertising buys, which influence both AM revenues and expenses. Thus a larger audience could result in higher advertising expenditures which would cause higher earnings, and therefore fewer stations. The result is unexpected in the sense that the FCC and other access advocates have argued that more stations mean more audience potential.

The lack of structural equations using endogenous variables from the system to predict FM variables, which instead relied on time parameters for estimates, indicated a failure to identify key variables for the subsystem. On the other hand, the simplicity of this subsystem could be attributed to FM's step-child role in a system dominated by AM-FM combinations, with profits reported jointly, and AM interest in the television industry.

The introduction of UHF television into the media system in 1945, as if no freeze had occurred and the decision was made to use both VHF and UHF bands for commercial television had little effect on the VHF subsector, indicating its strength and ability to withstand competition. Hence, under the conditions of the model, UHF stations might always have been less profitable than VHF stations, an argument not accepted by those UHF proponents who maintain the ranking occurred only because VHF had an eight-year head start. The subsector equations showed that advertising expenditures on VHF were predictors of both VHF revenue and expenses, a logical relationship since a broadcaster would spend more on programming to attract a large audience which in turn would attract more advertising dollars. No variables except disposable income and time were found to be significant predictors of the size of the VHF television audience. While such variables as receiver supply, receiver costs, number of AM households, circulation of newspapers and magazines were included in regression equations in the model development stage, none of the variables produced significant coefficients. The consumer decision to watch television, or in actuality to own a television set, must be based on an entirely different set of variables from those included in the model.

Lack of predictor variables for the UHF television audience followed from the experience of the FM subsector. However, like the FM subsector, the UHF subsector equations contained few endogenous system variables and relied mostly on time variables. When the subsector functions early, (Experiment 1) or alone (Experiments 5 and 6), changes in variables were due primarily to the greater range of UNYR (0 to 15, instead of 0 to 8). Also, earnings were not equal to the difference between revenues and expenses in this subsector. The actual computation of UHF earnings used this difference, but with a negative coefficient. The relationship held only for negative income for UHF; results were dramatically different when UHF incomes turned positive.

As discussed in Chapter 4, advertising buys in the model were remarkably insensitive to changes in retail profits and hence budget.

Also, retail profits and the advertising budget showed an inverse relationship, with the advertising budget increasing as retail profits declined. One could argue that a decline in sales, and hence profits, would lead a businessperson to advertise more in the hope of stimulating more sales.

At the macroscopic level, overall, the system represented by MASSMOD showed a remarkable stability during 1945-1960, when television, first VHF and then UHF, was introduced to the system. The number of magazines and newspapers published in the period remained fairly constant; revenues grew slightly as both advertising expenditures on each medium and circulation increased. The print sector was not integrally linked to the broadcast sector in terms of sensitivity to change. AM stations increased in number and listenership, although earnings declined and advertising expenditures were transferred to television. FM stations grew steadily, while revenues and expenses declined, and then took an upward swing. UHF television seemed the most unstable subsector, with most variables decreasing in value over the years and earnings in the red. The experiments performed on the system, which assumed that initial conditions were the same as the historical situation, indicated that the system would remain remarkably the same under different policy parameters. Only a total FM and/or a total UHF broadcasting system would make those media prominent and profitable, though still not as successful as historical AM radio or VHF television.

Future Directions

The construction of MASSMOD and the execution of experimental manipulations suggest future directions and further research dealing with systems simulation as a methodology to study the mass media industry and to aid in policymaking. Some suggestions deal with direct modifications of the model, others with additional experiments which could be performed, and still others with possibilities for MASSMOD beyond its 1960 cutoff date.

Model Improvements

Most of the weaknesses of the model have been discussed in some detail elsewhere in this document. They are summarized here.

First, better data sources, if they exist, need to be found for the UHF and FM subsectors to aid in the search for more meaningful prediction equations using variables of importance to the model. The heavy reliance on a time variable is not desirable.

The calculation of number of FM stations is an especially poor link in the FM subsector. Either a different function must replace the exponential relationship that is used, or other variables of significance need to be located.

Another data problem exists in the advertiser sector. Compatible data describing the advertising expenditures and retail profits of the same group of industries and businesses need to be found to make the allocation of advertising expenditures more sensitive to changes in profits. This also involves the inclusion of expenses of those same industries so that a real calculation of profits can be made.

The allocation of advertising moneys to radio and television is made on a two-step basis. First, network, spot and local purchases on all radio and television stations are computed and totalled. Then, on a straight percentage basis, 20 percent of the total is assigned to FM and 80 percent to AM. Likewise, 25 percent of the television total is assigned to UHF, and 75 percent to VHF. A functional relationship, relating percentage and time, should be introduced to put this allocation on a sliding scale. It is not certain that data exist to describe this function, however.

Each subsector in the system is relatively autonomous. The search for variables and relationships that interweave system components must be continued to make components more sensitive to each other. It is difficult to imagine that UHF television introduced in 1945 did not have more of an effect on VHF television. It is also difficult to reconcile the enormous changes to the FM sector in the spectrum allocation experiments caused by the faulty FMNO calculation with the relatively small changes in Theil's U when experiments and the benchmark were compared.

UHF television households did not add significance to regression equations in the benchmark version of the model, when VHF television households were also included as predictors. This stems from the fact that UHF audiences duplicate VHF audiences, rather than comprise their own unique audience. UHF-only television sets did not, and still do not, exist. However, when the model operates in a UHF television-only mode, the values for UHF television households need to be substituted for VHF households, since it is the only television competitor against print and radio. Allowing the model to run with a value of 0 for VHF households in the UHF-only mode is not correct.

The allocation of advertising expenditures among the media should be made more complex, though still remain stochastic, to introduce an element of choice and substitutability among media options. At a more microscopic level, this would begin to involve optimization of buys in terms of cost, reach and frequency. A way of expressing this at a macro level, without target audiences of product specificity, needs to be found.

Finally, the consumer sector should be modified from its deterministic state to a more stochastic model, integrating some of the previous research on consumer allocations of time to the media with the prediction of media audiences. This would expand the model from its structural, economic representation to a behavioral system as well. The task here is to relate consumer time allocations to the head count of persons and/or households required by audience and circulation measures.

Also, media costs need to be considered in the subsector, in terms of subscription costs and receiver expenditures. A cursory attempt was made to incorporate such cost into audience regression equations, but the results were not significant. More work needs to be done on this problem.

Further Experiments

Once a basic simulation model has been constructed, the number of experiments which can be designed for execution is almost limitless. Included here are further experiments either initially suggested as part of the current study, or which emerged from this research.

In the area of spectrum use, experiments in this study dealt only with reduced or increased spectrum assignment to a medium, but did not consider the width of the broadcast channel. In the light of the debate over changing AM channels from 10 to 9 kHz, this might make an interesting exploration.

Another area of discussion about the spectrum deals with abandonment of the traditional FCC licensing procedure in favor of marketplace economics. Introducing a fee or auction bid for a frequency assignment into the system would help predict the effect of such a plan, part of a larger deregulation package circulating among House and Senate Communication Subcommittees. (U.S. Congress, H.R. 13015, 1978)

Two experiments in this study imposed external controls on advertising expenditures. Also mentioned in the rationale for those experiments was the possibility of limiting the amount of advertising time and space available for purchase. This would involve the advertiser sector, and focus on supply, demand and advertising costs as they affect media revenues and growth.

