MODELLING ENERGY AND SOCIETY: THEORY AND METHOD IN ASSESSING THE SOCIAL EFFECTS OF ENERGY POLICIES

VOLUME THREE

THE MEASUREMENT MODEL

CENTER FOR RESEARCH
ON THE ACTS OF MAN

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MODELLING ENERGY AND SOCIETY:

THEORY AND METHOD IN ASSESSING THE SOCIAL EFFECTS OF ENERGY POLICIES

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ABSTRACT

Common sense suggests that when more people are employed, more energy is consumed. However, this study of the social effects of energy policy finds a positive correlation between unemployment and per capita energy use. The social theory upon which the study model is based anticipates this otherwise counter-intuitive finding. It is not the number of men or machines at work but the number of social roles and the intensity of activity in those roles which determine the level of energy consumption.

This study assesses the feasibility of a society/energy model which, when completed, may be used to monitor and to forecast the social effects of energy policies. We find that such a model is feasible. An introductory chapter provides a philosophical grounding for relating social scientific concepts to social policy, in general. This chapter establishes a logical basis for the feasibility of the model. The report then consists of two parts. The first provides guidelines for the interpretation of social activities and rules for conceptualizing those activities in several institutional contexts, religious, political and economic, and in the energy social system itself. The second part is a mathematical statement of typical equations expressing "causal" relations between measures of physical energy consumption and both the attributes of various social institutions and the behavior of actors in those institutions.

The concluding pages of the report demonstrate a way of testing the proposed model with empirical data. National, annualized time series data from published sources for the period from 1960 to 1974 are used and empirical tests of the model were limited to three strategic types of energy policies: those involving fuel price controls, changes in employment rates, and changes in economic output. For the moment, we did not consider such issues as interfuel substitutions or comparisons of different price elasticities for different fuels in different geographic or institutional contexts.

The success of the selection of social indicators for the model, as expressed in a system of nested structural equations, is verified in the documentation supporting the technical report.

TECHNICAL SUMMARY AND RECOMMENDATIONS

Recommendations

1. The social indicator model has been shown to be feasible or, at the very least, merits additional examination and experimentation. It will contribute to improving general understanding of the society-energy systems and enhancing forecasting capabilities for public policy decisions.

2. The social indicator-energy use model should be coordinated with a model of physical energy systems as well as a pure economic model on both the national level and in various disaggregated forms.

3. Future studies might disaggregate our model for each institutional area, for consumer and institutional subsectors, by fuel types in relation to social purposes and by geographic subarea in the light of the characteristics of the society and physical environment of that area. This will permit the use of cross-sectional data (by geographic location, by energy uses, by energy source) in concert with time series (the same data over several years).

4. Indicators should be selected which provide quarterly data which increases the number of observations. This is especially useful when utilizing economic data series.

5. The unobtrusive indicators used in this study should be combined with survey data such as that now being collected on energy consumption behavior and attitude. This will facilitate the evaluation of the attitudinal component of social effects.

6. Additional effort is needed in the development and validation of indicators. Indicators are needed in several social subsectors called for by the social theory but not yet included in the model. More refined

"unobtrusive" social indicators should be developed to reflect social behavior variables more precisely.

Some Findings and Their Rationales

Illustrative Products of the Model

A scientific revolution, says Thomas Kuhn, is presaged by an anomaly, an observation not well explained in terms of current thinking. A seemingly anomalous finding puzzled the competent team validating our work--though something less than a scientific revolution is presaged. A positive correlation between unemployment rate and per capita energy usage was established and adumbrated in a positive correlation between a one year lagged unemployment rate and per capita GNP. Certainly common sense suggests that employment, not unemployment, rate should predict energy consumption, that when a greater proportion of the people are tending machines, more energy would be consumed. Our outside validators, committed to examine only the statistical aspects of our model and not its theoretical underpinning, nevertheless called the finding contradictory to what should be expected and suggested further investigation. Upon discovering the GNP-unemployment association, they said, "This equation should probably be discarded because it is highly contradictory to what a rational *a priori* expectation requires." Finally, when the finding refused to disappear, they wrote, "This is very contradictory to an *a priori* expectation that the more jobs would require more energy use...therefore, in spite of its very good fit to the historical data and the significance of all the coefficients of the explanatory variable, the equation should not be used in the subsystem."

Our project economist had accounted for the finding in two ways--one substantive and one methodological--in traditional economic terms. Substantively, during the fourteen years of observation, a secular increase in energy usage per capita paralleled a mild secular increase in the national unemployment rate. This suggests that some exogenous variable is affecting a long range trend in both. Methodologically, the size of the labor force may be increasing faster than the number of jobs. Indeed, in a period of affluence relatively more women, minorities and the young are likely to be in the labor force. These categories of workers have higher unemployment rates and so the (observed) unemployment rate grows while energy consumption grows.

The finding was anticipated in the social theory which had provided the basis for selecting indicators. That the outside validators failed to understand the relation, and were prepared to discard a finding that met traditional statistical criteria, had little to do with whether economic or sociological interpretations were called for--the paradox could be resolved in either frame of reference. The indicators of individual behavior had taken on common sense meaning, as ends in themselves, rather than as proxies for theoretical concepts. This approach was atomistic--presuming that a collective phenomenon has no more to it than what is given by the aggregate of the individual measures--an image of individual workers consuming energy at their individual machines. The employment measure was, in fact, selected as an indicator of intensity of social activity at the collective level. The reference was to roles as consumers of energy rather than directly to the occupants of those roles. More intense role and organizational activity means more energy consumption. In a high energy society, fewer people are needed to control the roles and organizations. This led to the hypothesis, in the conceptual section of the report, about the "depopulation of the productive unit." The energy measure, in per capita terms, is a proxy for per role (or per operating unit).

The analysis of the social effects of energy consumption must be conducted at the social organizational level and in the context of social institutional or cultural factors. Neither the man nor the machine but the social role or the social activity is the energy consumer. Our social effects model was constructed from this perspective.

The empirical models developed in this study used national annualized data (1960-1974) to examine the relationship between energy use and the social system. A policy component, a social behavioral component and an energy usage component became three interdependent elements of a "general" social effects model. Social sector variables are, thus, explicitly incorporated into the energy use-public policy model.

Three related empirical examples, each representing a subsystem of social behavior and energy use, are presented: (1) the interrelationship between "exogenous" socioeconomic variables and "endogenous" variables representing automobile purchases and use; (2) the well known GNP-unemployment-energy use triangle and its social behavioral determinants and (3) a composite of five endogenous variables in which the energy use-GNP-unemployment triangle is simultaneously considered endogenous along with automobile purchase and use. In general, the findings are statistically significant in terms of individual social indicators as well as overall fit.

Some results of the analysis may be of intrinsic interest--though the purpose of the examples is heuristic. Total energy usage per capita is positively related to current GNP per capita but negatively related to GNP lagged one period. This latter result reflects the social system's feedback mechanism and is consistent with the social theory underlying the model. The "feedback mechanism" consists of social activities.

In quantitative terms, for instance, a one percent increase in GNP per capita in 1974 would have increased energy consumption per capita in 1974 by about 0.58 percent. These results translate into a change in GNP per capita of $46 (or approximately $10 billion in aggregate) and about 2.04 million BTU's per capita. Similarly, an increase in the average national unemployment rate in 1974 by one percent from 6.7% to 7.7% would have been expected to reduce energy consumption per capita in 1975 via its lagged effect by about 0.8 percent, or 2.8 million BTU's per capita.

The purchase of smaller automobiles will have significant impacts on energy usage. For instance, in 1974 if new small automobile purchase patterns had shifted from 62.9% to 63.6% of all new automobile sales, total energy consumption per capita would have been reduced by 1.35 million BTU's. This energy saving is not generated solely from the smaller automobiles being purchased. The purchase of a small automobile is a declaration that travel plays a relatively smaller part in the lives of the purchasers.

As manufacturing employment increases relative to total employment energy usage per capita decreases. Since a factory worker consumes more energy in his occupation than a bank employee, this seems to be an anomaly. Manufacturing employment, however, means more blue collar workers who, in their personal lives, are less energy demanding than white collar workers. The latter live increasingly complex lives--joining voluntary organizations, participating in community politics, travelling for recreation--and the organizations themselves proliferate as they support this more complex social life.

Several other indicators were successful predictors of social behavior. An increase in the fuel component of the CPI relative to the total CPI is associated with an increase in the proportion of smaller households and in teenage employment. Smaller households imply structural differentiation of the family--a factor increasing intensity of social interaction. This increases the per capita level of energy consumption despite a relative increase in the price of fuel. The increase of teenagers in the labor force signals more ties with the economy on the part of each family--for teenagers living at home--and thus more intense social activity and energy consumption. For teenagers not at home, it signals the establishment of new independent social units, each a new energy consumer.

The Model as a Policy Tester

The Mathtech report, Appendix A to Volume Three, presents an illustrative policy impact analysis. Since only a small sector of the social effects model has been constructed, the exercise should be taken as a demonstration of how the model may be used to forecast policy outcomes but not as a realistic guide for policy.

The policy sensitivity of the model was tested for three types of energy policies.

(1) a fiscal policy, causing the price of fuel to increase more rapidly than the CPI. Such a policy would increase unemployment, gross energy consumption, lagged GNP, the total number of miles driven and the proportion of large cars purchased.

(2) employment policies, one introducing a larger proportion of teenagers into the labor force and a second increasing the non-white component of the labor force. The effect of the first parallels that of the fiscal policy and the second decreases the GNP per capita and decreases energy use and increases the general unemployment rate.

(3) encouraging productivity--however that would be accomplished--and measured by one year lagged GNP per capita. The outcome would be a positive effect on current miles driven. A policy which increases the three year lagged GNP per capita would increase current year fuel efficiency. These findings, though counter-intuitive in a supply/demand framework, are consistent with the underlying social theory that the driving variable is the increasing intensity of social activity and the process of structural differentiation.

A Sketch of the Theory

The concepts needed for analyzing society and energy are the same as those for analyzing social action implicating any physical environmental object. Further, the manner of analyzing environmental disamenities is the same as that for analyzing society in relation to its resources and technology. The environmental object is treated in terms of the meaning it has for social action--and, thus, not necessarily the meaning it might have for a physical scientifist or an engineer. Social groups enter into relations with one another in virtue of their common concern with an environmental event and the nature of that relationship gives the meaning to the environmental object. Social actors may compete for energy as a resource or one actor may produce a disamenity for another in the process of conversion or extraction. The social contention produces an environmental issue.

The basis for an environmental social conflict is set by the fact that the physical environment is not divisible in accord with the partitioning of social activities. Groups may have incompatible ways of relating to the same resource, as when hunter and harvester of timber eye the same forest. One group may change the values of an environmental attribute to which another is oriented, say, by polluting the air. Resolutions of environmental conflicts may take the form of changing the boundaries of the social system, as in enlarging a market to internalize externalities.

Environmental social conflict serves a social purpose. Human conflict has a tendency to develop around social and cultural institutional foci--around life style, around religion. An environmental issue restructures the axes of social conflict making allies of groups otherwise in conflict, realigning groups with respect to interests in physical features such as territory or the allocation of material resources.

The physical environment also has a direct impact on society. It is incorporated within, becomes constitutive of, social activity as a facility or a reward--or their opposites. Energy is a social potentiator, functioning as would surplus labor. It allows society to become more complex and social activity more intense and, as a further consequence, increases the rate of social differentiation. Energy creates the conditions for the social and technical division of labor but does not, by and large, determine the axes along which that differentiation takes place. The direction of social development is determined by culture.

Culture is a key to the social influence of energy, in its role in organizing social activities around energy as an environmental object and in its direct impact on society. The institutional context in which energy is used, the social purposes which it facilitates, defines its cultural significance. The significance is expressed in the way people organize to use or control it and in the type and severity of struggles that ensue.

So accustomed are we to thinking of physical objects, in general, and of energy, in particular, as tools by which social actors achieve their ends that we forget that religious action is their most fundamental source of meaning. In religion, the physical object is a vehicle for the dramatic expression of meanings which evoke social action. Religious meanings rarely appear in pure form but tend to infuse economic and political meanings, introducing non-rational elements into them. Totemism is the prototypical religious action respecting an environmental object. In this dramatic form, the natural and the social orders symbolically interpenetrate. As the mundane activities of the social order are sanctified, they enjoy a "surplus" meaning. This "surplus" meaning restricts the license to use holy things. Wilderness, taking on a sacred meaning, was the abode of evil to be purified and tamed by the frontiersman. Tamed nature may be withdrawn from the sacred--becoming neither good nor evil but neutral. When energy is itself withdrawn from the sacred but used in the pursuit of sacred aims, a basis is established for the exploitation of nature and of energy. Economically and politically defined physical objects never lose their parentage in religious meanings. A "surplus" evocative meaning adheres to the most rationally defined economic "commodities."

A physical object in political action is, prototypically, a means of coercion, a weapon. In religion, meanings are part of the relation to the object, a symbol of community. In a political context, the relation to the object is instrumental. Energy resources are strategic.

Having a potentiating effect, they aid in extending the range of control over physical objects. Political power reacts on itself, promoting self-growth and the development of an independent system of power relations.

Where political control is of the processes of exchange, it combines with the economic meaning of objects. Economic action, prototypically, is directed to the acquisition of resources by society, for subsistence, among other needs, and the allocation of those resources among sectors of society. Physical objects become resources, or have social utility, when the activity implicating them has some positive social function. Exchange or the transfer of rights in utilities is at the core of economic actions. The price and utility attributed to the object define its value on a matrix of exchange. Evaluated on these two abstracted dimensions, it is a commodity.

Political and economic are the most salient meanings of energy in contemporary society. Six socially relevant characteristics of energy from natural resources promote its "rationalizing" role in political and economic relations. Unlike animal and human labor, (1) it is detachable from biological and psychological constraints. (2) It has no inherently social location and so may be used indifferently by prince and pauper. Giving it an economic location, a price, is a limitation imposed by our form of economic organization as a condition for its social availability. (3) It is divisible into units of almost any size. (4) It is deliverable continuously and at whatever rate desired. (5) It is generally storable, in its state as a resource, and, thus, free of many constraints of time. (6) It is generally transportable and, thus, free of many constraints of space.

Social activities developing around the processes of acquisition, conversion and distribution of energy determine the character of social relations and, thus, of culture. In this sense, these attributes of energy influence the direction of social change. The characteristics of detachability, divisibility and transferability facilitate its exchange through markets and so support social change in the direction of "rationalization." In this spirit, energy related activities may be expected to have twelve more specific influences on the direction of social change.

(1) Special occupational groups develop around the acquisition and processing of each energy resource. Their particular conditions of life produce distinctive cultures. A society of coal miners is politically different, for instance, from a society of nuclear engineers.

(2) A specialized energy industry emerges as energy activities become encompassing enough to claim their own staff. Other social organizations relinquish command over self-produced energy in return for cheaper and more efficient energy. These specialized producers and distributors of energy develop peculiar social characteristics and forms of exchange with the rest of society.

(3) The social role of the working class changes from its traditional role as shaper of materials to that as laborer administrator as tasks become more complex.

(4) The increasing control available to each actor extends the social and physical space of activities producing a social centrifugality and a depopulation of the productive unit. On the battlefield, massed troops with muskets give way to a few men who control wide spaces with automatic weapons. The battlefield becomes a barren silent area.

(5) As the potency of human acts increases, the problem of social control becomes insistent. In our culture this has turned attention to the psychological control of "instincts."

(6) The content of culture changes as property law becomes more important relative to personal status law. With the depopulation of the productive unit society has fewer norms controlling face-to-face relations and more social norms governing activity in relation to products.

(7) Social and spatial centrifugality also diminishes the role of traditional groups in society relative to forms of secondary association for instrumental purposes.

(8) The basis of social power shifts from land holding to industry and the power holder from the landed aristocracy to entrepreneurs. Stratification based on control of material processes becomes more important than stratification based on lineage.

(9) The allocation of social power among social institutions shifts from solidary social relations, such as kinship and religion, to economic and political relations. The institutions dealing with social means, instrumental action, make more telling use of energy supported technological innovation.

(10) The allocation of social power among ecological organizations shifts among geographic regions depending upon their access to energy resources and among specific industries according to their energy dependency and their contribution to the energy needs of other organizations.

(11) Industry, transportation and warfare, as social forms most susceptible to energy potentiation, become especially prominent types of social organization in high energy societies.

(12) Social contraction around energy depletion does not reverse social expansion around energy increments. As energy becomes less available the initial social strains are located in and radiate from those social relations most, directly or indirectly, energy dependent

and so most vulnerable to its withdrawal. Actors in relationships formed around energy become a vanguard in the struggle against energy reduction.

The content of each of these consequences may be specified further by examining them in the light of the type of fuel, whether coal, gas, wood, oil or atomic, and the character of the technology through which it is consumed.

Comments on Method

These theoretical considerations guided the selection of unobtrusive indicators from published sources. The total United States was taken as the unit for analysis and annual data from 1960-1974 were collected. The indicators tend to be rates or ratios such as the proportion of employment in one industrial sector compared with total employment or the amount of energy consumed per social unit such as per capita, per household or per firm. Measures were selected of social behavior and of energy use in the several institutional spheres: economy, polity, religion, family, etc. Social indicators were meant to reflect (1) the intensity of social interaction and of structural differentiation in each setting, (2) the levels of energy consumed and the allocation of energy among various social activities, (3) possible policy interventions and (4) acts which function to cope with stress in response to energy changes. These indicators became the variables in structural equations which, if read in one direction, show the social effects of changing levels and allocations of energy and, if read in the other direction, the effects on energy consumption of varying social arrangements. Multicollinearity is dealt with by residualization and autocorrelation assessed through the Durbin-Watson statistic. The model, being but a first step, does not deal with issues such as interfuel substitution, the fact that a reduction in the use of one energy form may not reduce the overall consumption. It also stops short of comparing the differing price elasticities for the different fuels in different situations and institutional contexts.

The aim of the study was not to develop a finished social model but to demonstrate the feasibility of such a model. Not all of the proposed indicators are used in equations and the theory is tested for only three types of social policy--that involving energy price adjustments, changes in levels of employment and in levels of economic output. Data availability on a national level and time and budget considerations constrained this phase of the work.

The technical success of the system of equations and the substantive findings, as sketched above, attest to the feasibility and support the recommendation that a more complete model of the social effects of energy policies be pursued. Empirical analyses of complex social systems and energy usage are fraught with implementation pitfalls. We are, however, sanguine about the long run viability and usefulness of the social indicator approach used here but should emphasize three types of choices to be made.

(1) Forecasting versus structural analysis. If the principal focus of the model is forecasting rather than "structural" analysis, the model would be "simplified" to engender testable results. For example, in econometric studies, forecasting equations are reduced form models, with strictly endogenous dependent variates of interest. On the other hand, if structure is the primary concern of the analyst, the "proper" specification of the model would be to set the dependent variable as a function of exogenous and endogenous variables. The latter approach is more complex in terms of underlying theoretical requirements and estimation procedures, but yields results pertaining to the structure and behavior of the system.

(2) The choice of method. Several competitive methodologies might be considered for forecasting. The analysis above utilizes econometric methods, which we believe are appropriate for examining social behavioral systems in relation to energy demand. To study physical energy systems or energy supply or energy cost equations, deterministic programming or probabilistic programming models might be more useful. This dichotomy is dealt with by the government energy agency in its development of the PIES and subsequent models for energy use in the United States.

(3) Assessment and evaluation. Assessment and evaluation of a model involves a rigorous examination of both the forecasts or results and the methods employed to derive them. This has been done for our models by Mathtech and reported in the text.

Three types of error might enter future work with the model. Errors in the basic data would vitiate the final outputs. Common causes of data errors include inadequate sample size, poorly constructed data collection methods (e.g., poor interviewers or questionnaires for survey data collection) and data manipulation errors. Survey or indicator data may evidence substance error. Here the analyst has failed to choose the proper variables for study. In the social indicator approach, this is likely to occur because the data surrogate used may not be characteristic of the underlying social behavior. Causal validity error may mask cause and effect results but this might not prevent the analyst from, say, generating forecasts of energy use.