Cross-media ownership (i.e., ownership of a broadcasting entity by a newspaper, or ownership of two or more different types of broadcasting media) is a reality assumed to exist and operate in MASSMOD, but it is never specifically quantified or manipulated. Revenue from cross-ownership interests could explain why earnings are not the simple difference between revenue and expenses in several subsectors. Given the FCC's concern and actions regarding broadcast interests owned by newspapers, it would be informative to quantify investments by one medium to another. Also, experimentation with the subsidization of one broadcasting medium by another (VHF television's early support from AM broadcasters, for example) would generate data of interest to those concerned with newer communications technologies and their possible subsidization. Manipulation of such a policy variable, once quantified in the model, could supply output which might address questions such as rate of acceptance by the public, cost of the technology, effect on existing communications systems with and without cross-subsidization. The difficulty of executing such experiments is that, to the researcher's knowledge, no data exist at the level of aggregation of this model which quantify the extent of cross-ownership, or deal with its effects. It seems that data from individual media owners, and/or microanalytical cross-ownership studies, may have to be located first, and then aggregated for use.

The history of the growth of the mass media, both print and broadcast, suggests that technological developments and improvements are keys to industry expansion and improvement. It is clear that until technological advances bring the cost of receiving equipment down to consumer-affordable levels, the medium does not advance. Not until printing presses were powered by steam and type set by linotype machines instead of by hand did newspaper circulations begin to reflect acceptance by the masses who were able to afford a penny per copy.

Competition in the marketplace is a prime motivator of such development: at the same time, claims about the high profit ratios of broadcasters and some publishers have been made. It seems that some form of control or requirement on research and development investments of broadcasters and publishers might provide a means of reinvestment for high profits and speed the growth of the communications technologies, which need capital to develop and sell. Finding historical research and development figures and building these into the model might be difficult, if not impossible.

Model Expansion

Perhaps even more important than the additional experiments which can be run with MASSMOD in the 1945-1960 time period, is the expansion of the model itself to reflect two more decades of growth and development within the mass media industry. The selection of the 15-year time period to study the mass media industry was designed to provide a contained system in which to establish initial structures and data bases. Now that a model has successfully been constructed and data sources located, MASSMOD needs to be updated and diversified to include developments such as color television, cable television, video discs and videocassette recorders and pay television. Such development may be easier in a two-step, one decade at a time approach, but more thorough record-keeping on the part of industry trade groups can only make the task easier than the present research. Once the model is updated to 1980, it can then be used to extrapolate beyond the data, to explore effects of even newer technologies, such as direct broadcast satellites, and the growth rate of video recorders and discs.

Another direction for improvement would be movement from a highly aggregate macroscopic investigation of the system to a less aggregate microscopic system, where the differences between individual stations, publications, advertisers and consumers can have an effect on system behavior. Such disaggregation could make the system more stochastic, and certainly more complex, but it would also lead to a more detailed understanding of the structure of the media system.

The suggestions for further research presented in this chapter reflect the fact that MASSMOD presents a simple, though valid, mathematical representation of the mass media industry from 1945-1960. As such it has lived up to its purpose as an exploratory effort into the use of systems simulation as an appropriate tool for study of the behavior of the mass media industry. Supported by additional data, the model needs to be expanded, and improved, so that mathematical relationships and theoretical speculations which are not included in MASSMOD, especially in the FM and UHF sectors, may be investigated. To be used as a real forecasting tool, the model needs to be updated to describe industry behavior in the 1960's and 1970's.

Despite its shortcomings, MASSMOD has pulled together elements of a media system too often studied in isolation, and quantified abstract relationships. It is a simulation of a historical reality, available for experimentation and questioning. Even if one is unwilling to accept the validity of the model built here, one should agree that this study has shown that it is possible to build a simulation model of an industry that can yield interesting, valuable, and sometimes counter-intuitive insights. Thus, as the minimum, this study has suggested an approach that someone with access to a rich data base could use to make accurate predictions of the consequences of policy decisions made to influence the behavior of the mass media system.

APPENDIX A

TABLE A1

REGRESSION EQUATIONS
NEWSPAPER SUBSECTOR

NSUBREV = 540.1973 + 0.01837 * NEWSCIR(t-1)
(.281) (.065)

F_2 = 4.414
R^2 = .329
P = .065

NEWSNO(t) = 1505.27 + 61.59 * ln(NEWEARN(t-1))
(.0000) (.162)
- 0.267 * GNP(t)
(.007)

F_2 = 8.438
R^2 = .565
P = .004

NPUBCST(t) = -14021.335 + 1797.32 * ln(NEWSPR(t))
(.0000) (.0000)

F_2 = 152.83
R^2 = .982
P = .0000

TABLE A2

REGRESSION EQUATIONS
MAGAZINE SUBSECTOR

$$\begin{array}{lllll} MAGNO(t) & = 204.41733 & - 0.0138 * MAGREV(t-1) & F & = 130.59 \\ & (.013) & \quad (.666) & R^2 & = .989 \\ & & + 0.144 * GNP(t) & P & = .001 \\ & & \quad (.066) & & \end{array}$$

$$\begin{array}{lllll} MPUBCST(t) & = 329.17166 & + 0.003043 * MAGCIRC(t-1) & F & = 441.19 \\ & (.000) & \quad (.022) & R^2 & = .988 \\ & & + 1.3181 * GNP(t) & P & = .000 \\ & & \quad (.000) & & \end{array}$$

$$\begin{array}{lllll} MAGCOST(t) & = 5.5580 & + 0.00104 * MPUBCST(t) & F & = 12.401 \\ & (.000) & \quad (.004) & R^2 & = .508 \\ & & & P & = .004 \end{array}$$

$$\begin{array}{lllll} MAGREV(t) & = 1073.93 & + 0.5794 * (MSUBREV + TMAGBUY(t)) & F & = 51.56 \\ & (.005) & \quad (.002) & R^2 & = .927 \\ & & & P & = .002 \end{array}$$

TABLE A3

REGRESSION EQUATIONS
AM RADIO SUBSECTOR

AMNO(t) = 2727.4112 - 3.1284 * GNP(t)
(.017) (.113)
- 1.7826 * AMEARN(t-1)
(.152)
+ 213.4629 * RNYR
(.000)

F = 144.805
R^2 = .973
P = .000

AMEXP(t) = 513.0369 + 0.0000199 * AMHH(t-1)
(.0000) (.0000)
+ 0.07119 * AMNO(t)
(.000)

F = 39.738
R^2 = .8559
P = .000

AMREV(t) = 118.423 + 0.760 * AMBUY(t)
(.194) (.000)
+ 0.689 * (RNYR**2)
(.000)

F = 35.662
R^2 = .856
P = .000

AMEARN(t) = 59.059 + 0.49 * AINCOME
(.194) (.001)

F = 16.048
R^2 = .534
P = .001

TABLE A4

REGRESSION EQUATIONS
FM RADIO SUBSECTOR

$$FMNO(t) = \exp(\underset{(.000)}{7.2081} - \underset{(.008)}{0.09624} * FMEARN(t-1) + \underset{(.0000)}{1.3663} * \ln(RNYR) - \underset{(.000)}{0.00633} * GNP(t))$$

$F = 88.93$, $R^2 = .9557$, $P = .000$

$$FMREV(t) = -\underset{(.000)}{16.518} + \underset{(.000)}{0.086} * FMBUY(t) + \underset{(.000)}{0.00023} * (RNYR**3)$$

$F = 296.63$, $R^2 = .983$, $P = .000$

$$FMEXP(t) = \underset{(.000)}{11.42477} + \underset{(.000)}{0.01899} * (RNYR**3) - \underset{(.000)}{0.28225} * (RNYR**2)$$

$F = 86.478$, $R^2 = .945$, $P = .000$

TABLE A5

REGRESSION EQUATIONS
VHF TELEVISION SUBSECTOR

VHFNO(t) = -177.1866 + 0.3032 * GNP(t)
(.299) (.388)
+ 0.62554 * VHFEARN(t-2)
(.060)
+ 20.4162 * RNYR
(.014)

F = 82.177
R^2 = .965
P = .000

VHFREV(t) = -24.63 + 0.48 * VHFBUY(t)
(.649) (.000)

F = 120.11
R^2 = .923
P = .000

VHFEXP(t) = -32.78 + 0.489 * VHFBUY(t)
(.780) (.072)
- 0.0053 * VHFHH(t-1)
(.519)

F = 31.552
R^2 = .875
P = .000

TABLE A6

REGRESSION EQUATIONS
UHF TELEVISION SUBSECTOR

$$UHFNO(t) = \underset{(.000)}{128.21031} - \underset{(.083)}{0.55432} * UHFEARN(t-1) + \underset{(.016)}{0.87311} * (UNYR^{**}2) - \underset{(.0030)}{13.8565} * UNYR$$

$F = 238.57$
$R^2 = .996$
$P = .000$

$$UHFEXP(t) = \underset{(.000)}{26.6837} - \underset{(.114)}{0.001047} * UHFHH(t-1) + \underset{(.000)}{0.25604} * UHFNO(t)$$

$F = 45.47$
$R^2 = .948$
$P = .001$

$$UHFREV(t) = \underset{(.000)}{34.317} - \underset{(.238)}{0.0216} * UHFBUY(t) + \underset{(.021)}{0.274} * UHFNO(t)$$

$F = 10.93$
$R^2 = .814$
$P = .015$

$$UHFEARN(t) = \underset{(.009)}{-5.380} - \underset{(.048)}{2.395} * (UINCOME^{**}2) - \underset{(.004)}{6.030} * UINCOME$$

$F = 12.96$
$R^2 = .838$
$P = .011$

TABLE A7

REGRESSION EQUATIONS
ADVERTISER SECTOR

AVNEW	= 24.285 + 0.00263*NEWSCIR(t-1)	F = 67.074
	(.0000) (.000)	R^2 = .912
	- 0.0667*NEWSNO(t-1)	P = .000
	(.000)	
AVMAG	= 9.194 + 0.0000183*MAGCIRC(t-1)	F = 50.788
	(.000) (.610)	R^2 = .927
	+ 0.0000696*VHFHH(t-1)	P = .000
	(.016)	
	- 0.0111*MAGNO(t-1)	
	(.593)	
AVNRD	= 5.3917 - 0.00004251*AMHH(t-1)	F = 223.052
	(.000) (.000)	R^2 = .974
	- 0.00006839*VHFHH(t-1)	P = .000
	(.000)	
AVSRD	= 2.4464 - 0.000007685*AMHH(t-1)	F = 28.728
	(.0000) (.059)	R^2 = .887
	- 0.00003470*VHFHH(t-1)	P = .000
	(.009)	
	+ 0.01238*(RNYR**2)	
	(.000)	
AVLRD	= 2.881 + 0.0456*SQRT(RADNO(t-1))	F = 65.245
	(.0000) (.000)	R^2 = .824
		P = .000
AVNTV	= 2.94781 + 0.0004359*VHFHH(t-1)	F = 1796.46
	(.0000) (.0000)	R^2 = .998
	- 0.044057*(RNYR**2)	P = .000
	(.000)	

TABLE A7 (cont'd)

AVSTV	= 1.20097 + 0.0001101*VHFHH(t-1)	F_2 = 434.671
	(.000) (.004)	R^2 = .990
	+ 0.009543*(RNYR**2)	P = .000
	(.188)	
AVLTV	= 1.562 + 0.0090*TVNO(t-1)	F_2 = 35.443
	(.000) (.017)	R^2 = .887
	- 0.0080*(RNYR**2)	P = .000
	(.368)	
BUDGET	= 4474.89 - 0.0013*RETPROF(t-1)	F_2 = 358.446
	(0) (.375)	R^2 = .982
	+ 413.43*RNYR	P = .000
	(0)	

TABLE A8

REGRESSION EQUATIONS
CONSUMER SECTOR

ADULTPC	= 0.709 - 0.0045*RNYR (.0000) (.000)	F_2 = 439.31 R^2 = .969 P = .000
AMHHPC	= 1.039 - 0.0000127*AMNO(t) (.0000) (.277) - 0.00000862*AMSETS(t) (.004)	F_2 = 34.073 R^2 = .883 P = .000
FMHHPC	= 0.043 + 0.093*ln(RNYR) (.097) (.0000) - 0.000018*DISINC(t) (.121)	F_2 = 3758.51 R^2 = .998 P = .000
VHFHHPC	= -1.058 - 0.0004*(RNYR**3) (.219) (.004) + 0.00045*DISINC(t) (.232) + 0.0097*(RNYR**2) (.002)	F_2 = 176.149 R^2 = .985 P = .000
UHFHHPC	= 0.0081 + 0.042*ln(UNYR) (.399) (.001) - GROWTH	F_2 = 37.616 R^2 = .862 P = .001
NEWSPC	= 0.463 + 0.0000504*NEWSNO(t) (.006) (.448) - 0.00326*NEWCOST(t) (.000) + 0.0000177*DISINC(t) (.054)	F_2 = 13.975 R^2 = .792 P = .000

TABLE A8 (cont'd)

MAGPC	= -0.536 + 0.00582*MAGNO(t)	F_2 = 158.067
	(.001) (.000)	R^2 = .963
	+ 0.000217*DISINC(t)	P = .000
	(.120)	