Variables that allow prediction of changes in energy use, even though they do not necessarily cause these changes, are to be incorporated. Since, in long run analyses, basic underlying structural relationships may change, the analyst should build models based upon the existence of a logical set of causal relationships (i.e., the theory). Ultimately, the operationalizing of empirical work requires the judgment of the analyst. There is no substitute for the "common sense" of the analyst, particularly in forecasting.

The Limits of Scientific Knowledge as a Basis for Policy

Success of a social policy rests upon the policy-makers' grasp of the "total" social phenomenon--not that one must know all of it but that one must know it concretely and strategically. Any social science analysis is bound to be abstract. Demographic and ecological analyses are abstract because their frame of reference isolates social actors as objects in space and uses only external descriptive data on their past mechanical movements to anticipate their future movements. A disciplinary analysis, psychological, sociological, cultural, is also abstract because its perspectival method isolates analytic variables. Any combination of disciplinary abstractions, of the economic and the political, for instance, is still abstract.

The opening section of the report places social science knowledge within the context of the types of knowledge necessary for a picture of a concrete society and for acting in society. Several levels of social science knowledge which can be articulated into a reasonably complete image--from a cognitive perspective--are delineated. It is possible to think of a series of nesting social and cultural systems, each with its own *sui generis* reality. The orientation of society to its physical environment, at the most general level, is controlled by cultural paradigms, a fundamental mental structure which delineates the categories of culture, defining the forms in which events appear to the social actor. At another level, institutional rules, specified for social action by the paradigm, cluster in accord with the tasks that society must fulfill to persist as a system. In doing the everyday work of society, the actor draws upon these institutional directives to develop organizations for the attainment of specific goals in space and time. These are as yet another level and include governments, churches and financial institutions.

An additional caveat is in order. The articulation of knowledge from all of these levels of generality provides only cognitive knowledge. Such knowledge of fact is insufficient for action since action implies value determinations. Cognitive social science studies values and offers a perspectival understanding of them but provides no further basis for choosing and acting on them. A policy analysis would bring to bear, at this point, value positions which are legitimated through philosophical and religious orientations and selected for application through the political process.

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Chapter I

AN EMPIRICAL SOCIO-ECONOMIC ENERGY WAGE MODEL

Two of the most commonly used aggregate indicators of social well-being are GNP per capita and the national unemployment rate. Also, for the United States, it has been recognized that per capita energy usage and the general level of economic activity are closely interrelated.[1] It is this latter fact that has been the focus of recent public concern, especially in an era of anticipated long-term energy shortages. It would appear to be natural, therefore, to analyze energy usage and its interrelationships with unemployment and GNP. Hence, this chapter, employing national annualized data for 1960 through 1974, develops a social indicators-econometric model for examining the interrelationships between energy usage per capita, the unemployment rate, and GNP per capita. Our analysis represents an empirical extension of the social indicators approach applied to the socio-economic effects on energy usage.

In the previous draft of this report,[2] which provides the direct stimulus for the current work, it was found, contrary to commonplace *a priori* expectations, that the unemployment rate and energy usage per capita were positively related statistically. This finding was accounted for in two ways: one methodological and the other substantive.

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[1] Starr (1971) was one of the first to explore this relationship systematically.

[2] Klausner and Edelstein (1977).

Methodologically, the size of the labor force over the 1960-1974 period increased faster than the number of jobs. Indeed, this may be the resultant of affluence and new social norms, which have jointly tended to increase the numbers of women, minorities and the young who have entered the labor force. These categories of workers tend to have higher unemployment rates, thus providing a partial explanation for why the observed unemployment rate could grow while energy consumption grew.

Substantively, during the fourteen year period of observation, a secular increase in energy usage per capita paralleled a mild secular increase in the national unemployment rate, suggesting that some other variables, in addition to methodological considerations, might be affecting these two long range trends. The principal hypothesis of this study is that the choices of production technique and societal organization have become increasingly capital intensive. Moreover, in a period of perceived relatively low-cost and available energy, techniques that are capital-intensive are, also, energy-intensive. Put somewhat differently, capital and energy are complementary inputs that are joint substitutes for labor. Hence, ceteris paribus, fewer men are needed to attend the "machines," thereby increasing unemployment rates as capital and energy are substituted for labor. This hypothesis, also, will explain the observed growth in the GNP-energy usage relationship. This chapter is directed to exploring these phenomena.

The chapter is set forth in four sections below. The first section discusses the theoretical use of social indicators in the model. The second section provides the conceptual framework for analysis, integrating social indicators into a policy-economic framework. The third section delineates the statistical model used for estimating the socio-economic relationships, and introduces the data base. In the final section, the empirical findings are outlined and discussed.

Social Indicators: Some Theoretical Issues

This is not the place nor is there sufficient time to go into all the intricacies of social indicators as a device for measuring societal well-being (see Volume Two, Chapter VIII for the list of all indicators used in this study). However, it is worthwhile to point out that we live in a complicated world and that it is both unrealistic and unnecessary to expect that one set of social indicators will summarize adequately all the nuances that should be included in the comprehensive notion of "well-being." A social indicator, as defined by Olson, is "a statistic of direct normative interest...a direct measure of welfare."[3] Furthermore, it is claimed that the social indicator should "reveal the status of the population in relation to a perceived social objective."[4] In the discussion that follows, it is taken as a given that the unemployment rate, GNP per capita and energy usage per capita are relevant indicators for study. These three social indicators are our main interest and are treated as endogenous to the social-economic system. The empirical task of this paper is to find the interrelationship among these social indicators as well as other exogenous social indicators. Put somewhat differently, the empirical analysis will assume that there exist observable relationships between and among exogenous

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[3] Mancur Olson (1973), p. 97.

[4] Social Indicators, (1973), p. XIII.

and endogenous social indicators. These are strong assumptions that deserve a brief comment here.

A Social Indicators Approach

Micro-Basis for Social Indicators

Focusing first on the endogenous social indicators of interest, it is convenient, following the approaches of Becker (1965), Muth (1966), and Lancaster (1966), among others, to view the basic micro-behavioral unit as a decision-making optimizer. According to this approach, the level of the objective function (e.g., well-being) is determined by the levels of the underlying properties or characteristics of the goods and services (which may be market or non-market, including time) received or disbursed by the micro-unit. That is, goods and services are inputs used in a "production" activity, in which the output is a collection of characteristics. The objective function orderings are, therefore, a function of the rankings made by the micro-unit on the collection of characteristics produced by the various bundles of goods and services. In this way, the objective function maximization is constrained by market feasibility and the technical relationships between commodities and the types and levels of characteristics they produce. This formulation permits identical behavior to have similar as well as dissimilar underlying characteristics in different settings.

The lower path in Figure 1 illustrates these notions schematically. For the micro-unit, it converts X,[5] goods and services, into S, characteristics,

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[5] X itself is determined within the system by "exogenous" factors, Z. Hence, $h : z \rightarrow X$ is the function transforming z into X. For our purposes, z is a vector of "indicators" used to determine the value of X.

by the "production" function $\mathfrak{f}$. Note that X is a vector, which might consist of the endogenous social indicators, such as labor supply, energy usage, income components and so forth.

$$\mathfrak{f}: \; X \rightarrow S$$

The production function may be complex, and its shape is dependent upon social norms and forms of societal organization. Similarly, the g function transforms characteristics into a metric of well-being (the objective function) W.

$$g: \; S \rightarrow W$$

In fact, the distinction between W and S, while illuminating, is usually not operational. However, since they are conceptually different objects, there is a linkage needed via the g function.

If X is to be utilized as a precise social indicator, it would require that the composite function of $\mathfrak{f}$ and g transform X into W for the micro-behavioral unit.

$$\mathfrak{f} o g: \; X \rightarrow W$$

This is represented as the upper path in Figure 1. While there exist functional forms which will satisfy this requriement, it is <u>not</u> likely that they will be one-to-one functions in many plausible situations. Hence, using X as an indicator of well-being depends on the values of X and the stability and shapes of the $\mathfrak{f}$ and g functions over their domains and ranges.[6]

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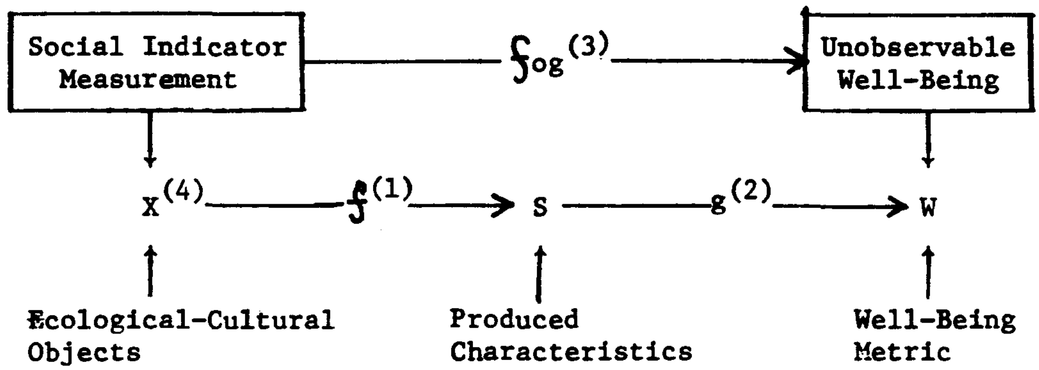
[6]This ignores another nagging issue: X might be measured with error in two senses. First, the conceptual indicator and "observed surrogate" measured indicator may differ. Thus, even if X is observed with complete accuracy, since it does not correspond to the correct concept, there will necessarily be a measurement problem. Second, if the concept and empirical variable choice are appropriate, there may be systematic or random observational errors, which closely relate to the "errors in variables" problem identified in the economics literature.

Figure 1: Social Indicators As Measures for Micro-Behavioral Unit: Well-Being



(1) Production Function -- f: $X \rightarrow S$

(2) Well-Being Metric -- g: $S \rightarrow W$

(3) Implied Social Indicator Metric -- $f \circ g$: $X \rightarrow W$

(4) X may be determined by exogenous factors, Z -- h: $Z \rightarrow X$

Z may be a vector of "indicators;" hence, the h function transforms the exogenous indicators Z into the endogenous indicators X.

Aggregative Social Indicators

The analysis will now turn to the relationship between endogenous and exogenous social indicators, when aggregate data is being used. The above discussion about social indicators has centered on micro-behavior as the unit for analysis. In fact, social indicators, as used in most studies, including this one, are aggregate data. Obviously, the use of "grouped" data (e.g., at the national level) frequently has the advantages of being readily available from public or quasi-public sources. However, there exists a well-documented problem of statistical efficiency, which is created by the use of, say, mean data (aggregated over micro-units and across geographic-sub-areas).[7] When observations are grouped, information is lost. Statistical regression coefficient estimates derived using least squares methods over grouped observations will be unbiased if the standard assumptions concerning error terms hold and the underlying data have not undergone a non-linear transformation. However, the variance of the estimator derived from the grouped data will be larger than that derived from the ungrouped data.

A brief hypothetical example will illustrate the difficulties with utilizing "aggregate" social indicators across groups in place of the "proper" micro-social indicators. Suppose energy usage can be divided properly into two subgroups, for each time period: e_{it} for $i = 1,2$ and $t = 1,\ldots,T$; and it is assumed that e is identically functionally related to the income level of each group I_{it}, $i = 1,2$ such that $e_{it} = a_{it} + b_{it} I_{it} + u_{it}$ for $i = 1,2$ and $t = 1,\ldots,T$ where u_{it} is the stochastic error term, assumed to have $E(u_{it}) = 0$ and $\sigma^2_{u_{it}} = \sigma^2_u$ for all i,t. Also, it is assumed that $\sigma^2 I_{it} = \sigma^2 I$ for all i, t and ρu and ρI are the correlation coefficients for u_{it} and I_{it} $(i = 1,2$ and $t = 1,\ldots,T)$, respectively. For the sample size T, ordinary least squares (OLS) can be used to estimate $\hat{b}_1 = \hat{b}_2$.

The aggregate energy use-income indicator relationship created by aggregating across groups 1 and 2 in each time period would yield (dropping the time subscripts for convenience), similarly, $(e_1 + e_2) = 2a + B\ (I_1 + I_2) + u_1 + u_2$. For the sample of aggregate data of size T, $\hat{B}$ would be the OLS

[7]For example, see Malinvaud (1970), pp. 281-285.

estimator of B. Finally, pooling the two samples of group 1 and group 2 together, but not aggregating data, would yield $e_i = a + B^* X_i + u_i$ for $i = 1,2$. $\hat{B}^*$ denotes the OLS estimator for the pooled micro-data.

If $b_1 = b_2 = b$, then it follows that $B^* = b$. The estimators, $\hat{b}_1 = \hat{b}_2 = \hat{B}^*$, will be unbiased but sampling variances will be $\sigma b_1^{\ 2} = \sigma b_2^{\ 2} = \dfrac{\sigma_u^2}{T\sigma_u^2}$ and, on the assumption that $\rho u = 0$, then $\sigma B^{*2} = \dfrac{\sigma_u^2}{2T\sigma_x^2}$.

Note that, in general, the estimator B for the aggregate indicator data will be of the form $\sigma B^2 = \dfrac{\sigma_u^2\ (1 + \rho u)}{T\sigma_x^2\ (1 + \rho x)}$. Hence for $\rho x = \rho u$ in this example, the aggregate indicator estimator's variance will be twice that for the pooled micro-data estimator.[8]

Further, if it is no longer assumed that all micro-units are identical (i.e., group 1 behavior is different from that of group 2), the problems of aggregate social indicators become more complex. More realistically, it is likely that the parameters $b_1 = b_2$ and that the distributions of the error terms for each group are inter-correlated and distributed differentially. In such circumstances the use of aggregate social indicator data to estimate the behavioral relationships will engender biased estimators, which depend upon the sample sizes and parameter values. Unfortunately, given the aggregative nature of the current study, like many of its predecessors, the potential existence of this "aggregative-indicator" problem can not be overcome. This stands as an admonition to take care in the interpreting of the empirical findings.

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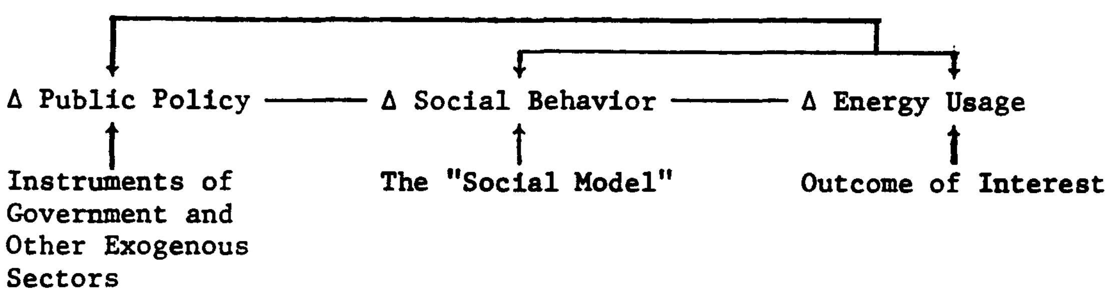
[8]Of course, if $\rho u > \rho x$, then $\sigma\hat{B}^2 > \sigma\hat{B}^{*2}$, and if, contrary to the usual assumptions, $1 + \rho u < \dfrac{(1 + \rho x)}{2}$, then $\sigma\hat{B}^2 < \sigma\hat{B}^{*2}$.

The Conceptual Framework

The following schema illustrates our conceptual framework for an indicator approach for analyzing society-energy relations.

Figure 2



According to this view, government policy affects social behavior, which, in turn, results in energy usage. Simultaneously, energy usage feeds back into both the social behavioral component of the model and the government sector. The empirical example described below will illustrate how social subsystems for energy usage and social behavior can be modelled and estimated. The example will examine explicitly the social behavior "black box," viewing the interrelationships between "exogenous" socio-economic variables and "endogenous" socio-economic and energy variables. In particular, the example will explore the interrelationship between a set of exogenous social indicators and the energy usage-GNP-unemployment endogenous social indicator triad.

Economists usually "assume away" the social sector for explicit modelling purposes, examining changes in policy at the "environmental" or "ecological" organizational level of actual energy usage. This short-circuiting approach, while convenient, is likely to miss feedback effects and over-simplify interactive effects. For example, the degree to which increases in energy prices stimulate conservation of energy is, according to economists, still an unresolved issue.[9] Most energy economic demand studies dealing with a single fuel show evidence of a significant own-price elasticity. One obvious implication of such a result is a substantial reduction in the growth of that energy source usage as a result of a substantial real price increase. However, because of the possibility of interfuel substitution, the result in energy consumption may not be an overall reduction. Further, the full impacts of these types of effects take time to reach complete readjustment. For instance, if electricity becomes more expensive than gas for cooking, people react at first by reducing their use of electricity for cooking, using the existing stock of appliances. Over time, appliance purchase choices will result in increased numbers of gas stoves relative to electric stoves. In the long run, the total energy usage for cooking may be unchanged though electricity consumption may have fallen. In summary, price elasticities are likely to differ with different fuels and in different situations.

The situational differences are potentially very important explanations of energy use. As another example, gasoline is a small portion of the total cost of an automobile for private passenger driving, and price changes alone are likely to have relatively small effects on use. Furthermore, gasoline usage might be expected to differ significantly depending

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[9] In the parlance of economists, the magnitude of the energy expenditure (or energy in physical units) price elasticity is not precisely known. This does not mean that economists have not attempted to estimate this price elasticity for the different types of energy uses. On the contrary, the literature abounds with such studies. The following represent a selected but representative list: Anderson (1971); Atkinson and Halvorsen (1976); Berndt and Wood (1975); and Fisher and Kaysen (1962).

on the institutional context in which the use was taking place. If the energy were being consumed in a religious context (e.g., going to church on Sunday), small usage-price elasticities might be exptected. In a political context, energy use might not be very price responsive. However, if the energy were being used as part of a profit-maximizing enterprise, its use might be extremely sensitive to price changes. That one cannot simply aggregate across the institutional sectors is a key implication of this study, which is suggestive for future research.

The Basic Statistical Model

From a statistical purview, the social energy use model represents a set of equations that need to be estimated. The socio-economic theory, of course, determines the variables included in each equation to be estimated. In particular, variables can be partitioned into endogenous and exogenous, according to whether the theory is or is not intended to account for their values. The exogenous variables are considered predetermined and given for the analysis of the model. The endogenous variables are considered to be determined within the context of the model. That is, for our statistical purposes, the relevant distinction between endogenous and exogenous variables is between jointly dependent social indicator variables and predetermined social indicator variables, respectively.

It is assumed that the general form of the model should be interactive. Hence, the basic model for the empirical analysis of the social sector is a constant elasticity function

$$(1) \quad R_{it} = \prod_{j=1}^{n} X_{jit}^{\beta_{jt}} \cdot e^{u_{it}}$$

where R_{it} is the relevant social variable (endogenous indicator) for geographic subarea i in time period t. Π is the multiplicative operator over $j = 0,\ldots,n$. The X_{jit}'s are the relevant explanatory social indicator variables, u is the stochastic error term, and the β_{jt}'s are the parameters to be estimated. Applying the natural logarithmic operator to each side of equation (1) yields the equation form that will be estimated statistically. In this form, the parametric coefficients are interpreted as the elasticity of the relevant social variable R with respect to the jth explanatory social indicator variable, and serve as a measure of the degree of social effect or "impact" that is achieved in terms of the X_{jit}'s. (That is, $\beta_{jt} = \frac{\delta R_{it}}{\delta X_{jit}} \cdot \frac{X_{jit}}{R_{it}}$ which is the definition of "elasticity.")