APPENDIX B

```
      PROGRAM MASSMOD(INPUT,OUTPUT,TAPE6=OUTPUT)
      IMPLICIT REAL(A-Z)
      INTEGER NIT,NYR
      COMMON/EXOG/GNP(16)
      COMMON/NEWDATA/NEWCOST(16),NEWSNO(16),NPUBCST(16),NEWSREV(16),
     +               NEWEARN(16),NEWPROF(16),NEWSCIR(16),TNEWBUY(16)
      COMMON/MAGDATA/MAGNO(16),MPUBCST(16),MAGCOST(16),MAGREV(16),
     +               MAGEARN(16),MAGPROF(16),MAGCIRC(16),TMAGBUY(16)
      COMMON/AMDATA/AMNO(16),AMREV(16),AMEXP(16),AMEARN(16),AMPROF(16),
     +              AMHH(16),AMBUY(16)
      COMMON/FMDATA/FMNO(16),FMREV(16),FMEXP(16),FMEARN(16),FMPROF(16),
     +              FMHH(16),FMBUY(16)
      COMMON/VHFDATA/VHFNO(16),VHFREV(16),VHFEXP(16),VHFEARN(16),
     +               VHFPROF(16),VHFHH(16),VHFBUY(16)
      COMMON/UHFDATA/UHFNO(16),UHFREV(16),UHFEXP(16),UHFEARN(16),
     +               UHFPROF(16),UHFHH(16),UHFBUY(16)
      COMMON/ADVDATA/TBUY(16),RETPROF(16)
      COMMON/POPDATA/POP(16),POPHH(16),POPADLT(16)
      COMMON/OWNDATA/CROWN
      DATA GNP/564.1,477.6,468.3,487.7,490.7,533.5,576.5,598.5,621.8,
     +         613.7,654.8,668.8,680.9,679.5,720.4,736.8/
      DATA CROWN/0./
C
C   SET SIMULATION RUN LENGTH
C
      RLNGTH=16.
      DT=1.
      NIT=RLNGTH/DT + 0.00001
C
C   EXECUTION
C
      DO 30 NYR=1,NIT
      CALL ADSEC(NYR)
      CALL PRSEC(NYR)
      CALL RADSEC(NYR)
      CALL CONSEC(NYR)
      CALL VHFSEC(NYR)
      CALL UHFSEC(NYR)
   30 CONTINUE
      CALL REPORT
      END
```

```
      SUBROUTINE ADSEC(NYR)
      IMPLICIT REAL(A-Z)
      COMMON/X/PARAM(128,4),ISEED
      COMMON/NEWDATA/NEWCOST(16),NEWSNO(16),NPUBCST(16),NEWSREV(16),
     +              NEWEARN(16),NEWPROF(16),NEWSCIR(16),TNEWBUY(16)
      COMMON/MAGDATA/MAGNO(16),MPUBCST(16),MAGCOST(16),MAGREV(16),
     +              MAGEARN(16),MAGPROF(16),MAGCIRC(16),TMAGBUY(16)
      COMMON/AMDATA/AMNO(16),AMREV(16),AMEXP(16),AMEARN(16),AMPROF(16),
     +             AMHH(16),AMBUY(16)
      COMMON/FMDATA/FMNO(16),FMREV(16),FMEXP(16),FMEARN(16),FMPROF(16),
     +             FMHH(16),FMBUY(16)
      COMMON/VHFDATA/VHFNO(16),VHFREV(16),VHFEXP(16),VHFEARN(16),
     +              VHFPROF(16),VHFHH(16),VHFBUY(16)
      COMMON/UHFDATA/UHFNO(16),UHFREV(16),UHFEXP(16),UHFEARN(16),
     +              UHFPROF(16),UHFHH(16),UHFBUY(16)
      COMMON/ADVDATA/TBUY(16),RETPROF(16)
      INTEGER ISEED,NYR,NIT,KKK,NYRNEW,NYRMAG,NYRNTV,NYRSTV,NYRLTV,
     +       NYRNRD,NYRSRD,NYRLRD,I,J
      DIMENSION SALES(16),TVNO(16),RADNO(16)
      DATA SALES/207537.,238729.,246290.,251637.,254340.,274651.,
     +          273208.,279919.,287087.,283308.,301395.,301636.,
     +          307695.,303565.,319130.,319547./
      DATA((PARAM(I,J),I=1,128),J=1,2)/256*0./
      DATA((PARAM(I,J),I=1,128),J=3,4)/26.60,28.59,32.19,34.84,38.02,
     +40.1,41.01,43.97,45.84,46.06,51.64,52.94,51.66,50.,54.07,54.59,
     +27.45,168.47,19.92,45.20,43.73,44.78,49.42,19.62,28.34,31.66,
     +39.20,38.60,53.85,33.50,44.44,55.31,39.68,109.66,33.50,32.02,
     +31.65,29.85,64.61,27.98,74.58,20.65,16.39,12.71,13.08,9.09,
     +7.41,7.28,26.60,25.06,24.14,24.48,28.52,29.85,27.92,31.03,
     +32.26,26.80,26.23,31.80,38.46,39.39,44.44,46.58,39.89,45.56,
     +50.3,56.5,57.03,59.7,61.08,68.97,67.91,65.33,65.57,65.18,64.62,
     +65.15,66.67,65.5,3*0.,1.7,5.7,15.86,37.03,24.48,53.92,83.85,154.82
     +,69.08,74.79,135.15,110.43,67.54,3*0.,0.5,1.9,9.33,13.09,17.24,
     +16.98,26.8,32.79,39.75,39.86,60.61,66.73,58.22,3*0.,1.0,3.8,11.19,
     +13.96,17.24,23.77,30.15,36.89,40.22,37.54,37.88,40.,40.76,
     +16*9.,16*3.,16*2.,32*5.,16*3.,32*6./
      DATA ISEED/1234/
      DATA NEWSCRI,MAGCIRI,AMHHI,VHFHHI/45955.,115967.,32500.,0./
      DATA NEWSNOI,MAGNOI,RADNOI,TVNOI/1857.,217.,954.,8./
C
C  LOCATE SPECIFIC MEDIA IN PARAM ARRAY
C
      NYRNEW=NYR
      NYRMAG=NYR+16
      NYRNRD=NYR+32
      NYRSRD=NYR+48
      NYRLRD=NYR+64
      NYRNTV=NYR+80
      NYRSTV=NYR+96
      NYRLTV=NYR+112
      RNYR=NYR-1
      IF(NYR .NE. 1) GO TO 1
```

```
C
C  INITIALIZE FIRST YEAR --LAGGED VARIABLES
C
      PARAM(NYRNEW,1)=(24.285 + 0.00263*NEWSCRI - 0.0667*NEWSNOI)/
     +                PARAM(NYRNEW,4)
      PARAM(NYRMAG,1)=(9.194 + 0.0000183*MAGCIRI + 0.0000696*VHFHHI
     +                -0.0111*MAGNOI)/PARAM(NYRMAG,4)
      PARAM(NYRNRD,1)=(5.3917 - 0.00004251*AMHHI - 0.00006839*
     +                VHFHHI)/PARAM(NYRNRD,4)
      PARAM(NYRSRD,1)=(2.4464 - 0.000007685*AMHHI - 0.00003470*
     +                VHFHHI)/PARAM(NYRSRD,4)
      PARAM(NYRLRD,1)=(2.881 + 0.0456*SQRT(RADNOI))/PARAM(NYRLRD,4)
      PARAM(NYRNTV,1)=(2.94781  + 0.0004359*VHFHHI)/PARAM(NYRNTV,4)
      PARAM(NYRSTV,1)=(1.20097 + 0.0001101*VHFHHI)/PARAM(NYRSTV,4)
      PARAM(NYRLTV,1)=(1.562 + 0.0090*TVNOI)/PARAM(NYRLTV,4)
      GO TO 2
    1 RADNO(NYR-1)=AMNO(NYR-1) + FMNO(NYR-1)
      TVNO(NYR-1)=VHFNO(NYR-1) + UHFNO(NYR-1)
      AVNEW=24.285 + 0.00263*NEWSCIR(NYR-1) - 0.0667*NEWSNO(NYR-1)
      PARAM(NYRNEW,1)=AVNEW/PARAM(NYRNEW,4)
      AVMAG=9.194 + 0.0000183*MAGCIRC(NYR-1) + 0.0000696*VHFHH(NYR-1)
     +      -0.0111*MAGNO(NYR-1)
      PARAM(NYRMAG,1)=AVMAG/PARAM(NYRMAG,4)
      AVNRD=5.3917 -0.00004251*AMHH(NYR-1) - 0.00006839*VHFHH(NYR-1)
      PARAM(NYRNRD,1)=AVNRD/PARAM(NYRNRD,4)
      AVSRD=2.4464 - 0.000007685*AMHH(NYR-1) - 0.00003470*VHFHH(NYR-1)
     +      + 0.01238*(RNYR**2)
      PARAM(NYRSRD,1)=AVSRD/PARAM(NYRSRD,4)
      AVLRD=2.881 + 0.0456*SQRT(RADNO(NYR-1))
      PARAM(NYRLRD,1)=AVLRD/PARAM(NYRLRD,4)
      AVNTV=2.94781 + 0.0004359*VHFHH(NYR-1) - 0.044057*(RNYR**2)
      PARAM(NYRNTV,1)=AVNTV/PARAM(NYRNTV,4)
      AVSTV=1.20097 + 0.0001101*VHFHH(NYR-1) + 0.009543*(RNYR**2)
      PARAM(NYRSTV,1)=AVSTV/PARAM(NYRSTV,4)
      AVLTV=1.562 + 0.0090*TVNO(NYR-1) - 0.0080*(RNYR**2)
      PARAM(NYRLTV,1)=AVLTV/PARAM(NYRLTV,4)
    2 BUDGET=0.007517*SALES(NYR) + 649.04688*RNYR + 4894.7131
C
C  CALCULATE TOTAL AD BUYS FOR 100ADVERTISERS
C
      TMAGBUY(NYR)=0.
      TNEWBUY(NYR)=0.
      TNRDBUY=0.
      TSRDBUY=0.
      TLRDBUY=0.
      TNTVBUY=0.
      TSTVBUY=0.
      TLTVBUY=0.
      TBUY(NYR)=0.
      DO 20 KKK=1,100
      TNEWBUY(NYR)=TNEWBUY(NYR) +ERLNG(NYRNEW)
      TMAGBUY(NYR)=TMAGBUY(NYR) + ERLNG(NYRMAG)
      TNRDBUY=TNRDBUY +ERLNG(NYRNRD)
      TSRDBUY=TSRDBUY +ERLNG(NYRSRD)
      TLRDBUY=TLRDBUY +ERLNG(NYRLRD)
```

```
   IF(NYR .LT. 4) GO TO 20
   TNTVBUY=TNTVBUY + ERLNG(NYRNTV)
   TSTVBUY=TSTVBUY +ERLNG(NYRSTV)
   TLTVBUY=TLTVBUY + ERLNG(NYRLTV)
20 CONTINUE
   TBUY(NYR)=TNEWBUY(NYR) + TMAGBUY(NYR) + TNRDBUY + TSRDBUY+
  +          TLRDBUY + TNTVBUY + TSTVBUY + TLTVBUY
   OBDGT=BUDGET - TBUY(NYR)
   RADTOT=TNRDBUY + TSRDBUY + TLRDBUY
   TVTOT=TNTVBUY + TSTVBUY + TLTVBUY
   AMBUY(NYR)=0.80*RADTOT
   FMBUY(NYR)=0.20*RADTOT
   IF(NYR - 8) 31,32,32
31 VHFBUY(NYR)=TVTOT
   UHFBUY(NYR)=0.
   GO TO 33
32 VHFBUY(NYR)=0.75*TVTOT
   UHFBUY(NYR)=0.25*TVTOT
33 RETPROF(NYR)=SALES(NYR) - TBUY(NYR)
   RETURN
```

```
      FUNCTION DRAND(ISEED)
      DRAND=RANF(ISEED)
      RETURN
      END
      FUNCTION ERLNG(J)
      COMMON/X/PARAM(128,4),ISEED
      K=PARAM(J,4)
      IF(K-1) 1,2,2
    1 PRINT 10,J
   10 FORMAT(/16H K=0 FOR ERLNG   , I7)
      RETURN
    2 R=1
      DO 3 I=1,K
      RNUM=DRAND(ISEED)
    3 R=R * RNUM
      ERLNG= -PARAM(J,1)*ALOG(R)
      IF(ERLNG - PARAM(J,2)) 4,5,6
    4 ERLNG=PARAM(J,2)
    5 RETURN
    6 IF(ERLNG - PARAM(J,3)) 5,5,7
    7 ERLNG=PARAM(J,3)
      RETURN
      END
```

```
      SUBROUTINE PRSEC(NYR)
      IMPLICIT REAL(A-Z)
      INTEGER NYR
      COMMON/NEWDATA/NEWCOST(16),NEWSNO(16),NPUBCST(16),NEWSREV(16),
     +               NEWEARN(16),NEWPROF(16),NEWSCIR(16),TNEWBUY(16)
      COMMON/MAGDATA/MAGNO(16),MPUBCST(16),MAGCOST(16),MAGREV(16),
     +               MAGEARN(16),MAGPROF(16),MAGCIRC(16),TMAGBUY(16)
      COMMON/OWNDATA/CROWN
      COMMON/EXOG/GNP(16)
      DIMENSION NEWSPR(16)
      DATA NEWSPR/3237.,3995.,4420.,4781.,5142.,5521.,5557.,5569.,
     +            5713.,5732.,6173.,6320.,6300.,6059.,6578.,6800./
      DATA NEWSCRI,NEARNI,MAGCIRI,MEARNI/45955.,3148.,115967.,2050./
C
C INITIALIZATION FOR YEAR ONE LAGGED VARIABLES
C
      IF(NYR .NE. 1)  GO TO 10
      NSUBREV=540.1973 + 0.01837*NEWSCRI
      NEWCOST(1)=NSUBREV/NEWSCRI*1000.
      NEWSNO(1)=1505.27 + 61.59*ALOG(NEARNI) - 0.267*GNP(1)
      MPUBCST(1)=329.1717 + 0.003043*MAGCIRI + 1.3181*GNP(1)
      MAGCOST(1)=5.5580 + 0.00104*MPUBCST(1)
      MAGNO(1)=204.41733 -0.0138*MEARNI + 0.144*GNP(1)
      MSUBREV=(MAGCOST(1)*MAGCIRI)/1000.
      GO TO 20
C
C  EXECUTION PHASE
C
   10 NSUBREV=540.1973 + 0.01837*NEWSCIR(NYR-1)
      NEWCOST(NYR)=NSUBREV/NEWSCIR(NYR-1)*1000.
      NEWSNO(NYR)=1505.27 + 61.59*ALOG(NEWEARN(NYR-1)) - 0.267
     +            *GNP(NYR)
      MAGNO(NYR)=204.41733 - 0.0138*MAGREV(NYR-1) + 0.144*GNP(NYR)
      MPUBCST(NYR)=329.17166 + 0.003043*MAGCIRC(NYR-1) + 1.3181*GNP(NYR)
      MAGCOST(NYR)=5.5580 + 0.00104*MPUBCST(NYR)
      MSUBREV=(MAGCOST(NYR)*MAGCIRC(NYR-1))/1000.
   20 NPUBCST(NYR)= -14021.335 + 1797.32*ALOG(NEWSPR(NYR))
      NEWSREV(NYR)=NSUBREV + TNEWBUY(NYR)
      NEWEARN(NYR)=NEWSREV(NYR) - NPUBCST(NYR)
      NEWPROF(NYR)=NEWEARN(NYR) +CROWN
      MAGREV(NYR)=1073.93 + 0.5794*(MSUBREV + TMAGBUY(NYR))
      MAGEARN(NYR)=MAGREV(NYR) - MPUBCST(NYR)
      MAGPROF(NYR)=MAGEARN(NYR) +CROWN
      RETURN
```

```
      SUBROUTINE RADSEC(NYR)
      COMMON/AMDATA/AMNO(16),AMREV(16),AMEXP(16),AMEARN(16),AMPROF(16),
     +              AMHH(16),AMBUY(16)
      COMMON/FMDATA/FMNO(16),FMREV(16),FMEXP(16),FMEARN(16),FMPROF(16),
     +              FMHH(16),FMBUY(16)
      COMMON/EXOG/GNP(16)
      COMMON/OWNDATA/CROWN
      DATA AMEARNI,AMHHI,FMEARNI/200.,32500.,-5.0/
C
C  INITIALIZATION
C
      RNYR=NYR-1
      IF(NYR .NE. 1)  GO TO 10
      AMNO(1)=2727.4112 - 3.1284*GNP(1) - 1.7826*AMEARNI + 313.4629
      AMEXP(1)=513.0369 + 0.000199*AMHHI + 0.07229*AMNO(1)
      FMNOLN=7.2081 - 0.09624*FMEARNI - 0.006339*GNP(1)
      FMNO(1)=EXP(FMNOLN)
      GO TO 20
C
C  EXECUTION PHASE
C
   10 AMNO(NYR)=2727.4112 - 3.1284*GNP(NYR) - 1.7826*AMEARN(NYR-1)
     +          + 213.4629*RNYR
      AMEXP(NYR)=513.0369 + 0.0000199*AMHH(NYR-1) + 0.07229*AMNO(NYR)
      FMNOLN=7.2081 - 0.09624*FMEARN(NYR-1) + 1.3663*ALOG(RNYR)
     +       - 0.00633*GNP(NYR)
      FMNO(NYR)=EXP(FMNOLN)
   20 AMREV(NYR)=118.423 + 0.760*AMBUY(NYR) + 0.689*(RNYR**2)
      AINCOME=AMREV(NYR) - AMEXP(NYR)
      AMEARN(NYR)=59.059 + 0.49*AINCOME
      AMPROF(NYR)=AMEARN(NYR) +CROWN
      FMREV(NYR)= -16.518 + 0.086*FMBUY(NYR) + 0.0023*(RNYR**3)
      FMEXP(NYR)=11.42477 + 0.01899*(RNYR**3) - 0.28225*(RNYR**2)
      FMEARN(NYR)=FMREV(NYR) - FMEXP(NYR)
      FMPROF(NYR)=FMEARN(NYR) + CROWN
      RETURN
```

```
      SUBROUTINE VHFSEC(NYR)
      COMMON/EXOG/GNP(16)
      COMMON/VHFDATA/VHFNO(16),VHFREV(16),VHFEXP(16),VHFEARN(16),
     +               VHFPROF(16),VHFHH(16),VHFBUY(16)
      COMMON/OWNDATA/CROWN
      VHFERNI=0.
      RNYR=NYR-1
      IF(NYR .EQ. 1) GO TO 4
      IF(NYR .LT. 4)GO TO 3
      VHFNO(NYR)= -177.2866 + 0.3032*GNP(NYR) + 0.6254*VHFEARN(NYR-2)
     +            + 20.4162*RNYR
      VHFREV(NYR)= -24.63 + 0.48*VHFBUY(NYR)
      VHFEXP(NYR)= -32.78 + 0.489*VHFBUY(NYR) - 0.0053*VHFHH(NYR-1)
      VHFEARN(NYR)=VHFREV(NYR) - VHFEXP(NYR)
      VHFPROF(NYR)=VHFEARN(NYR) + CROWN
      RETURN
    3 VHFNO(NYR)= -149.156 + 0.4043*VHFERNI + 0.343*GNP(NYR)
      GO TO 5
    4 VHFNO(NYR)=0.
    5 VHFEXP(NYR)=0.
      VHFREV(NYR)=0.
      VHFEARN(NYR)=0.
      VHFPROF(NYR)=0.
      RETURN
      END
```