An especially important case of equation (1), one emphasized by economists, is equation (2). Dropping the time subscript for convenience, equation (2) is

$$(2) \quad R_i = \alpha_0 + \alpha_1 \ln Y_i + u_i$$

where Y_i is income (or some relevant measure of general economic activity) for the ith subarea. The parameter α_1 is the operational measure of the effect of income on R. If $\alpha_1 = 0$, R is unrelated to the level of Y in the ith subarea and is consistent with "perfectly" unresponsive social interaction in a statistical sense. If, in addition, $u_i \equiv 0$ for all i, then there would exist total, deterministic non-interaction.

More generally, R_i should be analyzed in a more complete system that contains more than one explanatory variable, such as equation (3).

$$(3) \quad \ln R_i = b_0 + b_1 \ln Y_i + b_2 \ln E_i + b_3 \ln Z_i + \sum_{j=4}^{n} b_j \ln X_{ji} + e_i$$

where E_i, for example, is the average employment rate in subarea i, Z_i is an exogenous shock variable for subarea i and X_{ji} represents the set of other relevant social indicators. Comparing equations (2) and (3), and using Thiel's (1965) notion of model misspecification, one can see that the "effects" measure α_1 is related to the behavioral parameters of the more complete formulation by equation (4) where γ_{gh} is the constant elasticity of g with respect to h:

$$(4) \quad \alpha_1 = b_1 + b_2 \gamma_{EY} + b_3 \gamma_{ZY} + \sum_{j=4}^{n} b_j \gamma_{X_j Y}$$

Note that equation (4) demonstrates that the measure R, while it is affected by Y, may be affected by other socio-economic-political variables as well, and, if the model is improperly specified, can yield misleading conclusions. This is key to our analysis: it suggests that proper modelling of social effects requires correct a priori theory of social behavior in order to avoid inferring invalid conclusions about behavior from the statistical model.

Finally, and related to the last point, it is important to reiterate that this model has significant limitations; this model "describes" the interrelationship between socio-economic variables and our endogenous indicator variable, R. This, because it is an indicator model, may not capture the full extent of the complex and comprehensive social structural system. In fact, it is the overwhelming modelling complexities and data requirements of the "complete" social model that has led this research to utilize an indicator approach in the first place. Hence, this representation is an oversimplification of the complex interactive behavioral model employing social indicators as surrogates for social behavioral variables.[10]

The Empirical Findings

Our empirical analysis, an econometric-social indicators model, is an example of the general model represented in Figure 2. Figure 3 is a diagramatic analog of Figure 2; it represents the specific social sub-system of interest, consisting of three equations. Each equation corresponds to a social indicator sector. They are the annual growth rate of GNP per capita, the change in the annual national unemployment rate, and the annual growth rate for per capita energy consumption; each is treated as an endogenous social indicator in the statistical model. The system is estimated in log-linear functional form for each of these variables in Tables 1, 2 and 3, respectively. The method of estimation is two stage least squares (TSLS).[11] Table 4 provides a complete glossary of variable definitions.

Figure 3, the schematic presentation of the empirical model, deserves several comments. First, it represents a complex social behavioral system. The extreme right hand box is the total energy usage component of the system, which is the principal concern of the analysis. According to this model, energy use is directly affected by only one of the two other

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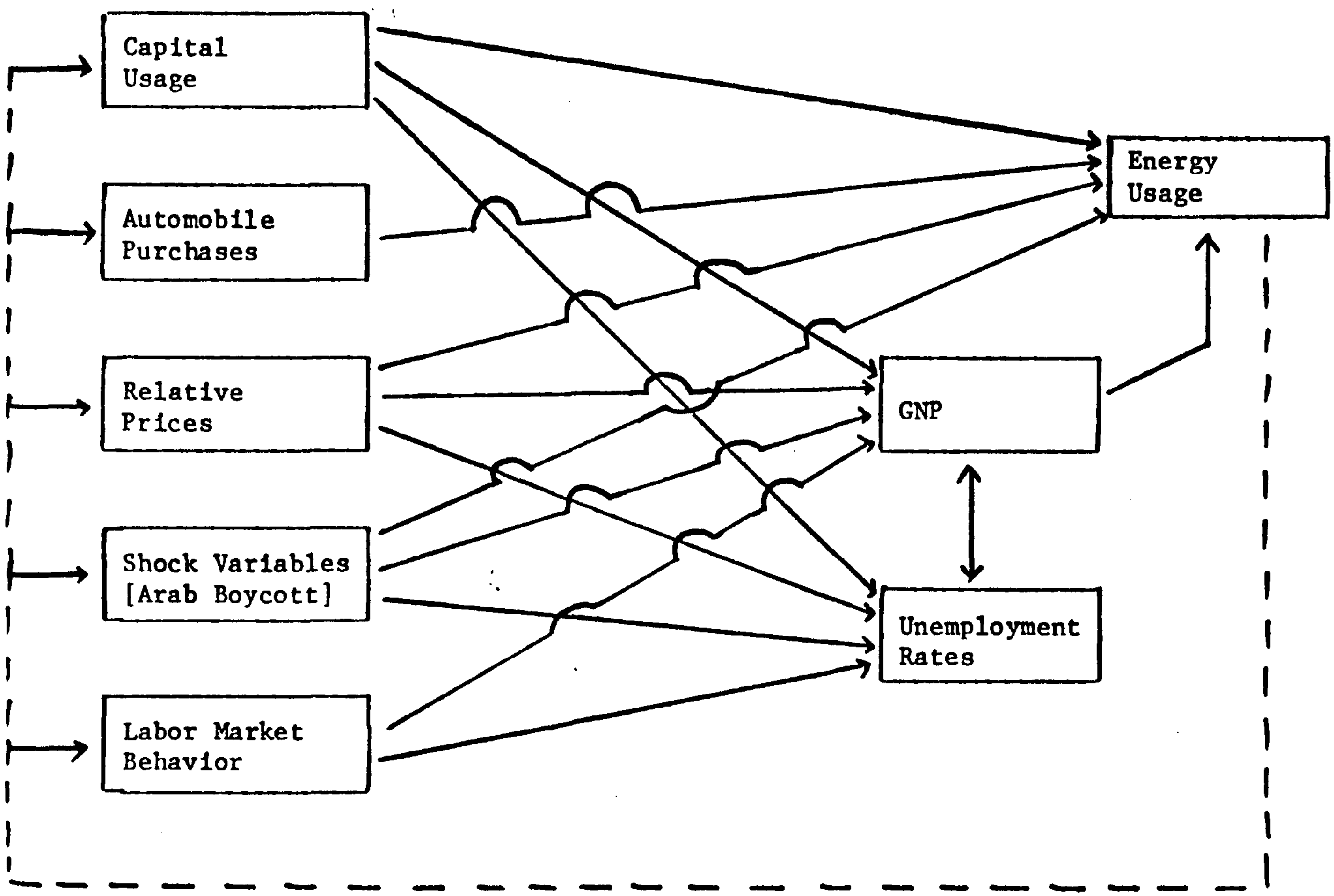
[10]The empirical example below will employ statistical models of the form of equation (3). Also, it should be noted that the use of national aggregate annual data for only fifteen years (1960-1974) limits the number of variables that can be used in the study.

[11]Since the social effects model in general will contain several equations, each with several endogenous explanatory variables, TSLS has been employed as the estimating procedure in order to avoid simultaneity bias. Simultaneity bias occurs when an endogenous variable is considered an independent explanatory variable because the assumption of stochastic independence between the error term and the regressors in the ordinary least squares model breaks down. As is well known, the use of ordinary least squares (OLS) in such circumstances would yield statistically inconsistent estimates of the parameters; the use of TSLS will produce statistically consistent estimators (though not necessarily unbiased). See, for example, J. Johnston (1972), especially Chapters 12 and 13.

FIGURE 3: THE GNP-UNEMPLOYMENT-ENERGY USAGE TRIANGLE

FIGURE 3



prime endogenous social indicators variables, GNP. This implies that unemployment, the other prime endogenous social indicator variable in the system, affects energy usage through indirect mechanisms, either through its interactions with the other endogenous social indicator (GNP) that directly impacts on energy use or through exogenous variables that interact directly or indirectly with energy usage behavior. In the statistical analysis, the inclusion of the unemployment rate variate as an explanatory variable (when accompanied by a capital-labor productivity measure) does not improve the statistical performance of the energy use equation. Tracing out the paths from the energy usage box shows that it does not affect GNP or unemployment directly, but does feedback into the exogenous social indicator variables.

Second, anticipating the discussion of the findings, the overall statistical performance of each of the equations in this sybsystem would appear to be highly satisfactory. In an important sense, it is startling how well these equations perform, considering that the model's basic data are national aggregative in nature. It should be realized that aggregation is not only national-geographic but across institutions and sectors as well. Refinement of the data by energy usage (consumption) subsector, by fuel types, by sub-geographic areas, and by institutions, though likely to reduce overall fits, is probably needed to enhance understanding of many nuances of the social behavior-energy use system that cannot possibly be observed at a national level.

A word about the data seems appropriate at this point. We use annualized time series data for the period 1960 through 1974. All of the data utilized in our statistical analyses are available from public or quasi-public sources. The typical variable name is in the form LXXXXXXR1. The "XXXXXX" part of a variable name is suggestive of its content such as "GNP" for Gross National Product. The prefix "L" signifies that the values of the variable are calculated as natural logarithms. The suffix R1 signifies that the variable is created as a ratio of the current period's value over the value lagged one period (i.e., one plus the growth rate for the variable). Furthermore, to assist the reader, in key places in each of the tables discussed below, a suggestive phrase or word has been inserted in parentheses next to the variable acronym. Finally, the "raw" data are annualized time series, which for the 1960 through 1974 period contain a very strong trend element. (On the other side, to a large extent, annual data washes out non-secular phenomenon, such as short cycles, short-run random shocks or seasonal variations.) Because of this trend problem, the rate of change (the growth rate) for each variable has been utilized in lieu of the raw data.[12] Put differently, the choice of variable form or its transformation, where possible, has been de-trended.

Though our principal interest will be related to the statistical results of Table 3, the energy usage equation, a few brief comments about Tables 1 and 2 are in order. Table 1 contains several alternative specifications of the GNP equation. The dependent variable is GNPPR1, the

[12] Hence, one must take care in the interpretation of results. For example, if the estimated relationship were $\log \frac{(Yt)}{(Yt-1)} = B \log \frac{(Xt)}{(Xt-1)} + u_t$, then the coefficient B is an elasticity comparing the <u>change</u> in the growth rate of Y with respect to the change in the growth rate of X over time. If $g_z = \frac{dz}{z}$, and $\Delta g_z = g_z|_t - g_z|_{t-1}$, then, in this example, $B = \frac{\Delta g_y}{\Delta g_x}$.

logarithm of the ratio of current period per capita real GNP to that lagged one period, multiplied by 100. The growth is the unemployment rate (UERR1), an endogenous explanatory variable, has a statistically significant negative coefficient in all specifications of the estimated equation. The growth in the output-capital ratio (LCAPR1), though not one of the model's dependent variables, is treated as endogenous. This is done because economic theory suggests that output determination and capital-intensity are part of the same simultaneous production decision. As would be expected if this view were correct, the coefficient of LCAPR1 is statistically significantly positive, reflecting that a growth in the output-capital ratio over time, ceteris paribus, will increase the rate of growth of per capita GNP. Note that energy usage does not appear to affect the growth of GNP per capita, when the output-capital variable is included in the equation.

One might, also, expect that as total employment rates grow or labor force participation rates increase, and as the economy reaches generally higher levels of activity, the real economic growth rate (though positive) may decrease. Hence, the negative signs for the coefficients of EMR1 and LPRTR1 are not unexpected. Note that the coefficient of RBCLF, the proportion of blacks in the civilian labor force, is statistically significantly positive, suggesting that blacks tend to enter the labor force when employment is available, and vice versa. The coefficient for the dummy variable for 1973-1974 (DD) has the anticipated negative coefficient, reflecting at least in part the effects of energy shortages and the induced general economic slow-down of that sub-period. Similarly, the coefficient for CPFR1, the growth in the fuel and utilities component of the CPI relative to the total CPI, is significantly statistically

Table 1: GNP Growth Rate Equation, Estimated by TSLS (2)
Dependent Variable: GNPPR1

Independent Variable	Equation (1) I-a	Equation I-b	Equation I-c
Unemployment Rate (UERR1)	-.096 (e) (-5.57*)	-.090 (e) (-6.14*)	-.072 (e) (-4.96*)
Output-Capital (LCAPR1)	.592 (e) (7.51*)	.427 (e) (4.62*)	.646 (e) (7.59*)
Employment Levels (EMR1)	-.335 (-1.73++)		
Black Employment (RBCLF)	1.27 (2.97**)		1.53 (3.29**)
Labor Force Participation (LPRTR1)		-.382 (-1.57++)	
1973-74 Dummy (DD)	-.033 (-4.42*)		-.039 (-5.02*)
Fuel Prices (CPFR1)		-.110 (-2.20+)	
Intercept	.839 (0.45)	5.35 (4.15*)	-1.68 (-1.14)
$\bar{R}^2$; D.W. (3)	.987;2.26	.966;1.51	.982;2.53

(1) For each independent variable, the coefficient value and t-statistic are reported; *, **, +, ++ denote that the t-statistic is significant at the 1%, 5%, 10% or 15% level, respectively. This notation is utilized in subsequent tables as well.

(2) The exogenous variables for the GNP equations are LPTR1, CPFR1, DD, MEMR, POPHR1, LEFFR1, EMR1 and RBCLF

(3) D.W. denotes Durbin-Watson statistic; $\bar{R}^2$ denotes coefficient of determination, corrected for degrees of freedom.

(e) Denotes that the independent variable is treated as endogenous in the TSLS estimation of the equation.

negative, intimating that fuel costs vis-a-vis other input costs may have significant deleterious impacts on the growth of output.

Turning to Table 2, three slightly different alternative specifications for the unemployment equation are presented. Each unemployment equation has UERR1, the logarithm of the ratio of the current to the lagged national unemployment rate, as its dependent variable. The growth in per capita GNP (GNPPR1), treated as endogenous, has a strong negative effect on unemployment, as is expected. In the earlier draft for this study, at first glance, surprisingly, per capita energy usage appeared to have a positive relationship with the unemployment rate.[13] This is likely to be in part the resultant of the time series trend of a secular increase in energy usage growth with a mild secular increase in the national unemployment rate for the sample period 1960 through 1974. Also, though not tested in the previous study, it seemed likely that this phenomenon resulted from not taking into account the variability in the capital-labor input intensities. With the inclusion of capital intensity variables and the de-trending of data by the use of growth rates, this study finds, in fact, that the energy use-unemployment relationship is no longer statistically significant.

In particular, in Table 2, the growth in the output-capital ratio (LCAPR1) increases the observed unemployment rate. This is to be expected if, as hypothesized, capital and energy are input complements, and capital and labor are input substitutes. Additional proof of this phenomenon is engendered by the negative coefficient for LOKRW, the logarithm of the ratio

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[13] Klausner and Edelstein (1977).

Table 2: Changes in the Unemployment Rate Equation, Estimated by TSLS (2)
Dependent Variable: UERR1

Independent Variable	Equation II-a (1)	Equation II-b	Equation II-c
GNP per Capita (GNPPR1)	-6.58 (e) (-7.05*)	-8.32 (e) (-8.87*)	-8.88 (-7.28*)
Capital-labor productivity (LOKRW)	-.096 (e) (-1.77++)		
Output-Capital (LCAPR1)		2.95 (e) (2.95**)	3.00 (2.56**)
Labor Force Participation (LPRTR1)	-11.3 (-2.67**)	-3.69 (-1.92+)	-4.43 (-2.03+)
Fuel Prices (CPFR1)	-1.34 (-1.91+)		-.818 (-1.60++)
1973-74 Dummy (DD)		-.110 (-2.54**)	
Intercept	94.3 (4.25*)	46.6 (4.57*)	56.2 (4.97*)
$\bar{R}^2$; D.W.	.879;1.69	.935;2.07	.911;1.56

(1) See Footnote 1 in Table 1.

(2) The exogenous variables for the unemployment equations are LEFFR1, POPHR1, CPFR1, DD, LPRTR1, MEMR, EMR1, RBCLF

(e) Denotes that the independent variable is treated as endogenous in the TSLS estimation of the equation.

of the average business output-capital ratio to the real wage. Borrowing from economic theory, if producers are in equilibrium, LOKRW corresponds to the relative factor payments to capital and labor, respectively. An increase in this ratio implies that capital is becoming relatively more expensive than labor, thereby encouraging producers to engage more labor, and thereby (at the margin) decreasing the rate of growth of the unemployment rate.

The coefficients for the other variables in Table 2 follow normal expectations. An increase in the labor force participation rate correlates with a decrease in the rate of growth of the unemployment rate. This is consistent with the commonly held belief that people, particularly minorities, the young and women, join the labor force (i.e., actively seek employment) when jobs are plentiful and the unemployment rate is generally decreasing or relatively low. Finally, increases in the relative price of fuels and utilities (CPFR1), while as shown in Table 1, tending to decrease GNP growth rates, appear to make labor, relative to capital-energy intensive production, more attractive. Hence, it has the negative coefficient. Similarly, DD is a surrogate for the energy shortage period of 1973-1974, and has a negative coefficient because of the implied increased attractiveness of labor-based production vis-a-vis capital-energy intensive production.

Table 3 presents the empirical findings under three slightly different specifications for EUPR1, the natural logarithm of the ratio of current to lagged total gross national energy consumption (measured in millions of BTU's) per capita. According to the results reported in this table, growth in GNP per capita (GNPPR1) has a statistically significant positive effect upon the growth rate in per capita energy consumption. Note that the unemployment rate variable does not have a direct effect upon energy consumption, once a measure of capital-labor intensity is included in the equation. LOKRW acts as a proxy for the relative marginal costs of capital and labor in production. Given the hypothesized capital-energy complementarity and their joint production substitutability for labor, the statistically significant negative coefficient for LOKRW is anticipated.

The other statistical findings are equally plausible. The coefficient for the dummy variable for 1973-1974 should be negatively related to the growth in energy usage per capita, as should be the coefficient for the relative price of energy (CPFR1). Finally, it is found that an increase in LEFFR1, the logarithm of the rate of growth in the market share of new, smaller (presumably fuel efficient) automobiles to all authomobiles, will decrease the rate of growth of per capita energy consumption, as indicated by its statistically significant negative coefficient.

Using the values of the estimated coefficients for specific explanatory variables, one can ascertain the energy consumption effects of the corresponding variables. For example, during the 1960-1974 period, the mean annual rates of growth of energy use per capita and GNP per capita were 2.42 percent and 2.95 percent, respectively. According to the estimated relationships for equations III-a,b, and c in Table 3, a one percent increase in the annual rate of growth in GNP per capita, from say, 2.95 percent to 3.95 percent per annum would induce energy usage per capita to grow by an additional 0.20 to 0.27 percent per annum. In 1974, a one percent increase in the growth of GNP per capita would have been translated

Table 3: Energy Use Per Capita Growth Equation, Estimated by TSLS[2]
Dependent Variable: EUPR1

Independent Variable	Equation III-a[1]	Equation III-b	Equation III-c
GNP per capita (GNPPR1)	.257(e) (1.96+)	.269(e) (2.36**)	.200(e) (1.74++)
Capital-Labor Productivity (LOKRW)	-.016(e) (-4.12*)	-.019(e) (-5.05*)	-.018(e) (-5.19*)
1973-74 Dummy (DD)	-.029 (-3.79*)	-.033 (-.350)	
Small Auto Buying (LEFFR1)	-.077 (-3.37*)		-.024 (-1.66++)
Fuel Prices (CPFR1)		-.431 (-3.97*)	-.411 (-4.68*)
Intercept	3.96 (5.85*)	5.58 (6.01*)	5.91 (8.03*)
$\bar{R}^2$; D.W.	.876;2.49	.899;2.08	.907;2.40

(1) See Footnote 1 in Table 1

(2) The exogenous variables for the energy use equation are LEFFR1, POPHR1, CPFR1, DD, LPRTR1, MEMR, EMR1 and RBCLF

(e) Denotes that the independent variable is treated as endogenous in the TSLS estimation of the equation.

into $46 per capita or slightly less than $10 billion in the aggregate. If it is assumed that energy usage per capita would have been required to grow by, say, 0.25 percent to increase the output by one percent, this would have resulted in an increase in energy consumption of a little less than one million BTU's per capita. Similarly, in 1974, a one percent increase in the cost of capital relative to real wages (i.e., an increase of one percent in LOKRW) would have caused growth in energy use per capita to decrease by about 0.2 percent. This would have translated in 1974 into a reduction of about 0.7 million BTU's per capita.