UHF Television Subsector--Subprogram

```
      SUBROUTINE UHFSEC(NYR)
      COMMON/UHFDATA/UHFNO(16),UHFREV(16),UHFEXP(16),UHFEARN(16),
     +               UHFPROF(16),UHFHH(16),UHFBUY(16)
      COMMON/OWNDATA/CROWN
      UNYR=NYR-9
      IF(NYR .LT. 9) GO TO 1
      UHFNO(NYR)=128.21031 - 0.55432*UHFEARN(NYR-1) + 0.87311*(UNYR**2)
     +          - 13.8565*UNYR
      IF (NYR .EQ. 9) UHFNO(NYR)=6.
      UHFEXP(NYR)=26.6837 - 0.001047*UHFHH(NYR-1)  + 0.25604*UHFNO(NYR)
      UHFREV(NYR)=34.317 -0.0216*UHFBUY(NYR) + 0.274*UHFNO(NYR)
      UINCOME=UHFREV(NYR) - UHFEXP(NYR)
      UHFEARN(NYR)= -5.380 -2.395*(UINCOME**2) -6.030*UINCOME
      UHFPROF(NYR)=UHFEARN(NYR) +CROWN
      RETURN
    1 UHFNO(NYR)=0.
      UHFEXP(NYR)=0.
      UHFREV(NYR)=0.
      UHFEARN(NYR)=0.
      UHFPROF(NYR)=0.
      RETURN
      END
```

```
      SUBROUTINE CONSEC(NYR)
      IMPLICIT REAL(A-Z)
      INTEGER NYR
      COMMON/NEWDATA/NEWCOST(16),NEWSNO(16),NPUBSCT(16),NEWSREV(16),
     +               NEWEARN(16),NEWPROF(16),NEWSCIR(16),TNEWBUY(16)
      COMMON/MAGDATA/MAGNO(16),MPUBCST(16),MAGCOST(16),MAGREV(16),
     +               MAGEARN(16),MAGPROF(16),MAGCIRC(16),TMAGBUY(16)
      COMMON/AMDATA/AMNO(16),AMREV(16),AMEXP(16),AMEARN(16),AMPROF(16),
     +              AMHH(16),AMBUY(16)
      COMMON/FMDATA/FMNO(16),FMREV(16),FMEXP(16),FMEARN(16),FMPROF(16),
     +              FMHH(16),FMBUY(16)
      COMMON/VHFDATA/VHFNO(16),VHFREV(16),VFEXP(16),VHFEARN(16),
     +               VHFPROF(16),VHFHH(16),VHFBUY(16)
      COMMON/UHFDATA/UHFNO(16),UHFREV(16),UHFEXP(16),UHFEARN(16),
     +                UHFPROF(16),UHFHH(16),UHFBUY(16)
      COMMON/POPDATA/POP(16),POPHH(16),POPADLT(16)
      DIMENSION BIRTHR(16),DEATHR(16),HHSIZE(16),AMHHPC(16),FMHHPC(16),
     +          VHFHHPC(16),UHFHHPC(16),AMSETS(16),DISINC(16),
     +          ADULTPC(16),MAGPC(16),NEWSPC(16)
      DATA BIRTHR/20.63,24.35,27.12,25.33,24.93,24.50,25.33,25.53,
     +            25.42,25.75,25.44,25.65,25.76,24.91,24.40,23.80/
      DATA DEATHR/10.72,10.10,10.30,10.07,9.87,9.76,9.87,9.77,9.76,9.36,
     +            9.47,9.57,9.77,9.66,9.56,9.54/
      DATA HHSIZE/3.40,3.61,3.63,3.56,3.50,3.47,3.44,3.44,3.43,3.45,
     +            3.40,3.39,3.39,3.44,3.35,3.29/
      DATA AMSETS/14021.0,14484.5,10465.5,9630.3,5961.2,8174.6,5974.3,
     +            4043.1,4403.0,3067.6,3393.8,3501.0,4100.0,5100.0,
     +            6100.0,7200.0/
      DATA DISINC/2300.0,2342.,2203.,2279.,2244.,2377.,2399.,2425.,
     +            2482.,2467.,2567.,2634.,2639.,2625.,2685.,2697./
C
C   INITIALIZATION
C
      RNYR=NYR-1
      UNYR=NYR-9
      GROWTH=0.0
      IF(NYR .NE. 1) GO TO 10
      POP44=138397.
      POP(1)=POP44 + (BIRTHR(1)*POP44 - DEATHR(1)*POP44)/1000.
      GO TO 1
   10 POP(NYR)=POP(NYR-1) + (BIRTHR(NYR)*POP(NYR-1) - DEATHR(NYR)*
     +        POP(NYR-1))/1000.
    1 POPHH(NYR)=POP(NYR)/HHSIZE(NYR)
      ADULTPC(NYR)=0.709 - 0.0045*RNYR
      POPADLT(NYR)=ADULTPC(NYR)*POP(NYR)
C
C   CALCULATE HOUSEHOLD PERCENTAGES FOR BROADCAST MEDIA
C
      AMHHPC(NYR)=1.039 - 0.0000127*AMNO(NYR) - 0.00000862*AMSETS(NYR)
      IF (NYR .GT. 2) GO TO 2
      FMHHPC(NYR)=0.01
      IF(NYR .GE. 3) GO TO 3
      VHFHHPC(NYR)=0.0002
      GO TO 5
    2 FMHHPC(NYR)=0.043 + 0.093*ALOG(RNYR) - 0.000018*DISINC(NYR)
```

```
    3 VHFHHPC(NYR)= -1.058 - 0.0004*(RNYR**3) + 0.00045*DISINC(NYR)
     +              + 0.0097*(RNYR**2)
      IF(VHFHHPC(NYR))4,5,5
    4 VHFHHPC(NYR)=0.008
    5 AMHH(NYR)=AMHHPC(NYR)*POPHH(NYR)
      FMHH(NYR)=FMHHPC(NYR)*POPHH(NYR)
      VHFHH(NYR)=VHFHHPC(NYR)*POPHH(NYR)
      IF(NYR .LT. 10) GO TO 6
      IF (UNYR .GE. 4) GROWTH= -0.0394 - 0.00144*UNYR + 0.00144*
     +                        (UNYR**2)
      UHFHHPC(NYR)=0.0081 + 0.042*ALOG(UNYR) - GROWTH
      UHFHH(NYR)=UHFHHPC(NYR) * POPHH(NYR)
      GO TO 7
    6 UHFHH(NYR)=0.
      UHFHHPC(NYR)=0.
C
C  CALCULATE ADULT PERCENTAGES FOR PRINT MEDIA
C
    7 NEWSPC(NYR)=0.463 + 0.0000504*NEWSNO(NYR) - 0.00326*NEWCOST(NYR)
     +             + 0.0000177*DISINC(NYR)
      MAGPC(NYR)= -0.536 + 0.00582*MAGNO(NYR) + 0.000217*DISINC(NYR)
      NEWSCIR(NYR)=NEWSPC(NYR)*POPADLT(NYR)
      MAGCIRC(NYR)=MAGPC(NYR)*POPADLT(NYR)
      RETURN
      END
```

```
      SUBROUTINE REPORT
      COMMON/NEWDATA/NEWCOST(16),NEWSNO(16),NPUBCST(16),NEWSREV(16),
     +                  NEWEARN(16),NEWPROF(16),NEWSCIR(16),TNEWBUY(16)
      COMMON/MAGDATA/MAGNO(16),MPUBCST(16),MAGCOST(16),MAGREV(16),
     +                  MAGEARN(16),MAGPROF(16),MAGCIRC(16),TMAGBUY(16)
      COMMON/AMDATA/AMNO(16),AMREV(16),AMEXP(16),AMEARN(16),AMPROF(16),
     +                 AMHH(16),AMBUY(16)
      COMMON/FMDATA/FMNO(16),FMREV(16),FMEXP(16),FMEARN(16),FMPROF(16),
     +                 FMHH(16),FMBUY(16)
      COMMON/VHFDATA/VHFNO(16),VHFREV(16),VHFEXP(16),VHFEARN(16),
     +                  VHFPROF(16),VHFHH(16),VHFBUY(16)
      COMMON/UHFDATA/UHFNO(16),UHFREV(16),UHFEXP(16),UHFEARN(16),
     +                  UHFPROF(16),UHFHH(16),UHFBUY(16)
      COMMON/ADVDATA/TBUY(16),RETPROF(16)
      COMMON/POPDATA/POP(16),POPHH(16),POPADLT(16)
      INTEGER NYEAR,NYR
      WRITE(6,100)
  100 FORMAT(1H1,30X,*A SIMULATION OF THE MASS MEDIA INDUSTRY  1945-1960
     +*,//)
      WRITE(6,110)
  110 FORMAT(1X,*PRINT SUBSECTOR OUTPUT*,/)
      WRITE(6,200)
  200 FORMAT(1X,*YEAR* 3X,*NEWSNO* 4X,*NEWSCIR* 2X,*NEWCOST* 6X,*NEWSREV
     +* 6X,*NPUBCST* 6X,*NEWEARN* 6X,*NEWPROF*,/)
      DO 10 NYR=1,16
      NYEAR=NYR+1944
      WRITE(6,210)NYEAR,NEWSNO(NYR),NEWSCIR(NYR),NEWCOST(NYR),
     +              NEWSREV(NYR),NPUBCST(NYR),NEWEARN(NYR),NEWPROF(NYR)
  210 FORMAT(1X,I4,4X,F5.0,4X,F7.0,4X,F5.2,4(4X,F9.3))
   10 CONTINUE
      WRITE(6,220)
  220 FORMAT(//,1X,*YEAR* 4X,*MAGNO* 4X, *MAGCIRC* 2X, *MAGCOST* 7X,
     +        *MAGREV* 6X,*MPUBCST* 6X,*MAGEARN* 6X,*MAGPROF*,/)
      DO 20 NYR=1,16
      NYEAR=NYR+1944
      WRITE(6,210)NYEAR,MAGNO(NYR),MAGCIRC(NYR),MAGCOST(NYR),
     +              MAGREV(NYR),MPUBCST(NYR),MAGEARN(NYR),MAGPROF(NYR)
   20 CONTINUE
      WRITE(6,120)
  120 FORMAT(///,1X,*RADIO SUBSECTOR OUTPUT*,/)
      WRITE(6,300)
  300 FORMAT(1X,*YEAR* 5X,*AMNO* 6X,*AMHH* 8X,*AMREV* 8X,*AMEXP* 7X,
     +        *AMEARN* 7X,*AMPROF*,/)
      DO 30 NYR=1,16
      NYEAR=NYR+1944
      WRITE(6,310)NYEAR,AMNO(NYR),AMHH(NYR),AMREV(NYR),AMEXP(NYR),
     +              AMEARN(NYR),AMPROF(NYR)
  310 FORMAT(1X,I4,4X,F5.0,4X,F6.0,4(4X,F9.3))
   30 CONTINUE
      WRITE(6,320)
  320 FORMAT(//,1X,*YEAR* 5X,*FMNO* 6X,*FMHH* 8X, *FMREV* 8X, *FMEXP* 7X,
     +        *FMEARN* 7X, *FMPROF*,/)
```

```
      DO 40 NYR=1,16
      NYEAR=NYR+1944
      WRITE(6,310)NYEAR,FMNO(NYR),FMHH(NYR),FMREV(NYR),FMEXP(NYR),
     +            FMEARN(NYR),FMPROF(NYR)
   40 CONTINUE
      WRITE(6,130)
  130 FORMAT(///,1X,*VHF SUBSECTOR OUTPUT*,/)
      WRITE(6,400)
  400 FORMAT(1X,*YEAR* 4X,*VHFNO* 5X,*VHFHH* 7X,*VHFREV* 7X,*VHFEXP*
     +       6X,*VHFEARN* 6X,*VHFPROF*,/)
      DO 50 NYR=1,16
      NYEAR=NYR+1944
      WRITE(6,310)NYEAR,VHFNO(NYR),VHFHH(NYR),VHFREV(NYR),VHFEXP(NYR),
     +            VHFEARN(NYR),VHFPROF(NYR)
   50 CONTINUE
      WRITE(6,140)
  140 FORMAT(///,1X,*UHF SUBSECTOR OUTPUT*,/)
      WRITE(6,500)
  500 FORMAT(1X,*YEAR* 4X,*UHFNO* 5X,*UHFHH* 7X,*UHFREV*7X,*UHFEXP*
     +       6X,*UHFEARN* 6X,*UHFPROF*,/)
      DO 60 NYR=1,16
      NYEAR=NYR+1944
      WRITE(6,310)NYEAR,UHFNO(NYR),UHFHH(NYR),UHFREV(NYR),UHFEXP(NYR),
     +             UHFEARN(NYR),UHFPROF(NYR)
   60 CONTINUE
      WRITE(6,150)
  150 FORMAT(///,1X,*ADVERTISER SUBSECTOR OUTPUT*,/)
      WRITE(6,600)
  600 FORMAT(1X,*YEAR* 10X,*TBUY* 7X,*TNEWBUY* 7X,*TMAGBUY* 9X,
     +       *AMBUY* 9X,*FMBUY* 8X,*VHFBUY* 8X,*UHFBUY* 7X,*RETPROF*,/)
      DO 70 NYR=1,16
      NYEAR=NYR+1944
      WRITE(6,610) NYEAR,TBUY(NYR),TNEWBUY(NYR),TMAGBUY(NYR),AMBUY(NYR),
     +             FMBUY(NYR),VHFBUY(NYR),UHFBUY(NYR),RETPROF(NYR)
  610 FORMAT(1X,I4,8F14.0)
   70 CONTINUE
      WRITE(6,160)
  160 FORMAT(///,1X,*CONSUMER SUBSECTOR OUTPUT*,/)
      WRITE(6,700)
  700 FORMAT(1X,*YEAR* 1X,*TOTAL POP* 4X,*HH POP* 1X,*ADULT POP*,/)
      DO 80 NYR=1,16
      NYEAR=NYR+1944
      WRITE(6,710)NYEAR,POP(NYR),POPHH(NYR),POPADLT(NYR)
  710 FORMAT(1X,I4,3F10.0)
   80 CONTINUE
      RETURN
      END
```