The usefulness of the model for tracing out public policy activities should be clear. If one were to refine this type of social model, it could be incorporated into policy decision making in at least two different ways, suggestive of our calculation of energy effects for Table 3. First, if one were to constrain energy consumption by some policy device, its time path of effects on the subsectors of the model, such as unemployment or GNP, could be simulated. Similarly, policies that influence exogenous indicators, such as automobile sales, could be analyzed in terms of their energy effects. Second, a set of public policies could be devised to affect GNP and energy usage per capita simultaneously by creating indirect "social" policies to affect other sectors that, in combination, indirectly influence the desired objective.

Table 4: Glossary of Variable Names

GNPPR1	Natural logarithm of the annual growth rate of GNP per capita multiplied by 100.
UERR1	Natural logarithm of the annual growth rate in the national unemployment rate multiplied by 100.
EUPR1	Natural logarithm of the annual growth rate for the total gross national energy consumption per capita (measured in millions of BTU) multiplied by 100.
LOKRW	Natural logarithm of the ratio of the average output-capital ratio and the real usage, multiplied by 1000.
LCAPR1	Natural logarithm of the annual growth rate of the output-capital ratio multiplied by 100.
DD	Dummy Variable: $\begin{Bmatrix} 1 \text{ for 1973 or 1974} \\ 0 \text{ otherwise} \end{Bmatrix}$
LEFFR1	Natural logarithm of the annual growth rate for the ratio of new 4 - and 6 - cylinder and imported car sales to total cales of new foreign and domestic cars multiplied by 100.
EMR1	Natural logarithm of the annual growth rate of the total number of employed members of the civilian labor force multiplied by 100.
RBCLF	Natural logarithm of the ratio of the blacks in the labor force to the total civilian labor force multiplied by 100.
LPRTR1	Natural logarithm of the annual growth rate of the ratio of the civilian labor force to the total population (i.e., participation rate) multiplied by 100.
CPFR1	Natural logarithm of the annual growth rate of the ratio of the household fuel and utilities components of the CPI index to the total CPI index multiplied by 100.

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CHAPTER II

SUMMARY AND PROSPECTUS

This study developed a theory relating energy use and social behavior. The theory then guided and justified the selection of a tentative list of social indicators pertaining to energy use in various social situations and assessing those social situations themselves. Each is a surrogate for a social theoretical construct. The indicators are "unobtrusive," being available from public or quasi-public data sources. An empirical model was devised, incorporating some of the selected social indicators,and then used to test the empirical worth of the social theory regarding the social effects of change in levels of energy use. Three empirical examples were developed. Their results suggest that the social indicator approach is a useful method for studying complex interrelationships between social, economic and political phenomena and energy usage.

The Potential for Future Modelling of the Interdependence of Energy Use and Social Behavior

It should, however, be clear that our approach is in a primordial stage of development and experimentation. Though we are cautiously sanguine about the long run viability and usefulness of the social indicator approach for enhancing the understanding about social behavior, general issues about its limitations should be emphasized. These limitations relate to (1) forecasting versus structural analysis, (2) the choice of methodology and (3) the evaluation and assessment of an indicators model.

(1) In the practice of empirical work it is unfortunate, but frequently true, that the choice of the model and methodology must be modified to the specific purpose or objective of the study. This may entail the taking of a shortcut or the truncating of the "whole" model in order to utilize either limited available data or resources. One of the most common problems of this sort stems from the consideration of the ultimate use of the model. If the principal focus of the model is forecasting rather than "structural" analysis, it is likely that the model shall be "simplified" to engender testable results. For example, in econometric studies, forecasting equations are reduced form models, with strictly endogenous dependent variates of interest. On the other hand, if structure were the primary concern of the analyst, the "proper" specification of the model is likely to set the dependent variable as a function of exogenous and endogenous variables. The latter approach is more complex in terms of underlying theoretical requirements and estimation procedures, but yields results pertaining to the structure and behavior of the system. Put somewhat differently, the choice of method often is a trade-off between the cost of modelling the full complexity of a system and the degree of improvement and the ultimate usefulness of the output. Hence, the choice of model and method depends upon the purpose of the study.

(2) If one were to claim that the purpose of the study were, for example, forecasting energy use, there are several competitive methodologies that one might consider. In all likelihood, the appropriate method for solving an empirical problem would be an ecclectic approach. The analysis above utilizes econometric methods, which we believe are appropriate for examining social behavioral systems and how they relate to energy demand. If we were to study physical energy systems or energy

supply or energy cost equations, deterministic programming or probabilistic programming models might be most useful. Incidentally, this dichotomy has been found to be relevant by the government energy agency in its development of the PIES and subsequent models for energy use in the United States.

(3) Assessment and evaluation of a model involve a rigorous examination of both the forecasts/results and the methods employed to derive them. The methodology is subject to tests in order to provide some indication of the validity of, say, the forecast. Of course, if the model does not perform adequately, one should examine the method closely. In addition to methodological assessments, the forecast results themselves can be examined. (This has been done for the models presented above in the evaluation report prepared by Mathtech, Appendix A of this volume). The objective here is to discern whether or not the results seem reasonable in the light of past experience and present and anticipated future developments.

In the assessment process, one should commence by determining the validity of the data. Errors in the basic data necessarily vitiate the final outputs. Common causes of data errors include inadequate sample size, poorly constructed data collection methods (e.g., poor interviewers or questionnaires for survey data collection) and data manipulation errors. Another type of error frequently contained in survey or indicator data is substance error. Here the analyst has failed to choose the proper variables for study. In the social indicator approach, this is likely to occur because the data surrogate used may not be characteristic of the underlying social behavior.

Closely related to substantive validity error is causal validity error. It is often difficult to prove cause and effect relationships. However, the absence of cause and effect would not prevent the analyst from, say, generating forecasts of energy use. The analyst incorporates into his forecasting approach variables that allow prediction of changes in energy use, even though they do not necessarily cause these changes. In time series analyses, for example, time may be treated as an independent variable (denoting trend effects), though it is not a causal variable *per se*. The causality issue is particularly troublesome in long run analyses since basic underlying structural relationships may change. The analyst, therefore, should build models based upon the existence of a logical set of causal relationships (i.e., the theory). Furthermore, the theory in the form of a model can be tested rigorously for "correlation" between dependent and independent variates as well as the existence of lead-lag relationships. Finally, it is typically not a trivial matter in choosing the exact specification of the model and the precise functional form to be tested. Ultimately, empirical work often requires the judgment of the analyst in order to be operationalized, and there appears to be no substitute for the "common sense" of the analyst, particularly in futuristic forecasting.

In summary, empirical analyses of complex social systems and energy usage are fraught with implementation pitfalls. However, it is our position that methods exist that, when used with extreme care and understanding, can yield in the long run viable, usable and useful insights into the complex interdependencies between social organizational behavior and its changes and energy usage.

Our Empirical Model: A Brief Summary of Findings

The empirical models developed in this study used national annualized data to examine the relationship between energy use and the social system. A "general" social effects model was developed with three interdependent elements: the policy component, the social behavioral component and the energy usage component. Government policy affects social behavior, which, in turn, results in changes in energy usage. Likewise, energy usage "feeds back" into the social behavioral component of the model and the government sector as well. The model suggested here provides for the explicit incorporation of social sector variables into the energy use-public policy model. Put somewhat differently, policy analysts approach policy changes affecting energy usage through a "black box"; the "black box" is a social system. The present model is designed to shed light upon the inner workings of this "black box."

In quantitative terms, using our statistical model, the estimating equation for the total energy use per capita suggests that, for instance, a one percent increase in GNP per capita in 1974 would have increased energy consumption per capita in 1974 by about 0.58 percent. These results translate into a change in GNP per capita of $46 (or approximately $10 billion in aggregate) and about 2.04 million BTU's per capita. Similarly, an increase in the average national unemployment rate in 1974 by one percent from 6.7% to 7.7% would have been expected to reduce energy consumption per capita in 1975 via its lagged effect by about 0.8 percent, or 2.8 million BTU's per capita.

Our statistical model demonstrates that the purchase of smaller automobiles should have significant impacts on energy usage. For instance, in 1974 if new small automobile purchase patterns had shifted from 62.9% to 63.6% of all new automobile sales, total energy consumption per capita would have been reduced by 1.35 million BTU's. This should not be interpreted to mean that this energy saving is generated solely from the smaller autos being purchased; more correctly, the change in automobile purchases is a social indicator of a complex phenomenon that leads to overall energy conservation. The purchase of a small automobile is a declaration that the appertenances of travel, and, perhaps, trip decisions, will play a smaller part in the lives of the purchasers.

It is interesting to note that a larger proportion of manufacturing employment to total employment has a depressing effect upon energy usage per capita. Directly interpreted this would seem to be an anomaly since a worker in a factory consumes more energy in his occupation than one in a bank or retail store. However, what is reflected here is a relatively greater proportion of blue to white collar workers in the population. Blue collar workers are, in their personal lives, less energy demanding. It is in the so-called post-industrial society of white collar workers that energy consumption rises as they live increasingly complex lives--joining voluntary organizations, participating in community politics, travelling for recreation--and proliferating the organizations required to support the more complex social life. Attempts to include other subsector employment and unemployment levels by finer SIC categories, for instance, for high energy industries, were not statistically successful. It is likely that this is the resultant of the highly aggregative nature of our model.

Several other indicators were generally successful predictors of social behavior in various equations. They included the price of energy, as reflected in the Fuel Component of the CPI relative to the total CPI, the manufacturing real wage rate, household size, teenage employment, non-white labor force size and the urban-rural driving mileage mix. Several of these merit explanation. As predicted by the social theory, a decrease in average household size reflects structural differentiation of the family--a factor increasing intensity of social interaction and, thus, the per capita level of energy consumption. The increase of teen-agers in the labor force is associated with energy use because it signals more ties with the economy on the part of each family--for teenagers living at home--and thus more intense social activity or--for teenagers not at home--it signals the establishment of new independent social units--each a new energy consumer.

Our statistical findings confirm that the unemployment rate and the level of GNP per capita are positively related during the sample period. This, in part, probably reflects the secular trends in the data as well as the fact that the unemployment rate, through enhanced participation rates, may grow during periods of rapid labor force growth. Moreover, labor force participation rate increases are usually correlated with growth in GNP per capita. In terms of the social theory, this represents the "depopulation of the production unit." In a high energy situation, fewer workers control larger amounts of energy and larger activity spaces. Thus, relatively fewer are needed. This produces the paradox of relatively more unemployed as GNP and energy consumption grow.

The statistical results generated by our model should be considered tentative, but they still demonstrate the feasibility of our social indicator approach for modelling social-energy use behavior. The potential for examin-ing systematically the effects of public policies should be clear. If one were to refine this type of social behavior-energy use model, it could be incorporated into public policy decision-making. For example, the model could be used to simulate time-paths of effects of social events or policy actions on energy usage. An illustrative policy impact analysis is presented in the Mathtech report. The output of the equations thus should not be taken as realistic policy guides, since only a small sector of the social effects model has been constructed. Rather, the exercise shows how the model would be used to forecast policy outcomes.

The policy sensitivity of the model was tested for three types of energy policies. The first test is developed around an energy pricing policy, specifically a policy that would cause the price of fuel to increase more rapidly than the CPI. The solution to the equations indicates that such a policy would increase unemployment, gross energy consumption, lagged GNP, the total number of miles driven and the proportion of large cars purchased. A second test was made on employment policies. For example, we tested an employment policy that would increase the non-white component of the labor force. This would, the equations indicate, decrease the GNP per capita and decrease energy use and increase the general unemployment rate.

A third type of policy, the encouragement of productivity--however that would be accomplished--was tested and shown to affect one year-lagged GNP per capita. The outcome would be a positive effect on current miles driven. A policy which increases three year lagged GNP per capita would positively increase current-year fuel efficiency. Some of these findings would be counter-intuitive if interpreted in a simple supply/demand framework, but they are consistent with the underlying social theory that the "driving" variable is the increasing intensity of social activity and the process of structural differentiation.

Suggestions for the Next Step

The social indicator-energy usage models developed in this report are a first step in a promising line of research and model development. Predicated on the assumption that future work will focus upon enhancing forecasting capabilities, improving general understanding of the social-energy systems and developing a tool for public policy decision-making, the social indicator model approach leads to several natural extensions. This project's results illustrate that social indicator modelling is feasible or, at the very least, merits additional examination and experimentation. A great deal remains to be learned.

Future studies might reduce the level of aggregation presented in our models. Disaggregation needs to be achieved in several directions. First, energy usage should be examined separately for each institutional area. Second, energy usage can be subdivided into consumer and institutional subsectors by fuel types in relation to social purposes. Third, energy usage can be further disaggregated by geographic subarea in the light of the characteristics of the society and physical environment of that area. This will permit the use of cross-sectional data (by geographic location, by energy uses, by energy source) in concert with time series (the same data over several years). Fourth, it is likely that social indicator-energy use models can be productively integrated into or coordinated with models of physical energy systems as well as to pure economic models. Fifth, it is also likely that quarterly data which increases the number of observations can be useful, especially when utilizing economic data series. Although quarterly data is more likely to contain autocorrelation, frequently it is an understanding of short term temporally lagged effects that is needed and can be obtained only by studying sub-annualized data series. Sixth, the "unobtrusive" indicators used in this study can be combined with survey data now being collected on energy consumption behavior and attitude. Finally, it is likely that more refined "unobtrusive" social indicators can be developed to reflect more precisely social behavior variables.

APPENDIX A

EVALUATION OF SOCIAL-ECONOMETRIC MODEL OF U.S. ENERGY/ECONOMIC RELATIONSHIPS DEVELOPED BY THE CENTER FOR RESEARCH ON THE ACTS OF MAN

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INTRODUCTION

The objective of this report is to evaluate an econometric model of the U. S. energy economy based on sociological theory. This model and the underlying social theory were developed by the Center for Research on the Acts of Man (CRAM) for the Federal Energy Administration. The social theory was developed and is so far summarized in the CRAM Report.

There are two parts to the analysis performed by MATHEMATICA of the CRAM Model. The first is a technical review of the characteristics of the Model itself against various criteria. The second is an evaluation of the impact of varying some of the policy parameters in the Model.

There are a number of limitations on our evaluation, of which the reviewer should be aware:

1. No attempt is made to judge the social or economic theory underlying the Model or its specifications. MATHEMATICA limited its analysis to an interpretation of the technical characteristics and the results of the model. While some inference as to the economic reasonableness of certain equation coefficients are made, no evaluation of the economic or social theory of the Model as a whole is undertaken. The underlying basis for the analysis is an enumeration of evaluative measures and not an interpretation of the theory from which it is derived.

2. No assessment of the reasonableness or generality of the data used for model estimation was undertaken.

3. The evaluation itself was done under tight time constraints and with only very limited documentation for the Model provided by CRAM.

4. In evaluating the response of the Model to policy measures, analysis is limited to documenting the sensitivity of the model parameters under specific conditions, and does not review the Model's usefulness for policy analysis.

PART I -- EVALUATION OF MODEL CHARACTERISTICS

A. SUMMARY OF THE MODEL

The model consists of one five-equation system and three subsystems based on national energy and economic data. The five equations in the system are in log-linear form and represent GNP per capita (LGNPP), total energy use per capita (LEUP), the national annual average unemployment rate (LUER), miles driven by passenger cars per capita (LMILEP), and the fuel efficiency of new car production and sales (LEFF). Three subsystems are: 1) ratio of energy use per capita (EUPR1), GNP ratio per capita (GNPPR1), and the ratio of unemployment rate (UERR1) between current year and lagged year; 2) energy use per capita, unemployment rate, and GNP per capita; and 3) miles per capita and fuel efficiency.

Neither the five-equation system nor the three subsystems is a closed system, i.e., these systems do not have a boundary because they never include an identity to close the system. These systems were estimated by two-stage least squares scheme on the sample period of 1961-1973. Simultaneous bias, multicollinearity and autocorrelation were "corrected" in this model.

There are a number of criteria on which the CRAM model is evaluated. These criteria, explained in more detail in the sections below, include:

- the degree of identification of the model
- statistical significance of model estimates
- the stability of parameter estimates
- the accuracy of the model in making projections

B. IDENTIFICATION PROBLEM

For any system with interdependent equations, a problem known as identification exists. If we have a two-equation system and rearrange into the "structural" form of the system we obtain:

Left-hand Side Variable, y_i (Endogenous Variables)		Right-hand Side Variable, x_i (Exogenous Variables)				
y_1	y_2	x_1	x_2	x_3	e	
1	a_{12}	b_{11}	b_{12}	b_{13}	e_1	(1)
a_{21}	1	b_{21}	b_{22}	b_{23}	e_2	(2)

Since the above two equations have exactly the same variables where the a_{ij}'s and b_{ij}'s are the coefficients of the exogenous and endogenous variables respectively, there is no way to tell the equation estimated is Equation (1) or (2), or even a combination of both equations. Because there is no way to fix the coefficients in Equations (1) and (2), one cannot guarantee that the matrix which transforms the exogenous variables to the endogenous variables will be singular.

$$D \equiv \begin{vmatrix} 1 & a_{21} \\ a_{21} & 1 \end{vmatrix} \neq 0 \tag{3}$$

Equations (1) and (2) can be expressed in matrix form:

$$\begin{pmatrix} 1 & a_{12} \\ a_{21} & 1 \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{pmatrix} e_1 \\ e_2 \end{pmatrix} \tag{4}$$

and then transformed into a "reduced" form:

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} 1 & a_{12} \\ a_{21} & 1 \end{pmatrix}^{-1} \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{pmatrix} 1 & a_{12} \\ a_{21} & 1 \end{pmatrix}^{-1} \begin{pmatrix} e_1 \\ e_2 \end{pmatrix} \tag{5}$$

If determinant D is equal to zero, then the equation (5) cannot be solved; the equation system is infinite and not likely to exist.

However, if we constrain

$b_{12} = 0$, and $b_{23} = 0$,

then Equations (1) and (2) become:

y_1	y_2	x_1	x_2	x_3	e	
1	a_{12}	b_{11}	0	b_{13}	e_1	(1)'
a_{21}	1	b_{21}	b_{22}	0	e_2	(2)'

Equation (1)' is significantly different from Equation (2)' , even from the combination of Equations (1)' and (2)' :

$$(\lambda_1 + \lambda_2 a_{21})\, y_1 + (\lambda_1 a_{12} + \lambda_2)\, y_2$$

$$= (\lambda_1 b_{11} + \lambda_2 b_{21})\, x_1 + \lambda_2 b_{22} x_2 + \lambda_1 b_{13} x_3 + \lambda_1 e_1 + \lambda_2 e_2 \quad . \qquad (3)'$$

Therefore, one can define a zero restriction theorem to test the identifiability of a system.

<u>Zero Restriction Theorem:</u>

Define

$$\underset{n(n+m)}{C} \equiv \begin{pmatrix} \underset{n\times n}{A} & \underset{n\times m}{B} \end{pmatrix}$$

and

$$A\, y_t + B\, x_t = e_t \qquad (6)$$

where C is an $n \times (n + m)$ matrix; A is an $n \times n$ matrix; and B is an $n \times m$ matrix. y_t is an $n \times 1$ endogenous variable vector; x_t is an $m \times 1$ exogenous variable vector; e_t is an $n \times 1$ error term vector with $N(0, \sigma^2)$.

TABLE 1: THE "STRUCTURAL" FORM OF THE FIVE EQUATION SYSTEM

Equation	LUER	LEUP	LGNPP	LMILEP	LEFF	Constant	TRES	MRES	RRES	CRES	DRES	GRES	URES	DD	PRES	ERES
1	1	-4.290	4.702			18.57/1+.9L	0.780	-4.162	-2.205	3.418	.203					
2		1	-0.575		+ .385	7.606		-1.166		+0.815		-1.894	- .054	-.015		
3	+0.180		1			7.055							.130	.174		1.046
4	-0.064		-1.322	1	- .414	-1.693					- .036		- .372		-1.95	
5	+0.490		3.467	-2.410	1	7.830				2.366	0.113					-3.242

$$(1 + .9L)LUER - 4.953(1 + .9L)LEUP + 5.443(1 + .9L)LGNPP$$
$$= 19.80 + 1.279(1 + .9L)TRES - 3.989(1 + .9L)MRES$$
$$- 1.620(1 + .9L)RRES + 2.979(1 + .9L)CRES + .103(1 + .9L)CRES \ .$$

Dividing both sides of the above equation by (1 + .9L), one obtains

$$LUER - 4.953\ LEUP + 5.443\ LGNPP$$
$$= 19.80/(1 + .9L) + 1.279\ TRES - 3.989\ MRES - 1.620\ RRES$$
$$+ 2.979\ CRES + .103\ CRES \qquad (8)$$

Equation (8) is the form used in Table 1.

We apply the zero restriction theorem to test the identification of each equation in Table 1.

- Equation 1: LUER

$$\text{Rank}(A_{22}\ B_{22}) = 4$$

Therefore, Equation 1 is identified.

A similar procedure was applied to the other four equations in the system. These are the equations LEUP, LGNNP, LMILEP and LEFF. In each of these equations,

$$\text{Rank}(A_{22}\ B_{22}) = 4$$

This satisfies the zero restriction theorem and indicates that each of these equations is identified.

Applying this procedure to the three-equation system, GNPPRI, EUPRI, UERRI, it was found that each equation in this system is identified. This is also true of the three-equation system, LEUR, LEUP, LGNPP. Tables 2 and 3 represent these two three-equation systems.

TABLE 2: THE FIRST THREE-EQUATION SUBSYSTEM

(in the Form of X_t/X_{t-1})

	LHS (1)			RHS (2)									
Equation	GNPPRI	EUPRI	UERRI	Constant	EMRES	ERRES	RBCLF	POPHRI	CPFRES	PRES	EFFRES	MEMRES	TNRES
1	1		.162	8.20	-.446	.728	-1.168			-.006			
2	-.406	1		6.096				-.728	-.250	-.025	-.145		
3	4.930		1	41/(1+.49L)					-.631	-.124	-	-.365	-.6305

TABLE 3: THE SECOND THREE EQUATION SUBSYSTEM

	LHS (1)			RHS (2)								
Equation	LUER	LEUP	LGNPP	TNRES	MEMRES	CPFRES	DDRES	UERRES	MEMRES	CPFRES	HHRES	RBCLF
1	1	-4.447	4.697	8.871 1.445	-5.630	1.358	.219					
2		1	-.924	.183				.919	-.675	-.429	.797	
3	.082	-.958	1	-2.673			-.102					1.527

The two equations in the two-equation subsystem are reported in Table 4. With eleven exogenous variables, it is very obvious that these two equations are over-identified.

A Final Note About the Identification Problem

The equations in the two-equation subsystem are over-identified. In small sample estimations such as the CRAM model, this simply means that the degrees of freedom are reduced because of the low efficiency of estimation. A principal-components scheme or a truncated two-stage least-squares scheme are suggested in order to reduce the number of variables and gain more degrees of freedom.

C. Statistical Significance of Model Estimates

In this section, representativeness of the model is discussed using criteria such as degree of freedom, significance of parameters estimated, correctness of the signs of parameters, and significance of model equations.

- Five Equation System

1. National Unemployment Rate Relationship

This rate was estimated on energy use, GNP and the residuals of ratio of teenagers in civilian labor force (CLF) to the total CLF, manufacturing production worker weekly earnings, and total labor force. There is a problem in interpreting the economic meaning of the coefficients of these residualized explanatory variables, although they may be useful in a statistical sense.* Therefore, we only examine the results which can be explained from the non-residualized variables. The estimated results indicate that the unemployment rate is positively affected by energy use, i.e. the more the energy use, the higher the unemployment rate. This result seems contradictory to what should be expected. It may need further investigation. GNP per capita has a negative impact on the unemployment rate. Both the

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* This problem is discussed in detail later.

TABLE 4: TWO-EQUATION SUBSYSTEM

LHS (1)			RHS (2)										
Equation	LMILEP	LEFF	LUER	EMRES 1	GNPRES 1	DDRES1	URMRES	CPFRES1	POPRES	GNPRES3	EMRES3	DDRES 3	LPFRES3
1	1	1.048	0	3.822	.475	-.046	.773	.852	-3.738				
2	.508	1	.103							-3.019	-3.842	.122	2.588

coefficients of energy use and GNP per capita are significantly different from zero in the statistical sense. Most coefficients of residualized variables are not significantly different from zero. The high coefficient of determination indicates this equation is a good fit to the historical data.

As a concluding comment, the lack of degrees of freedom, i. e., only three in the equations and one in instrumental variable estimations, greatly distorts the above results of estimation. This is due to the tenuousness of the assumption of normal distribution in the error term when there are so few degrees of freedom. Although we will not mention this problem often in the following discussions, most of the equations estimated in the CRAM Model do appear to have the problem of lack of degrees of freedom.

2. Energy Use Relationship

Energy use is estimated as a function of GNP per capita, efficiency and the residuals of other explanatory variables. The signs of the coefficients of the variables of GNP and efficiency are not contradictory to our *a priori* expectation. The coefficient of GNP is significantly different from zero. The high coefficient of determination with low variance of estimate indicates a good fit to the historical data. This equation in general is satisfactory except that it only had one degree of freedom in the first stage of the two stages least squares scheme.

3. GNP Per Capita Relationships

The equation for GNP per capita was calculated using the unemployment rate and other residualized exogenous variables.

4. Miles Driven By Passenger Car Per Capita Relation

Miles driven by passenger cars are estimated as a function of unemployment rate, GNP, efficiency, and other residualized exogenous variables. It does not seem reasonable that miles driven is positively correlated with unemployment rate, i. e., the higher the unemployment rate is, the more miles people drive. This explanatory variable needs more study. The signs and significance the coefficients of GNP and efficiency are satisfactory. The equation is a very good fit to the historical data. However, the low degrees of freedom (only five) calls into question its credibility.

5. Fuel Efficiency Relation

The fuel efficiency was defined as the ratio of 4 and 6 cylinder and imported cars sold to total sales of foreign and domestic cars. It was estimated on unemployment rate, GNP per capita, miles driven and other residualized variables. The results of the estimation indicate that the higher the unemployment rate is, the more people will buy bigger cars (more than 6-cylinder). These results pose some interesting problems and need further examination. Although the high coefficient of determination shows a good fit to the historical data, all coefficients of explanatory variables are not significantly different from zero. Therefore, this equation should best be re-estimated with other explanatory variables.

- First Three-Equation Subsystem (the form of X_t/X_{t-1})

The three equations in this subsystem are used to test the ratio of national unemployment rate, energy use and GNP per capita. They are all in the logarithmic form.

1. Ratio Between Current Year GNP Per Capita and One-Year Lagged GNP Per Capita

This ratio was regressed on unemployment rate, ratio of non-whites in the civilian labor force to total civilian labor force, and other residuals of exogenous variables. A two stage least squares scheme was used with the 1961 to 1974 data. With ten instrument variables and 5 explanatory variables, the results of the estimation show a lack of degrees of freedom. With so few degrees of freedom, that it is difficult to hold the assumption that the error term (e) in the equation is an independent normal distribution. The signs of the coefficients of unemployment rate and non-white rate chosen correct and the coefficients for these two variables are significantly different from zero. The use of two stage least squares scheme eliminates simultaneous bias. The high value of the coefficient of determination indicates a satisfactory fit to the historical data. The use of residualized variables might make statistical sense, however, it is very difficult to interpret the results of estimation in economic terms. Additionally, it is groundless to residualize dummy variables which have only artificial meaning.

2. Ratio of Current Energy Use Per Capita to Lagged Energy Use Per Capita

This ratio is expressed as a function of GNP per capita, ratio of current to lagged population per household and residuals of other explanatory variables. This equation also has the problem of lack of degrees of freedom. The sign of the coefficient is contradictory to an a priori expectation that more people in the household use more energy, although the coefficient of the population ratio is significantly different from zero at the 95% level. The coefficient of determination shows a satisfactory fit to the historical data. The use of residualized variables creates a problem in economic interpretation of the estimated results.

3. Ratio of Current to Lagged National Annual Average Unemployment Rate

This ratio was estimated using GNP per capita ratio and some other residualized explanatory variables. Because of the elimination of autocorrection in the error term, the already small sample data lost one period. As in the previous two equations, it shows a good fit to the historical data, but lacks degrees of freedom and it is difficult to infer direct economic meaning to the explanatory variables used in the equation.

- Second Three-Equation Subsystem (LUER, LEUP, LGNPP)

This subsystem consists of three equations for unemployment rate, energy use and GNP per capita respectively. The main purpose of the system is to determine the relationships among energy use and GNP and unemployment rate.

1. Unemployment Rate Relationship

Unemployment rate is regressed on energy use, GNP per capita and some other residualized variables. The estimated results indicate that the unemployment rate has a positive correlation with total energy use, i.e., the more energy the nation uses, the higher the unemployment rate it will have. This is very contradictory to an a priori expectation that the more jobs would require more energy use, especially over the period estimated. Therefore, in spite of its very good fit to the historical data and the significance of all the coefficients of the explanatory variable, this equation should be examined carefully to determine the economic reasonableness of the results.

2. Energy Use Relation

Energy use was estimated as a function of GNP per capita and other residualized variables. The equation estimated is very satisfactory in a statistical and economic sense. All the coefficients of its explanatory variables are very significantly different from zero. Energy use has a very high positive correlation with GNP per capita. The high coefficient of determination with a low standard error of estimate indicates a good fit to the historical data.

3. GNP Per Capita Relationship

GNP per capita is estimated on the unemployment rate, energy use, non-white ratio in the labor force, and some other residualized variables. The signs of the coefficients of unemployment, energy use and non-white labor force are not contradictory to any a priori expectations; these are negative, positive, and positive respectively. All the coefficients of the explanatory variables are very significantly different from zero. The high coefficient of determination with low standard error of estimate indicates a good fit to the historical data. This equation, generally, is satisfactory, except for its lack of degrees of freedom.

- Two-Equation Subsystem (LMICEP, LEFF)

Essentially, this subsystem is used to test the relationship between miles driven and fuel efficiency. However, it consists of a relationship with the unemployment rate.

1. Miles Driven Relationship

Miles driven by passenger cars are estimated as a function of fuel efficiency and other residualized explanatory variables. The equation estimated shows the very surprising effect that the miles driven have a negative correlation with fuel efficiency, i.e. the smaller the cars which people have, the fewer miles they will drive. This result may pose some interesting causal questions and should be examined thoroughly to determine its real economic significance, if any, as a number of processes may be occuring to explain this result. Other statistical indices show that it is a good fit to the historical data.

2. Fuel Efficiency Relationship

Fuel efficiency is expressed as a function of the miles driven, the unemployment rate and other residualized variables. The results show that in this model:

- The more people drive, the more they buy small cars;
- The higher the umemployment rate of the nation, the more people buy small foreign cars.

The above two results do seem to make economic sense. Also, the coefficients of the explanatory variables are significantly different from zero. The equation is generally satisfactory, other than its lack of degrees of freedom.

Final Remarks About the Statistical Significance

The complexity of the model mechanics in these four systems makes it difficult to understand the model. Complexity itself does not necessarily increase the accuracy or value of the model. Since the sample size is so small (a maximum of only fifteen sample points), the residualization and autocorrelation corrections employed by the CRAM model seriously weaken the credibility of the model. Both multi-collinearity and autocorrelation may be easily corrected by respecifying the equations, and not resorting to more complex correction techniques.

There are several serious problems in the CRAM model because a lagged endogenous variable is regressed against a current exogenous variable in order to residualize the lagged endogenous variable. Using the Fuel Efficiency variable of the New Car Sales (LEFF) equation in the five-equation system as an example,* we cite the following equations from computer print-outs provided by CRAM:

$$\widehat{LGNPP}(-1) = \alpha_1 LGNPP + \beta_1 \; LEFF + \gamma_1 LUER(-1) + \phi_1 LCPIF \qquad (1)''$$

$$\widehat{LUER}(-1) = \alpha_2 LGNPP + \beta_2 LEFF + \gamma_2 MERR \qquad (2)''$$

$$\widehat{LCPIF} = \alpha_3 \; LGNPP + \beta_3 LEFF + \gamma_3 MEMR + \delta_4 DD \qquad (3)''$$

$$CRES = LCPIF - \widehat{LCPIF}$$

$$\therefore LEUP = a_1 LGNPP + b_1 LEFF + c_1 \; [LGNPP(-1) - \widehat{LGNPP}(-1)]$$

$$+ d_1 \; [LUER(-1) - \widehat{LUER}(-1)] + MEMR + CRES + DD \qquad (4)''$$

where LGNPP(-1) is one year lagged value of LGNPP, and LUER(-1) is one year lagged value of LUER.

Equation 1" is not reasonable. It just does not make sense to estimate this year's GNP on the future years' GNP. One could conceivably envision a scheme whereby it is possible to estimate the

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* This is not a special case. This occurs repeatedly in estimations of other equations in the systems.

present year's GNP based on an expected value of future GNP, but no one knows its actual value. Also, it is assumed that the lagged endogenous variables are independent of the present exogenous variables.

Last year's unemployment was not caused by this year's GNP and fuel efficiency in any sense. "Last" year, people did not have any knowledge about the true figures in the "present" year. The only information they have is "expected" values. Because of the meaninglessness of equations 1" and 2", the residualized variables in equation 4" have no validity and it becomes difficult to interpret the social meaning of equation 4".

A further problem is that the residualization technique only applies to exogenous variables. Since the lagged endogenous variables are assumed independent of the current exogenous variables, there must be no multi-collinearity among exogenous and lagged endogenous variables. In the CRAM model, the multi-collinearity is corrected by regressing an explanatory variable against one or several variables which were considered to be highly correlated. If more than one variable is used, then an explanation of the residualized variable becomes very difficult. In this case, there is no easy way to separate the impacts of these variables on the residualized variable. This difficulty arises because interactions exist among these variables. Additionally, the use of the residualized variables in equation 4" may not eliminate multi-collinearity because in that equation,

$$[\mathrm{LGNPP}(-1) - \widehat{\mathrm{LGNPP}}(-1)] = f(\mathrm{LGNPP}), \text{ and}$$

$$\widehat{\mathrm{CRES}} = \mathrm{LCPIF} - \widehat{\mathrm{LCPIF}} = f(\mathrm{LGNPP})$$

Here, the residualized variable $[\mathrm{LGNPP}(-1) - \widehat{\mathrm{LGNPP}}(-1)]$ is still a function of the residualized variable $[\mathrm{LCPIF} - \widehat{\mathrm{LCPIF}}]$.

In conclusion, the validity of the five-equation system is questionable, although some statistical tests, such as t-ratios and f tests are generally satisfactory.

D. Stability of Model Estimates

The Chow Test* is used to examine the stability of the model parameters through the sample period. The procedure was first to estimate an equation for a sample size, n-1, and then to see the difference between the sum of the squares of the residuals of this equation and the equation with a sample size of n. To the first n-1 observations fit the regression

$$y_1 = x_1 b_1 + e_1$$

and compute the residual sum of squares $e_1'e$. Use the n sample observation to fit the regression

$$y = xb + e$$

again computing the residual sum of squares e'e.

The test of null hypothesis, that the parameters obtained from the n-1 observations obey the same relation as the parameters from n observations, is given:

$$|F| = \left| \frac{(e'e - e_1'e_1)}{e_1 e_1/n-k} \right| \quad (9)$$

which is distributed as F with (m, n-k) degrees of freedom.

This is done three times. Only the first, tenth and last observations are deleted one time for each equation in order to test the stability of the equation's parameters over the sample period. We do notuse this procedure for each year due to the time constraint. However, with three sample years, one should be able to determine parameter stability for each equation.

- Five-Equation System

Table 5 indicates that the parameters in equations of unemployment rate and energy use are very stable over the sample period, but the other parameters in the other equations are not. Especially, the parameters in GNP per capita equation in the sample of 1961 to 1972 are significantly different from those for the equation in the period of 1961

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* Johnston, Econometric Methods, McGraw-Hill Publishing Co., New York, New York, 2nd. Edition, p. 207.

TABLE 5

A PARAMETER STABILITY TEST FOR THE FIVE-EQUATION SYSTEM

EQUATION	ELIMINATING DATA POINT	|Fe|	F.95 (1, n-k)	F.99 (1, n-k)	STABLE
LUERRHO	3	1.125	10.1	34.1	YES
	10	2.97	10.1	34.1	YES
	14	2.7	10.1	34.1	YES
LEUP	2	3.17	7.71	21.2	YES
	10	3.72	7.71	21.2	YES
	13	3.13	7.71	21.2	YES
LGNPP	2	1.377	5.59	12.2	YES
	10	.664	5.59	12.2	YES
	13	5.751	5.59	12.2	?
LEFF	2	6.25	6.61	16.3	YES
	10	.504	6.61	16.3	YES
	14	2.77	6.61	16.3	YES
LMILEP	2	4.665	5.99	13.7	YES
	10	4.277	5.99	13.7	YES
	14	.1337	5.99	13.7	YES

to 1973. Evidently, they are from different populations. It will be more clear if we examine the parameters for these two samples:

For sample period 1961 - 1973, the equation is,

$$LGNPP = 7.055 - .180\ LUER + --- \qquad \text{(a)}$$

For the sample period 1961 - 1972, the equation is,

$$LGNPP = 5.843 + .184\ LUER + --- \qquad \text{(b)}$$

The signs of the parameters of LUER in equations (a) and (b) are opposite, i.e., one is negative and the other is positive. Therefore, we may claim those two sets of parameters come from different populations.

- Three-Equation Subsystem of VERRHO, GNPPR1, EUPR1

Table 6 clearly indicates that the parameters in the ratio of the unemployment rate equation are very stable over the sample period. However, the parameters in the equations of the ratio of GNP per capita and energy use are not stable, i.e. in 1974, there is a dramatic change for energy consumption pattern and GNP per capita trend. This result is expected. It can be validated in the following section, Accuracy of the Model.

- Three-Equation Subsystem (LUER, LEUP and LGNPP)

Table 7 summarizes all the results for equations LUER, LEUP, and LGNPP. Surprisingly, the parameters for the equations of energy use and GNP per capita are stable over the sample period, including 1974. This result might be due to the fact that the adjustment speed, because of the energy shortage, is equally distributed over all parameters in the equations.

- Two-Equation Subsystem (LMILEP, LEFF)

As reported in Table 8, the parameters of the equations of miles driven and fuel efficiency are stable over the sample period of 1960-1973.

TABLE 6

A PARAMETER STABILITY TEST FOR THE THREE-EQUATION SUBSYSTEM(LUERRHO, GNPPR1, EUPR1)

Equation	Eliminating Data Point	|Fe|	F.95(1,n-k)	F.99(1,n-k)	Stable
LUERRHO	3	+ .01	5.59	12.2	Yes
	10	+3.01			Yes
	15	+ .826			Yes
GNPPR1	3	5.13	5.32	11.3	Yes
	10	5.11			Yes
	15	6.313			?
EUPR1	3	+4.53	5.32	11.3	Yes
	10	+4.09			Yes
	15	+5.73			?