Theil's U Validation Program

```
      PROGRAM THEILU(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION PREDICT(16),ACTUAL(16)
      READ(5,33) EXP
33    FORMAT(A10)
      READ(5,34) NUM
34    FORMAT(I2)
      DO 300 KKK=1,NUM
      PSUM=0.
      ASUM=0.
      DSUM=0.
      N=0
      READ(5,20) IVAR
20    FORMAT(A10)
      READ(5,100) (PREDICT(I),I=1,16)
100   FORMAT(4F14.3)
      READ(5,200) (ACTUAL(J),J=1,16)
200   FORMAT(4F14.3)
      WRITE(6,2000) IVAR
2000  FORMAT(/,1X,1A7)
      WRITE(6,1000)
1000  FORMAT(6X,*PREDICTED*,8X,*ACTUAL*)
      DO 10 K=1,16
      IF(ACTUAL(K))8,9,8
8     PSUM=PSUM + PREDICT(K)**2
      ASUM=ASUM + ACTUAL(K)**2
      DSUM=DSUM + (PREDICT(K) - ACTUAL(K))**2
      N=N+1
9     WRITE(6,1100) PREDICT(K),ACTUAL(K)
1100  FORMAT(1X,2F14.3)
10    CONTINUE
      TOP=SQRT(1.0/N * DSUM)
      BOT=SQRT(1.0/N * PSUM) + SQRT(1.0/N * ASUM)
      U=TOP/BOT
      WRITE(6,1200) U
1200  FORMAT(/,1X,*THEILS U=*,F14.8)
300   CONTINUE
      END
```

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