TABLE 7

A PARAMETER STABILITY TEST FOR THE THREE-EQUATION SUBSYSTEM (LUER, LEUP and LGNPP)

Equation	Eliminating Data Point	|Fe|	F.95(1,n-k)	F.99(1,n-k)	Stable
	2	.306			Yes
LUER	10	+3.774	5.59	12.2	Yes
	15	+ .102			Yes
	2	+ .864			Yes
LEUP	10	+1	5.32	11.3	Yes
	15	+3			Yes
	2	+ .0618			Yes
LGNPP	10	+ .55	5.12	10.6	Yes
	15	+ .151			Yes

TABLE 8

A PARAMETER STABILITY TEST FOR THE TWO-EQUATION SUBSYSTEM (LMILEP, LEFF)

Equation	Eliminating Data Point	$\lvert Fe \rvert$	F.95(1,n-k)	F.99(1,n-k)	Stable
	1	+ .05			Yes
LMILEP	10	+ .9	5.99	13.7	Yes
	14	+ .008			Yes
	1	+ .15			Yes
LEFF	10	+ .007	5.59	12.2	Yes
	14	+ .013			Yes

E. Accuracy of the Model

We use absolute error percentage to evaluate the performance of the model. The procedure is to estimate an equation for a sample of size n-1, then predict for the remaining year, and then see the percentage of absolute errors to the actual values. This is done n times for each equation, so that each year in the sample is deleted (and hence predicted) one time for each equation. Tables 9, 10, 11, 12 and 13 show the performance of the equations of the unemployment rate, energy use, fuel efficiency, GNP per capita and miles driven respectively. The predicted values were given by CRAM. Excluding several computation errors in the predicted values for Year 14 (1973), shown in Table 9 (LUEP), and Table 11 (LGNPP), the absolute error percentage for the equation is also shown in these tables.

In order to further examine the accuracy of the model, we generated a "naive" model which is merely expressed by a secondpower time trend. If the CRAM models are to have significant usefulness as predictive tools, then performance should be considerably better than that from a naive time trend model. The naive model shows a very good fit to the histroical data and all the coefficients of the explanatory variables in the equation are very significantly different from zero. Signs of the coefficients of the explanatory variables are not contradictory to a priori expectation. The estimated equations for the "naive" model are shown in Table 14.

TABLE 9

PERFORMANCE OF THE EQUATION, LUERRHO

CRAM MODEL

YEAR	ACTUAL (1)	PREDICTED (2)	(2) - (1) (3)	$\left\| \frac{(3)}{(1)} \right\| \times 100\%$
1962	192143.60	221460.60	29317.00	15.26
1963	166874.60	169227.60	2353.00	1.41
1964	157156.60	150693.00	-6463.60	4.11
1965	125241.30	140645.80	15404.50	12.30
1966	92781.12	116657.78	23876.66	25.73
1967	79697.93	108336.78	28638.85	35.93
1968	75508.37	80983.44	5475.07	7.25
1969	69912.31	82867.65	12955.34	18.53
1970	95511.18	114347.80	18836.62	19.72
Average				15.58

TABLE 10

PERFORMANCE OF THE EQUATION, LEUP

CRAM MODEL

YEAR	ACTUAL (1)	PREDICTED (2)	(2) - (1) (3)	$\left\lvert \frac{(3)}{(1)} \right\rvert$ x 100%
1961	246.499	242.912	-3.587	1.455
1962	254.100	248.489	-5.611	2.208
1963	260.499	260.447	- .052	.020
1964	266.898	262.277	-4.621	1.731
1965	274.298	274.788	.490	.179
1966	286.898	289.281	2.383	.831
1967	293.400	300.396	6.996	2.384
1968	307.399	309.080	1.681	.547
1969	320.700	316.208	-4.492	1.401
1970	327.500	292.218	-35.282	10.773
1971	331.898	338.289	6.391	1.926
1972	345.298	382.413	37.115	10.749
Average				2.850

TABLE 11

PERFORMANCE OF THE EQUATION, LEFF

CRAM MODEL

YEAR	ACTUAL (1)	PREDICTED (2)	$\frac{(2) - (1)}{(3)}$	$\left\lvert \frac{(3)}{(1)} \right\rvert$ x 100%
1961	74.000	69.200	-4.800	6.487
1962	72.119	75.369	3.250	4.507
1963	68.840	68.965	.125	.182
1964	64.943	68.027	3.084	4.748
1965	63.135	62.178	-.957	1.516
1966	60.223	57.077	-3.146	5.224
1967	57.953	57.870	-.083	.143
1968	57.423	55.924	-1.499	2.610
1969	55.519	57.478	1.959	3.528
1970	54.818	59.764	4.946	9.022
1971	63.708	60.709	-2.999	4.707
1972	60.909	59.098	-1.811	2.973
1973	57.747	43.645	-14.102	24.419
Average				5.390

TABLE 12

PERFORMANCE OF THE EQUATION, LGNPP

CRAM MODEL

YEAR	ACTUAL (1)	PREDICTED	(2) - (1) (3)	$\left\lvert \frac{(3)}{(1)} \right\rvert$ x 100%
1961	302.088	310.660	8.572	2.838
1962	324.215	341.040	16.825	5.189
1963	335.891	320.666	-15.225	4.533
1964	353.141	349.045	- 4.096	1.160
1965	373.799	365.330	- 8.469	2.266
1966	395.499	386.256	- 9.243	2.337
1967	402.063	397.184	- 4.879	1.213
1968	416.251	379.631	-36.620	8.798
1969	422.571	449.754	27.183	6.433
1970	415.885	412.856	- 3.029	.728
1971	423.493	410.962	-12.531	2.959
1972	442.203	497.154	54.951	12.427
Average				4.240

TABLE 13

PERFORMANCE OF THE EQUATION, LIMILEP

CRAM MODEL

YEAR	ACTUAL (1)	PREDICTED (2)	(2) - (1) (3)	$\left\lvert \frac{(3)}{(1)} \right\rvert \times 100\%$
1961	3303.732	2960.756	-342.976	10.381
1962	3386.417	3248.342	-138.075	4.077
1963	3424.011	3424.121	.110	.003
1964	3561.083	3616.276	55.193	1.550
1965	3676.985	3681.222	4.237	.115
1966	3843.728	3827.626	- 16.102	.419
1967	3920.870	3876.159	- 44.711	1.140
1968	4082.386	4202.353	119.967	2.939
1969	4264.738	4413.839	149.101	3.496
1970	4420.805	4404.579	- 16.226	.367
1971	4627.063	4537.811	- 89.252	1.929
1972	4819.172	5006.038	186.866	3.878
1973	4939.145	5408.894	469.749	9.511
Average				3.062

TABLE 14

ESTIMATED EQUATIONS FOR "NAIVE" MODEL

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SUMMARY TABLE OF RESULTS
NB DEPENDENT  R-SQUARED /INDEPENDENTS/...
  ESTIMATION  DURB-WAT.  COEFFICIENTS...
OBSERVATIONS  VARIABLES  T-TESTS     ...
```

NB / Dependent / Estimation / Observations	R-Squared / Durb-Wat. / Variables	Independents / Coefficients / T-Tests			
1 LGNPP	0.9816	/C	/T	/TT	/
OLSQ	1.4663	5.61901569	0.06085036	-0.00187410	
15	3	301.093506	11.3373375	-5.74526405	
2 ELEFF	0.8257	/C	/T	/TT	/
OLSQ	1.7561	80.3749390	-4.25988007	0.20399344	
15	3	32.0859222	-5.91286182	4.65893936	
3 LMILEF	0.9982	/C	/T	/LT	/
OLSQ	2.1756	8318.66016	43.9244690	-58.1023254	
14	3	231.839366	33.9072113	-8.29965305	
4 LFUP	0.9802	/C	/T	/	
OLSQ	1.1673	5.45806503	0.02868243		
15	2	530.673096	25.3553314		
5 ELUERH	0.8828	/C	/T	/TT	/
OLSQ	1.2338	391212.250	-73053.5625	4312.48437	
11	3	11.2933626	-7.67408371	7.35782719	

NOTES:
TT = T ** 2, where T = 1, 2, ... 15
LT = Logarithm of T * 100
ELUERH = EXP (LUERRHO)
ELEFF = EXP (LEFF)
The other symbols are the same as those in the CRAM Model.

Absolute error percentages are calculated for those equations in the naive model as they were done for the CRAM model.* They are reported in Tables 9-1, 10-1, 11-1, 12-1 and 13-1, respectively. A comparison of mean absolute error percentages of the naive model with those from the CRAM models is shown in Table 15. Examining this table, we conclude that, except for the equation of the unemployment rate which is not the function of time, the performance equations in the CRAM model are not better than that of the equations in the naive model, even though the CRAM model is much more complex.

*That is, estimates were made for each predicted year based on a sample space composed only of those data from other years. This procedure was followed in both the CRAM and naive models in order to eliminate the effect of sample bias.

TABLE 9-1

PERFORMANCE OF THE EQUATION, LUERRHO*

IN THE NAIVE MODEL

YEAR	ACTUAL VALUE	PREDICTED	DIFFERENCE	ABSOLUTE PERCENT
1960	0.000	0.000	0.000	0 000
1961	0.000	0.000	0.000	0.000
1962	192143.600	236760.300	-44616.680	+23.220
1963	166874.600	168430.600	- 1556.000	+ 0.932
1964	157156.600	128830.900	28325.680	18.024
1965	125241.300	104656.600	20584.680	16.436
1966	92781.120	90754.680	2026.438	2.184
1967	79697.930	83589.620	- 3891.688	+ 4.883
1968	75508.370	84858.620	- 9350.250	+12.383
1969	69912.310	96408.560	-26496.250	+37.899
1970	95511.180	112363.100	-16852.000	+17.644
1971	155592.800	127842.900	27749.870	17.835
1972	174555.700	164471.800	10083.870	5.777
1973	0.000	0.000	0.000	0.000
1974	0.000	0.000	0.000	0.000
Average				14.47

* Values here are in real terms, instead of in logarithmic values as in Table 9.

TABLE 10-1

PERFORMANCE OF THE EQUATION, LEUP*

IN THE NAIVE MODEL

YEAR	ACTUAL VALUE	PREDICTION	DIFFERENCE	ABSOLUTE PERCENT
1960	246.800	239.607	7.193	2.915
1961	246.499	248.638	- 2.140	+0.868
1962	254.100	256.467	- 2.367	+0.931
1963	260.499	264.013	- 3.514	+1.349
1964	266.898	271.782	- 4.884	+1.830
1965	274.298	279.779	- 5.480	+1.998
1966	286.898	287.436	- 0.538	+0.187
1967	293.400	295.893	- 2.493	+0.850
1968	307.399	304.600	2.799	0.910
1969	320.700	310.443	10.258	3.198
1970	327.500	319.258	8.241	2.516
1971	331.898	332.287	- 0.389	+0.117
1972	345.298	337.984	7.314	2.118
1973	355.000	352.834	2.165	0.610
1974	344.997	365.037	-20.040	+5.809
Average				1.657

* Values here are real values, instead of in logarithmic values as in Table 10.

TABLE 11-1

PERFORMANCE OF THE EQUATION, LEFF*

IN THE NAIVE MODEL

YEAR	ACTUAL VALUE	PREDICTION	DIFFERENCE	ABSOLUTE PERCENT
1960	72.054	80.022	-7.968	+11.058
1961	74.000	72.183	1.817	2.456
1962	72.119	68.898	3.221	4.466
1963	68.840	66.282	2.558	3.715
1964	64.943	64.070	0.873	1.345
1965	63.135	61.973	1.162	1.841
1966	60.223	60.590	-0.367	+ 0.610
1967	57.953	59.627	-1.674	+ 2.889
1968	57.423	58.738	-1.315	+ 2.291
1969	55.519	58.580	-3.061	+ 5.514
1970	54.818	58.673	-3.855	+ 7.032
1971	63.708	57.938	5.770	9.057
1972	60.909	59.131	1.778	2.920
1973	57.747	61.795	-4.048	+ 7.010
1974	64.001	61.033	2.968	4.637
Average				4.456

* Values here are in real terms, instead of in logarithmic values as in Table 11.

TABLE 12-1

PERFORMANCE OF THE EQUATION, LGNPP*

IN THE NAIVE MODEL

YEAR	ACTUAL VALUE	PREDICTION	DIFFERENCE	ABSOLUTE PERCENT
1960	298.867	286.861	12.006	4.017
1961	302.088	311.064	- 8.976	+2.971
1962	324.215	325.382	- 1.167	+0.360
1963	335.891	341.040	- 5.148	+1.533
1964	353.141	356.024	- 2.883	+0.816
1965	373.799	367.601	6.197	1.658
1966	395.499	378.796	16.703	4.223
1967	402.063	392.682	9.381	2.333
1968	416.251	399.813	16.437	3.949
1969	422.571	411.578	10.993	2.601
1970	415.885	430.953	-15.068	+3.623
1971	423.493	433.547	-10.053	+2.374
1972	442.203	433.980	8.222	1.859
1973	460.244	448.541	11.704	2.543
1974	449.056	432.680	16.376	3.647
Average				2.500

* The values used here are real values, instead of the logarithmic values used in Table 12.

TABLE 13-1

PERFORMANCE OF THE EQUATION, LIMILEP*

IN THE NAIVE MODEL

YEAR	ACTUAL VALUE	PREDICTION	DIFFERENCE	ABSOLUTE PERCENT
1960	3267.491	3311.833	-44.342	+1.357
1961	3303.732	3285.997	17.735	0.537
1962	3386.418	3351.971	34.448	1.017
1963	3424.011	3455.756	-31.746	+0.927
1964	3561.083	3561.624	-16.541	+0.467
1965	3676.985	3679.911	- 2.926	+0.080
1966	3843.728	3805.278	38.450	1.000
1967	3920.870	3954.623	-33.753	+0.861
1968	4082.386	4101.984	-19.598	+0.480
1969	4264.738	4227.813	36.926	0.866
1970	4420.805	4425.105	- 4.301	+0.097
1971	4627.063	4594.328	32.734	0.707
1972	4819.172	4772.754	46.418	0.963
1973	4939.145	4998.738	-59.594	+1.207
1974	0.000	0.000	0.000	0.000
Average				0.697

* Values used in this table are real values, instead of logarithmic values as used in Table 13.

TABLE 15

MEAN ABSOLUTE ERROR PERCENTAGE FOR THE CRAM MODEL AND NAIVE MODEL

EQUATION	CRAM Model	NAIVE Model
LUERRHO	15.58	14.845
LEFF	5.390	3.934
LGNPP	4.240	2.358
LEUP	2.850	1.406
LIMILEP	2.062	0.708

PART II- POLICY IMPACT ANALYSIS

In this section the CRAM model is evaluated to determine the impact of changing the values of some of the variables in the model. The structural and reduced form equation of the model so specified by CRAM are examined to determine this sensitivity. In most cases, the variable definitions, documentation results presented by CRAM, were so ambiguous as to make difficult an evaluation of specific policies, especially within the time constraints of this evaluation. Instead, the variables given in the CRAM model were parametrically assessed as they were used in the model. It is believed that the analysis presented in this section will allow the reader to draw the proper conclusions as to the policy sensitivity of this model.

The structural form of the system is general in the following type:

$$y = f(<y>, <x>) \qquad (1)$$

where y is the endogenous dependent variable

$<x>$ is the vector of relevant exogenous explanatory variables

$<y>$ is the vector of relevant endogenous explanatory variables

We rearrange those endogenous explanatory variables to the left side of the equations, System 1 becomes:

$$AY = BX \qquad (2)$$

$$IY = A^{-1}BX \qquad (3)$$

where A is the matrix for the coefficients of endogenous variables and B is the matrix for the coefficients of exogenous variables. An impact analysis of exogenous variables on the endogenous variables can be based on System Form 3.

If System 3 is a linear system, then the exogenous variable effects on endogenous variables may be expressed as the following:

$$I\Delta Y = A^{-1}B\Delta X \qquad (4)$$

If there is no explicit lagged endogenous variable in System 1, one may not be able to directly examine a longrun on multi-period impact on the endogenous variables. Thus, we may only examine multiperiod impacts where lagged variables are included in the model formulation.

For the complex multiple exogenous variable impacts on the endogenous, it is desireable to see the direction of the changes of the exogenous variables. Because exogenous variables are generally assumed independent and the equations are in log-linear or linear form, the impact of the complex multi-variable impact will be the sum of the individual impacts. We examine impacts for four systems in the following sections.

o <u>Five-Equation System</u>

Neglecting constant terms, we rearrange the system taken from Table 1 in the form shown in System 2 above:

$$\begin{pmatrix} 1 & -4.290 & 4.702 & 0 & 0 \\ 0 & 1 & -0.575 & 0 & +.385 \\ -.018 & 0 & 1 & 0 & 0 \\ -.064 & 0 & 1.322 & 1 & -.414 \\ 0.490 & 0 & 3.467 & -2.410 & 1 \end{pmatrix} \begin{pmatrix} LUER \\ LEUP \\ LGNNP \\ LMILEP \\ LEFF \end{pmatrix} =$$

$$\begin{pmatrix} .780 & -4.162 & -2.205 & 3.418 & .203 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1.166 & 0 & 0.815 & 0 & -1.894 & -.054 & -.015 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & .130 & .174 & 0 & 1.046 \\ 0 & 0 & 0 & 0 & .036 & 0 & -.372 & 0 & -1.95 & 0 \\ 0 & 0 & 0 & 2.366 & -.113 & 0 & 0 & 0 & 0 & -3.242 \end{pmatrix} \times \begin{pmatrix} TRES \\ MRES \\ RRES \\ CRES \\ DRES \\ GRES \\ URES \\ DP \\ PRES \\ ERES \end{pmatrix} \qquad (5)$$

In system 4, we find that some variables such as CRES*, which will be affected by changes in energy prices, will only have explicit impact on LUER, LEUP and LEFF, but, because of the simultaneousness of the equations in the system, the change of CRES will affect all the endogenous variables. System 5 may be arranged as follows:

---

* CRES is the residualized logarithm of the ratio of the energy component of the consumer price index to the overall CPI index.

I. (5x5)

$$\begin{pmatrix} \blacktriangle LUER \\ \blacktriangle LEUP \\ \blacktriangle LGNPP \\ \blacktriangle LMILEP \\ \blacktriangle LEFF \end{pmatrix} = \qquad (6)$$

$$\begin{pmatrix} -0.003 & 0.038 & 0.009 & 7.154 & 0.079 & 0.038 & -2.83 & -.15 & -14.27 & -10.725 \\ -.18 & .98 & .516 & 0.73 & -.031 & 0.007 & -.46 & .16 & 3.04 & -1.14 \\ 0 & -0.0007 & 0 & -1.13 & -0.001 & -.0006 & .18 & .18 & .26 & 1.24 \\ .20 & -2.30 & -.55 & 0.30 & -.0009 & -2.04 & -.24 & .15 & -0.91 & +2.95 \\ +.47 & -5.57 & -1.34 & +.03 & +.08 & -4.93 & +1.33 & -.19 & +8.29 & 4.82 \end{pmatrix} \times \begin{pmatrix} \blacktriangle TRES \\ \blacktriangle MRES \\ \blacktriangle RRES \\ \blacktriangle CRES \\ \blacktriangle DRES \\ \blacktriangle GRES \\ \blacktriangle URES \\ \blacktriangle DP \\ \blacktriangle PRES \\ \blacktriangle ERES \end{pmatrix}$$

In system 6, we find that any change which makes CRES* increase one unit will have the following impacts on unemployment, energy use, GNP, miles driven and fuel efficiency:

$$\begin{matrix} \blacktriangle LUER & & 7.154 & \text{units} \\ \blacktriangle LEUP & & 0.73 & \text{units} \\ \blacktriangle LGNNP & = & -0.13 & \text{units} \\ \blacktriangle LMILEP & & .30 & \text{units} \\ \blacktriangle LEFF & & +.03 & \text{units} \end{matrix} \qquad (7)$$

The above results show a contradiction: The factor to cause CRES to increase, whatever those increases may be, will cause the unemployment rate, energy consumption, miles driven, and fuel efficiency to increase simultaneously. When the price of energy rises relative to other prices, as for a more specific energy price policy, it is difficult to evaluate, using this model, because the variables are defined so ambiguously as with CRES. This problem is caused by the original estimation of the model, discussed in the previous sections.

---

*Since the log-log equation form is used, the coefficients here can be interpreted as elasticities. However, because of the ambiguities of the variable CRES, it is difficult to interpret their actual economic meaning.

If we examine two variables, for example CRES and TRES, let us say that they both increase one unit so that the impact on the five endogenous variables will be:

$$\begin{array}{lcrl} \blacktriangle \text{ LUER} & & 2.61 & \text{units} \\ \blacktriangle \text{ LEUP} & & 2.51 & \text{units} \\ \blacktriangle \text{ LGNPP} & = & 2.52 & \text{units} \\ \blacktriangle \text{ LMILEP} & & .98 & \text{units} \\ \blacktriangle \text{ LEFF} & & -\ .31 & \text{units} \end{array} \qquad (8)$$

The results in 8 express the compound effects of both public policies to affect fuel price and the employment component (specifically, employing more teenagers), because both policies have the same directionality of effects on these five endogenous variables so that their effects are magnified.

A further analysis can be made by examining the system in 6. It should also be pointed out that because no lagged endogenous variables are included in the system, it is not possible to analyze the long-run or multi-period dynamic impact on the endogenous variables using this model.*

---

*Lagged endogenous variables were included in the residualized variables. However, as discussed in the previous section, the residualized variables in the system do not provide much meaning. Thus, it is not possible to examine dynamic impacts by using this system.

- <u>First Three-Equation Subsystem (In the Form of x_t/x_{t-1})</u>

Neglecting the constant terms in the equations, this subsystem may be arranged as:

$$\begin{pmatrix} 1 & 0 & .162 \\ -.406 & 1 & 0 \\ 4.930 & 0 & 1 \end{pmatrix} \begin{pmatrix} \text{GNPPR1} \\ \text{EUPR1} \\ \text{UERR1} \end{pmatrix} = \begin{pmatrix} -.45 & .73 & -1.17 & 0 & 0 & -.01 & 0 & 0 & 0 \\ 0 & 0 & 0 & -.73 & -.25 & -.03 & -.15 & 0 & 0 \\ 0 & 0 & 0 & 0 & -.63 & -.12 & 0 & -. & -.63 \end{pmatrix} \times \begin{pmatrix} \text{EMRES} \\ \text{ERRES} \\ \text{RBCLF} \\ \text{POPHR1} \\ \text{CPFRES} \\ \text{DRES} \\ \text{GFFRES} \\ \text{MEMRES} \\ \text{TNRES} \end{pmatrix} \quad (9)$$

In (9), it is clear that an increase in non-white employment (RBCLF) will only have direct negative impact on GNP rate of increase (GNPPR1). If we rearrange (9) into:

$$\begin{pmatrix} \Delta\,\text{GNPPR1} \\ \Delta\,\text{EUPR1} \\ \Delta\,\text{UERR1} \end{pmatrix} = \begin{pmatrix} -2.22 & 3.62 & -5.80 & -.17 & .51 & .10 & -.03 & .29 & .51 \\ -.90 & 1.47 & -2.36 & -.72 & -.04 & .02 & -.16 & .12 & .21 \\ 10.92 & -17.83 & 28.60 & 0 & -3.13 & -.62 & .15 & -1.81 & -3.13 \end{pmatrix} \times \begin{pmatrix} \Delta\,\text{EMRES} \\ \Delta\,\text{ERRES} \\ \Delta\,\text{RBCLF} \\ \Delta\,\text{FOPHR1} \\ \Delta\,\text{CPFRES} \\ \Delta\,\text{DRES} \\ \Delta\,\text{GFFRES} \\ \Delta\,\text{MEMRES} \\ \Delta\,\text{TNRES} \end{pmatrix} \quad (10)$$

System 10 explicitly shows that in this model any policies which increase the relative non-white component of the labor force (RBCLF) will decrease GNP per capita and energy use moderately and dramatically increase the employment rate! Some compound effects of multiple variables may be tested in System 10. Additionally, this system has implicit lagged endogenous variables in the equation in the following form:

$$\log\left(\frac{x}{x_{-1}}\right) = \log x - \log x_{-1}$$

However, because the coefficient of $\log x_{-1}$ is one, there is no possiblity of analyzing long-run impacts using this system.

- <u>Second Three-Equation Subsystem (LUER, LEUP, LGNPP)</u>

This system may be expressed by neglecting its constant term as follows:

$$\begin{pmatrix} 1 & -4.447 & 4.697 \\ 0 & 1 & -.924 \\ .082 & -.958 & 1 \end{pmatrix} \begin{pmatrix} \text{LUER} \\ \text{LEUP} \\ \text{LGNPP} \end{pmatrix} = \begin{pmatrix} 1.45 & -5.63 & 1.36 & .22 & 0 & 0 & 0 & 0 & \boxed{0} \\ 0 & 0 & 0 & 0 & .92 & -.68 & .43 & .80 & \boxed{0} \\ 0 & 0 & 0 & -.102 & 0 & 0 & 0 & 0 & \boxed{1.53} \end{pmatrix} \times \begin{pmatrix} \text{TNRES} \\ \text{MEMRES} \\ \text{CPFRES} \\ \text{DDRES} \\ \text{UERRES} \\ \text{MEMRES} \\ \text{CPFRES} \\ \text{HHRES} \\ \text{RBCLF} \end{pmatrix} \quad (11)$$

System 11 clearly indicates that each of the exogenous variables, except DDRES (residualized dummy variable!) directly affects only one endogenous variable. Also, the magnitude of the impact may be small as can be seen from the coefficients of exogenous variables in the first equation of this system. Because of simultaneity of the system, these impacts can be expanded as follows:

$$\begin{pmatrix} \Delta\,\text{LUER} \\ \Delta\,\text{LEUP} \\ \Delta\,\text{LGNPP} \end{pmatrix} = \begin{pmatrix} 2.34 & -9.13 & 2.20 & 1.13 & -.04 & -.03 & .02 & -.04 & \boxed{-11.56} \\ .09 & -.37 & .09 & .10 & .49 & -.36 & -.22 & -.42 & \boxed{-1.21} \\ -.10 & .40 & -.10 & -.10 & .47 & -.34 & -.22 & -.41 & \boxed{1.31} \end{pmatrix} \times \begin{pmatrix} \Delta\,\text{TNRES} \\ \Delta\,\text{MEMRES} \\ \Delta\,\text{CPFRES} \\ \Delta\,\text{DDRES} \\ \Delta\,\text{UERRES} \\ \Delta\,\text{MEMRES} \\ \Delta\,\text{CPFRES} \\ \Delta\,\text{HHRES} \\ \Delta\,\text{RBCLF} \end{pmatrix} \quad (12)$$

If we assume that some public policies have caused the non-white ratio to increase one unit, we will find that even its effect will cause a direct change in the system only on GNP per capita as shown in 12. However, the actual direct and indirect impacts on the system are as follows:

$$\begin{matrix} \Delta\,\text{LUER} \\ \Delta\,\text{LEUP} \\ \Delta\,\text{LGNPP} \end{matrix} \quad = \quad \begin{matrix} -11.56 \\ -1.21 \\ 1.31 \end{matrix} \quad \text{units} \;.$$

Examination of Equation 12 can further be expanded to obtain other variable impacts on the system.

o <u>Two-Equation Subsystem</u>

This system, without showing intercepts, may be written as follows:

$$
\begin{pmatrix} 1 & 1.048 \\ .508 & 1 \end{pmatrix}
\begin{pmatrix} \text{LMILEP} \\ \text{LEFF} \end{pmatrix}
=
\begin{pmatrix}
 & & 1 & & & & & 2 & & & \\
0 & 3.82 & \boxed{.48} & -.046 & .773 & .852 & -3.74 & \boxed{0} & 0 & 0 & 0 \\
.10 & 0 & \boxed{0} & 0 & 0 & 0 & 0 & \boxed{3.02} & .384 & .12 & 2.59
\end{pmatrix}
\times
\begin{pmatrix} \text{LUER} \\ \text{EMRES1} \\ \text{GNPRES1} \\ \text{DDRES1} \\ \text{URMRES} \\ \text{CPFRES1} \\ \text{POPRES} \\ \text{GNPRES3} \\ \text{EMRES3} \\ \text{DDRES3} \\ \text{LPFRES3} \end{pmatrix}
\qquad (13)
$$

System 13 indicates that exogenous variables in the first equation may not directly affect endogenous variables in the second equation and vice versa. Simply put, this means that the policies which affect GNP per capita will affect miles-driven but not fuel efficiency. However, examining changes in variables, the following system shows differently:

$$
\begin{pmatrix} \Delta\,\text{LMILEP} \\ \Delta\,\text{LEFF} \end{pmatrix}
=
\begin{pmatrix}
 & & 1 & & & & & & 2 & & \\
-.23 & 8.17 & \boxed{1.02} & -.09 & .65 & 1.82 & -7.99 & 6.77 & \boxed{8.61} & -.27 & -5.80 \\
.22 & -4.15 & \boxed{-.52} & .05 & -.84 & -.93 & 4.06 & -6.46 & \boxed{-8.22} & .26 & 5.53
\end{pmatrix}
\times
\begin{pmatrix} \Delta\,\text{LUER} \\ \Delta\,\text{EMRES1} \\ \Delta\,\text{GNPRES1} \\ \Delta\,\text{DDRES1} \\ \Delta\,\text{URMRES} \\ \Delta\,\text{CPFRES1} \\ \Delta\,\text{POPRES} \\ \Delta\,\text{GNPRES3} \\ \Delta\,\text{EMRES3} \\ \Delta\,\text{DDRES3} \\ \Delta\,\text{LPFRES3} \end{pmatrix}
\qquad (14)
$$

The GNP per capita here is chosen to explain the functions of System 14. As shown in System 14, in this model the policies which affect one year lagged GNP per capita will positively affect current gear-miles driven, and the policies which increase three year lagged GNP per capita will positively increase the current year fuel efficiency. After having transformed System 14 into System 15, we find one year lagged GNP per capita, and three year GNP per capita will affect miles-driven and fuel efficiency as follows:

	GNP_{-1} (1)	GNP_{-3} (2)	TOTAL (1) + (2)
LMILEP	1.02	8.61	9.63
LEFF	- .52	-8.22	-8.74

Therefore, the sum of the two period (one year lagged and two year lagged) GNP per capita will be the multiple period impacts of GNP per capita on the miles-driven and fuel efficiency. The same reasoning may be applied to analyze other exogenous variables.

APPENDIX B

CODEBOOK

CARD 1

Columns		Format*	Source
2-5	Year		
7-8	Card number - Enter 01		
	EMPLOYMENT STATUS OF CIVILIAN LABOR FORCE (CLF)** (see also cards 28-29) (in thousands)***		
10-14	Total number persons, 16 years and older, in CLF	F5.0	I-1
16-20	Total number males, 16 years and older, in CLF	F5.0	I-1
22-26	Total number females, 16 years and older, in CLF	F5.0	I-1
27-31	Total number employed members of CLF	F5.0	I-1
33-37	Number employed white males of CLF	F5.0	I-19
39-43	Number employed white females of CLF	F5.0	I-19
45-48	Number employed "Negro and other races" males of CLF	F4.0	I-19
50-53	Number employed "Negro and other races" females of CLF	F4.0	I-19
55-58	Number males in CLF, 16-17 years	F4.0	I-3
60-63	Number males in CLF, 18-19 years	F4.0	I-3
65-68	Number males in CLF, 20-24 years	F4.0	I-3
70-74	Number males in CLF, 25-34 years	F5.0	I-3
76-80	Number males in CLF, 35-44 years	F5.0	I-3

---

*This column gives the appropriate format under which each variable should be read in for use in a computer program.

**"White" plus "Negro and other races" = Total

***For these items, Fn.0 format expresses each variable in thousands where n is the number of card columns allocated to the variable.

CARD 2

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 02		
	EMPLOYMENT STATUS OF CLF (continued) (in thousands)		I-3
10-14	Number males in CLF, 45-54 years	F5.0	
16-19	Number males in CLF, 55-64 years	F4.0	
21-24	Number males in CLF, 65 years ald older	F4.0	
26-29	Number females in CLF, 16-17 years	F4.0	
31-34	Number females in CLF, 18-19 years	F4.0	
36-39	Number females in CLF, 20-24 years	F4.0	
41-44	Number females in CLF, 25-34 years	F4.0	
46-49	Number females in CLF, 35-44 years	F4.0	
51-54	Number females in CLF, 45-54 years	F4.0	
56-59	Number females in CLF, 55-64 years	F4.0	
61-64	Number females in CLF, 65 years and older	F4.0	
66-70	Total number white males in CLF, 16 years and older	F5.0	
72-75	Number white males in CLF, 16-17 years	F4.0	
77-80	Number white males in CLF, 18-19 years	F4.0	

CARD 3

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 03		
	EMPLOYMENT STATUS OF CLF (continued) (in thousands)		I-3
10-13	Number white males in CLF, 20-24 years	F4.0	
15-19	Number white males in CLF, 25-34 years	F5.0	
21-25	Number white males in CLF, 35-44 years	F5.0	
27-30	Number white males in CLF, 45-54 years	F4.0	
32-35	Number white males in CLF, 55-64 years	F4.0	
37-40	Number white males in CLF, 65 years and older	F4.0	
42-46	Total number white females in CLF, 16 years and older	F5.0	
48-51	Number white females in CLF, 16-17 years	F4.0	
53-56	Number white females in CLF, 18-19 years	F4.0	
58-61	Number white females in CLF, 20-24 years	F4.0	
63-66	Number white females in CLF, 25-34 years	F4.0	
68-71	Number white females in CLF, 35-44 years	F4.0	
73-76	Number white females in CLF, 45-54 years	F4.0	

CARD 4

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 04		
	EMPLOYMENT STATUS OF CLF (continued) (in thousands)		I-3
10-13	Number white females in CLF, 55-64 years	F4.0	
15-17	Number white females in CLF, 65 years and older	F3.0	
	EMPLOYED PERSONS, BY OCCUPATION, COLOR, SEX*		I-19
	Professional and Technical Workers		
19-21	% employed white males who are in this occupational group	F3.1	
23-25	% employed white females who are in this occupational group	F3.1	
27-29	% employed "Negro and other races" males who are in this occupational group	F3.1	
31-33	% employed "Negro and other races" females who are in this occupational group	F3.1	
	Managers and Administrators, except Farm		
35-37	% employed white males who are in this occupational group	F3.1	
39-41	% employed white females who are in this occupational group	F3.1	
43-45	% employed "Negro and other races" males who are in this occupational group	F3.1	
47-49	% employed "Negro and other races" females who are in this occupational group	F3.1	
	Sales		
51-53	% employed white males who are in this occupational group	F3.1	
55-57	% employed white females who are in this occupational group	F3.1	

*For these items, Fn.1 format expresses each variable as per cent (e.g., 20.1% is coded as 201 on the data card).

CARD 4 (continued)

Columns		Format	Source
	EMPLOYED PERSONS, BY OCCUPATION, COLOR SEX (continued		I-19
	Sales (continued)		
59-61	% employed "Negro"* males who are in this occupational group	F3.1	
63-64	% employed Negro females who are in this occupational group	F2.1	
	Clerical		
66-68	% employed white males who are in this occupational group	F3.1	
70-72	% employed white females who are in this occupational group	F3.1	
74-76	% employed Negro males who are in this occupational group	F3.1	
78-80	% employed Negro females who are in this occupational group	F3.1	

*"Negro" means "Negro and other races" (or non-white).

CARD 5

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 05		
	EMPLOYED PERSONS, BY OCCUPATION, COLOR SEX (continued)		I-19
	Craft and Kindred		
10-12	% employed white males who are in this occupational group	F3.1	
14-15	% employed white females who are in this occupational group	F2.1	
17-19	% employed Negro males who are in this occupational group	F3.1	
21-22	% employed Negro females who are in this occupational group	F2.1	
	Operatives		
24-26	% employed white males who are in this occupational group	F3.1	
28-30	% employed white females who are in this occupational group	F3.1	
32-34	% employed Negro males who are in this occupational group	F3.1	
36-38	% employed Negro females who are in this occupational group	F3.1	
	Non-Farm Labor		
40-41	% employed white males who are in this occupational group	F2.1	
42-43	% employed white females who are in this occupational group	F2.1	
45-47	% employed Negro males who are in this occupational group	F3.1	
49-50	% employed Negro females who are in this occupational group	F2.1	

CARD 5 (continued)

Columns		Format	Source
	EMPLOYED PERSONS, BY OCCUPATION, COLOR SEX (continued)		I-19
	Service Workers		
52-53	% employed white males who are in this occupational group	F2.1	
55-57	% employed white females who are in this occupational group	F3.1	
59-61	% employed Negro males who are in this occupational group	F3.1	
63-65	% employed Negro females who are in this occupational group	F3.1	

CARD 6

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 06		
	EMPLOYED PERSONS, BY OCCUPATION, COLOR, SEX (continued)		I-19
	Farm Workers		
10-12	% employed white males who are in this occupational group	F3.1	
14-15	% employed white females who are in this occupational group	F2.1	
17-19	% employed Negro males who are in this occupational group	F3.1	
21-23	% employed Negro females who are in this occupational group	F3.1	
	EMPLOYED PERSONS, BY SELECTED OCCUPATIONAL SUB-CATEGORIES, COLOR, SEX*		I-19
	Managers and Administrators - Self-employed in Retail Trade		
25-26	% employed white males who are in this sub-group	F2.1	
28-29	% employed white females who are in this sub-group	F2.1	
31-32	% employed Negro males who are in this sub-group	F2.1	
34-35	% employed Negro females who are in this sub-group	F2.1	
	Sales - Retail		
37-38	% employed white males who are in this sub-group	F2.1	
40-41	% employed white females who are in this sub-group	F2.1	
43-44	% employed Negro males who are in this sub-group	F2.1	
46-47	% employed Negro females who are in this sub-group	F2.1	

---

*For these items, Fn.1 format expresses each variable at per cent (e.g., 3.6 is coded as 36 on the data card).

B-10

CARD 6 (continued)

Columns		Format	Source
	EMPLOYED PERSONS, BY SELECTED OCCUPATIONAL SUB-CATEGORIES, COLOR, SEX (continued)		I-19
	Operatives - Drivers, Motor Vehicles		
49-50	% employed white males who are in this sub-group	F2.1	
52	% employed white females who are in this sub-group	F1.1	
54-55	% employed Negro males who are in this sub-group	F2.1	
57	% employed Negro females who are in this sub-group	F1.1	
	Non-Farm Labor - Management		
59-60	% employed white males who are in this sub-group	F2.1	
62	% employed white females who are in this sub-group	F1.1	
64-65	% employed Negro males who are in this sub-group	F2.1	
67	% employed Negro females who are in this sub-group	F1.1	

CARD 7

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 07		
	EMPLOYMENT BY INDUSTRY DIVISIONS (in thousands)*		I-39
10-14	Total number employees on non-agricultural payrolls	F5.0	
16-18	Number employees in B - Mining	F3.0	
20-23	Number employees in C - Contract Construction	F4.0	
25-29	Number employees in D - Manufacturing	F5.0	
31-34	Number employees in E - Transportation and Public Utilities	F4.0	
36-39	Number employees in F - Wholesale Trade	F4.0	
41-45	Number employees in G- Retail Trade	F5.0	
47-50	Number employees in H - Finance, Insurance, Real Estate	F4.0	
52-56	Number employees in I - Services	F5.0	
58-61	Number employees in J - Federal Government	F4.0	
63-67	Number employees in J - State and Local Government	F5.0	
	MANUFACTURING EMPLOYMENT, BY 2-digit SIC GROUPS (in thousands)**		I-40
69-72	19-Ordnance and Accessories	F4.1	
74-77	24-Lumber and Wood Products, except Furniture	F4.1	

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*For these items, Fn.0 format expresses each variable in thousands.

**For these items, Fn.1 expresses each variable in thousands.

CARD 8

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 08		
	MANUFACTURING EMPLOYMENT, BY 2-digit SIC GROUPS (in thousands) (continued)		I-40
10-13	25-Furniture and Fixtures	F4.1	
15-18	32-Stone, Clay, Glass and Concrete Products	F4.1	
20-24	33-Primary Metal Products	F5.1	
26-30	34-Fabricated Metal Products, except Machinery and Transportation Equipment	F5.1	
32-36	35-Machinery, except Electrical	F5.1	
38-42	36-Electrical and Electronic Machinery, Equipment and Supplies	F5.1	
44-48	37-Transportation Equipment	F5.1	
50-53	38-Instruments and Related Products	F4.1	
55-58	39-Miscellaneous Manufacturing Industries	F4.1	
60-64	20-Food and Kindred Products	F5.1	
66-68	21-Tobacco Manufactures	F3.1	
70-74	22-Textile Mill Products	F5.1	
76-80	23-Apparel and Other Textile Products	F5.1	

CARD 9

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 09		
	MANUFACTURING EMPLOYMENT, BY 2-digit SIC GROUPS (in thousands) (continued)		I-40
10-13	26-Paper and Allied Products	F4.1	
15-19	27-Printing, Publishing and Allied Industries	F5.1	
21-25	28-Chemicals and Allied Products	F5.1	
27-30	29-Petroleum Refining and Related Products	F4.1	
32-35	30-Rubber and Miscellaneous Plastics Products	F4.1	
37-40	31-Leather and Leather Products	F4.1	
	PRODUCTION WORKERS EMPLOYED IN MANUFACTURING, BY 2-digit SIC GROUPS (in thousands)*		I-42
42-45	19-Ordnance and Accessories	F4.1	
47-50	24-Lumber and Wood Products	F4.1	
52-55	25-Furniture and Fixtures	F4.1	
57-60	32-Stone, Clay, and Glass Products	F4.1	
62-66	33-Primary Metal Industries	F5.1	
68-72	34-Fabricated Metal Products	F5.1	
74-78	35-Machinery, except Electrical	F5.1	

*For these items, Fn.1 format expresses each variable in thousands.

CARD 10

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 10		
	PRODUCTION WORKERS EMPLOYED IN MANUFACTURING, BY 2-digit SIC GROUPS (in thousands) (continued)		I-42
10-14	36-Electrical Equipment	F5.1	
16-20	37-Transportation Equipment	F5.1	
22-25	38-Instruments and Related Products	F4.1	
27-30	39-Miscellaneous Manufacturing Industries	F4.1	
32-36	20-Food and Kindred Products	F5.1	
38-40	21-Tobacco Manufactures	F3.1	
42-45	22-Textile Mill Products	F4.1	
47-51	23-Apparel and Other Textile Products	F5.1	
53-56	26-Paper and Allied Products	F4.1	
58-61	27-Printing and Publishing	F4.1	
63-66	28-Chemicals and Allied Products	F4.1	
68-71	29-Petroleum and Coal Products	F4.1	
74-77	30-Rubber and Plastics Products	F4.1	

CARD 11

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 11		
	PRODUCTION WORKERS EMPLOYED IN MANUFACTURING, BY 2-digit SIC GROUPS (in thousands) (continued)		I-42
10-13	Leather and Leather Products	F4.1	
	FARM EMPLOYMENT (in thousands)*		I-46
15-19	Farm employment	F4.0	
	RATES (per 100 employees) OF "NEW HIRES" IN MANUFACTURING, BY 2-digit SIC GROUPS**		I-54
20-21	19-Ordnance and Accessories	F2.1	
23-24	24-Llmber and Wood Products	F2.1	
26-27	25-Furniture and Fixtures	F2.1	
29-30	32-Stone, Clay, and Glass Products	F2.1	
32-33	33-Primary Metal Industries	F2.1	
35-36	34-Fabricated Metal Products	F2.1	
38-39	35-Machinery, except Electrical	F2.1	
41-42	36-Electrical Equipment	F2.1	
44-45	37-Transportation Equipment	F2.1	
47-48	38-Instruments and Related Products	F2.1	
50-51	39-Miscellaneous Manufacturing Industries	F2.1	
53-54	20-Food and Kindred Products	F2.1	
56-57	21-Tobacco Manufactures	F2.1	
59-60	22-Textile Mill Prodcuts	F2.1	
62-63	23-Apparel and Other Textile Products	F2.1	

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*For this item, F4.0 format expresses the variable in thousands.

**For these items, F2.1 format expresses each variable as a rate per 100 employees.

CARD 11 (continued)

Columns		Format	Source
	RATE (per 100 employees) OF "NEW HIRES" IN MANUFACTURING, BY 2-digit SIC GROUPS (continued)		I-54
65-66	26-Paper and Allied Products	F2.1	
68-69	27-Printing and Publishing	F2.1	
71-72	28-Chemicals and Allied Products	F2.1	
74-75	29-Petroleum and Coal Products	F2.1	
77-78	30-Rubber and Plastics Products	F2.1	

CARD 12

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 12		
	RATES (per 100 employees) OF "NEW HIRES" IN MANUFACTURING, BY 2-digit SIC GROUPS (continued)		I-54
10-11	31-Leather and Leather Products	F2.1	
	RATES (per 100 employees) OF "QUITS IN MANUFACTURING, BY 2-digit SIC GROUPS*		I-54
13-14	19-Ordnance and Accessories	F2.1	
16-17	24-Lumber and Wood Products	F2.1	
19-20	25-Furniture and Fixtures	F2.1	
22-23	32-Stone, Clay, and Glass Products	F2.1	
25-26	33-Primary Metal Industries	F2.1	
28-29	34-Fabricated Metal Products	F2.1	
31-32	35-Machinery, except Electrical	F2.1	
34-35	36-Electrical Equipment	F2.1	
37-38	37-Transportation Equipment	F2.1	
40-41	38-Instruments and Related Products	F2.1	
43-44	39-Miscellaneous Manufacturing Industries	F2.1	
46-47	20-Food and Kindred	F2.1	
49-50	21-Tobacco Manfactures	F2.1	
52-53	22-Textile Mill Products	F2.1	
55-56	23-Apparel and Other Textile Products	F2.1	
58-59	26-Paper and Allied Products	F2.1	
61-62	27-Printing and Publishing	F2.1	
64-65	28-Chemicals and Allied Products	F2.1	

*For these items, F2.1 format expresses each variable as a rate per 100 employees.

CARD 12 (continued)

Columns		Format	Source
	RATES (per 100 employees) OF "QUITS" IN MANUFACTURING, BY 2-digit SIC GROUPS (continued)		I-54
67-68	29-Petroleum and Coal Products	F2.1	
70-71	30-Rubber and Plastics Products	F2.1	
73-74	31-Leather and Leather Products	F2.1	

CARD 13

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 13		
	RATES (per 100 employees) OF "LAYOFFS" IN MANUFACTURING, BY 2-digit SIC GROUPS*		I-54
10-11	19-Ordnance and Accessories	F2.1	
13-14	24-Lumber and Wood Products	F2.1	
16-17	25-Furniture and Fixtures	F2.1	
19-20	32-Stone, Clay, and Glass Products	F2.1	
22-23	33-Primary Metal Industries	F2.1	
25-26	34-Fabricated Metal Products	F2.1	
28-29	35-Machinery, except Electrical	F2.1	
31-32	36-Electrical Equipment	F2.1	
34-35	37-Transportation Equipment	F2.1	
37-38	38-Instruments and Related Products	F2.1	
40-41	39-Miscellaneous Manufacturing Industries	F2.1	
43-44	20-Food and Kindred Products	F2.1	
46-47	21-Tobacco Manufactures	F2.1	
49-50	22-Textile Mill Products	F2.1	
52-53	23-Apparel and Other Textile Products	F2.1	
55-56	26-Paper and Allied Products	F2.1	
58-59	27-Printing and Publishing	F2.1	
61-62	28-Chemicals and Allied Products	F2.1	
64-65	29-Petroleum and Coal Products	F2.1	
67-68	30-Rubber and Plastics Products	F2.1	
70-72	31-Leather and Leather Products	F2.1	

*For these items, F2.1 format expresses each variable as a rate per 100 employees.

CARD 14

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 14		
	UNEMPLOYMENT RATES (expressed as a percentage of the CLF) (annual averages)*		
10-11	Total	F2.1	I-60
13-14	Males	F2.1	I-60
16-17	Females	F2.1	I-60
19-20	White - total	F2.1	I-60
22-23	White - males	F2.1	I-60
25-26	White - females	F2.1	I-60
28-30	"Negro and other races" - total	F3.1	I-60
32-34	"Negro and other races" - males	F3.1	I-60
36-38	"Negro and other races" - females	F3.1	I-60
40-42	White males - 16-17 years	F3.1	I-63
44-46	White males - 18-19 years	F3.1	I-63
48-50	White males - 20-24 years	F3.1	I-63
52-53	White males - 25-34 years	F2.1	I-63
55-56	White males - 35-44 years	F2.1	I-63
58-59	White males - 45-54 years	F2.1	I-63
61-62	White males - 55-64 years	F2.1	I-63
64-65	White males - 65 years and older	F2.1	I-63

*For these items, Fn.1 format expresses each variable as a percent (e.g., 6.1% is coded as 61 on the data card).

CARD 15

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 15		
	UNEMPLOYMENT RATES (expressed as a percentage of the CLF) (annual averages) (continued)		I-63
10-12	White females - 16-17 years	F3.1	
14-16	White females - 18-19 years	F3.1	
18-19	White females - 20-24 years	F2.1	
21-22	White females - 25-34 years	F2.1	
24-25	White females - 35-44 years	F2.1	
27-28	White females - 45-54 years	F2.1	
30-31	White females - 55-64 years	F2.1	
33-34	White females - 65 years and older	F2.1	
36-38	"Negro and other races" males - 16-17 years	F3.1	
40-42	"Negro"* males - 18-19 years	F3.1	
44-46	Negro males - 20-24 years	F3.1	
48-50	Negro males - 25-34 years	F3.1	
52-54	Negro males - 35-44 years	F3.1	
56-58	Negro males - 45-54 years	F3.1	
60-62	Negro males - 55-64 years	F3.1	
64-66	Negro males - 65 years and older	F3.1	

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*"Negro" means "Negro and other races" (or non-white).

CARD 16

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 16		
	UNEMPLOYMENT RATES (expressed as a percentage of the CLF) (annual averages) (continued)		I-63
10-12	Negro females - 16-17 years	F3.1	
14-16	Negro females - 18-19 years	F3.1	
18-20	Negro females - 20-24 years	F3.1	
22-24	Negro females - 25-34 years	F3.1	
26-28	Negro females - 35-44 years	F3.1	
30-31	Negro females - 45-54 years	F2.1	
33-34	Negro females - 55-64 years	F2.1	
36-37	Negro females - 65 years and older	F2.1	
	UNEMPLOYMENT RATES, BY OCCUPATIONAL GROUP (expressed as a percentage of the CLF) (annual averages)*		I-65
39-40	Professional and Technical	F2.1	
42-43	Managers and Administrators, except Farm	F2.1	
45-46	Sales	F2.1	
48-49	Clerical	F2.1	
51-52	Craft and Kindred	F2.1	
54-55	Operatives	F2.1	
57-59	Non-farm Labor	F3.1	
61-62	Service Workers	F2.1	
64-65	Farm Workers	F2.1	

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*For these items, Fn.1 format expresses each variable as a percent (e.g., 3.6% is coded as 36 on the data card).

CARD 17

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 17		
	UNEMPLOYMENT RATES, BY MAJOR INDUSTRY GROUP*		I-73
10-11	A-Agriculture	F2.1	
13-15	B-Mining	F3.1	
17-19	C-Construction	F3.1	
21-22	D-Manufacturing	F2.1	
24-25	E-Transportation	F2.1	
27-28	F,G-Wholesale and Retail Trade	F2.1	
30-31	H-Finance	F2.1	
33-34	I-Service Industries	F2.1	
36-37	J-Government	F2.1	
	NUMBER OF MAN-DAYS LOST TO WORK STOPPAGES (in thousands) (1972, 1974 missing)		AWS
39-43	All Industries	F5.0	
46-50	D-Manufacturing	F5.0	
53-56	19-Ordnance and Accessories	F4.1	
57-61	20-Food and Kindred Products	F4.1	
62-65	21-Tobacco Manufactures	F4.1	
66-69	22-Textile Mill Products	F4.1	
71-74	23-Apparel and Other Textile Products	F4.1	
76-79	24-Lumber and Wood Products, except Furniture	F4.1	

*For these items, Fn.1 format expresses each variable as a per cent (e.g., 3.6% is coded as 36 on the data card).

CARD 18

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 18		
	NUMBER OF MAN-DAYS LOST TO WORK STOPPAGES (in thousands) (continued)		AWS
10-12	25-Furniture and Fixtures	F3.0	
14-17	26-Paper and Allied Products	F4.0	
19-23	27-Printing, Publishing, and Allied Industries	F4.1	
24-27	28-Chemicals and Allied Products	F4.0	
29-33	29-Petroleum Refining and Related Industries	F5.1	
34-37	30-Rubber and Miscellaneous Plastics Products	F4.0	
40-43	31-Leather and Leather Products	F4.1	
44-47	32-Stone, Clay, Glass, and Concrete Products	F4.0	
50-53	33-Primary Metal Industries	F4.0	
55-58	34-Fabricated Metal Products	F4.0	
61-64	35-Machinery, except Electrical	F4.0	
67-70	36-Electrical Equipment	F4.0	

CARD 19

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 19		
	NUMBER OF MAN-DAYS LOST TO WORK STOPPAGES (in thousands) (continued)		AWS
9-13	37-Transportation Equipment	F5.0	
1			
15-18	38-Instruments and Related Products	F4.1	
21-24	39-Miscellaneous Manufacturing Industries	F4.1	
26-30	Total Non-manufacturing	F5.0	
33-36	Agriculture, Forestry, Fishing	F4.1	
37-40	Mining	F4.0	
42-46	Construction	F5.0	
47-51	Transportation, Communications, Electric, Gas and Sanitary Services	F5.0	
53-56	Wholesale and Retail Trade	F4.0	
58-61	Finance, Insurance, and Real Estate	F4.1	
64-66	Services	F3.0	
68-72	Government	F5.1	

CARD 20

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 20		
	AVERAGE WEEKLY EARNINGS OF PRODUCTION OR NON-SUPERVISORY WORKERS, BY INDUSTRY DIVISION (in current dollars)*		I-102
10-14	Mining	F5.2	
16-20	Construction	F5.2	
22-26	Manufacturing	F5.2	
28-32	Transportation and Publi Utilities (1964-1974 only)	F5.2	
34-38	Wholesale Trade	F5.2	
40-44	Retail Trade	F5.2	
46-50	Finance, Insurance, and Real Estate	F5.2	
52-56	Services (1964-1974 only)	F5.2	
	AVERAGE WEEKLY EARNINGS OF PRODUCTION WORKERS IN MANUFACTURING, BY 2-digit SIC GROUPS (see also Card 28) (in current dollars)*		I-103
58-62	19-Ordnance and Accessories	F5.2	
64-68	24-Lumber and Wood Products, except Furniture	F5.2	

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*For these items, F5.2 format expresses each variable as "dollars and cents" (e.g., $232.54 is coded as 23254 on the data card).

CARD 21

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 21		
	AVERAGE WEEKLY EARNINGS OF PRODUCTION WORKERS IN MANUFACTURING, BY 2-digit SIC GROUPS (in current dollars) (continued)		I-103
10-14	25-Furniture Fixtures	F5.2	
16-20	32-Stone, Clay, and Glass Products	F5.2	
22-26	33-Primary Metal Industries	F5.2	
28-32	34-Fabricated Metal Products	F5.2	
34-38	35-Machinery, except Electrical	F5.2	
40-44	36-Electrical Equipment and Supplies	F5.2	
46-50	37-Transportation Equipment	F5.2	
52-56	38-Instruments and Related Products	F5.2	
58-62	39-Miscellaneous Manufacturing	F5.2	
64-68	20-Food and Kindred Products	F5.2	

CARD 22

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 22		
	AVERAGE WEEKLY EARNINGS OF PRODUCTION WORKERS IN MANUFACTURING, BY 2-digit SIC GROUPS (in current dollars) (continued)		I-103
10-14	21-Tobacco Manufactures	F5.2	
16-20	22-Textile Mill Products	F5.2	
22-26	23-Apparel and Other Textile Products	F5.2	
28-32	26-Paper and Allied Products	F5.2	
34-38	27-Printing and Publishing	F5.2	
40-44	28-Chemicals and Allied Products	F5.2	
46-50	29-Petroleum and Coal Products	F5.2	
52-56	30-Rubber and Miscellaneous Plastics Products	F5.2	
58-62	31-Leather and Leather Products	F5.2	
	CONSUMER PRICE INDEX (1967+100.00)		
64-67	All Items	F4.1	SCB,BS
69-72	Fuels and Utilities, Total (Housing) (includes data for items shown separately)	F4.1	SCB,BS

CARD 23

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 23		
	CONSUMER PRICE INDEX (1967=100.00) (continued)		SCB,BS
10-13	Fuel Oil and Coal (Housing)	F4.1	
15-18	Gas and Electricity (Housing)	F4.1	
	GROSS NATIONAL PRODUCT		
20-23	Gross National Product (1967 dollars) (billions of dollars) $Y_t^{67\$} = Y_{67}^{67\$}$ 1+% $(Y_t^{58\$}, Y_{67}^{58\$})$	F4.1	
	HOUSEHOLDS (see also Cards 24,26,27)		SA
25-29	Number of U.S. Households (in thousands)	F4.0	
	RESIDENTIAL CONSTRUCTION, PRIVATE (in thousands of dwelling units)		
31-34	Number of starts, single family dwelling units	F4.0	FRBul
36-39	Number of starts, dwelling units in structures of 2 or more units	F4.0	FRBul
41-44	Mobile home shipments to dealers (in thousands)	F4.0	HUD,YB
	AUTOMOBILE DATA		
46-48	Number of highway deaths (in thousands)	F3.1	MVMA
50-52	Death rate per 100 million vehicle miles	F3.2	MVMA
54-56	Death rate per 100,000 population	F3.1	MVMA
58-63	Number of registered privately and publicly owned passenger cars (in thousands)	F6.0	MVMA
65-68	Retail sales, domestic passenger cards (in thousands)	F4.0	MVMA
70-73	Retail sales, imported passenger cars (in thousands)	F4.0	MVMA
74-76	4-cylinder cars as a per cent of domestic production (model year)	F3.1	WARD'S
78-80	6-cylinder cars as a per cent of domestic production (model year)	F3.1	WARD'S

CARD 24

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 24		
	AUTOMOBILE DATA (continued)		
10-12	8-cylinder cars as per cent of domestic production (model year)	F3.1	WARD's
14-17	Average MPG, all passenger cars* (1960-1974 only)	F4.2	FHWA
19-22	Average MPG, all passeneer vehicles** (1960-1974 only)	F4.2	FHWA
24-27	Average MPG, all motor vehicles (1960-1974 only)	F4.2	FHWA
	MILES OF TRAVEL (millions of vehicle-miles) (1960-1973)		FHWA
29-34	Passenger cars*, on main rural roads+	F6.0	
36-41	Passenger cars*, on all rural roads	F6.0	
43-48	Passenger cars*, on urban streets	F6.0	
50-56	All passenger vehicles**	F7.0	
58-64	All motor vehicles	F7.0	
	AUTOMOBILE PRODUCTION		WARD'S
65-72	U.S. domestic automobile production (model year) (in thousands)	F5.0	
	POPULATION (see also Cards 23, 26, 27)		SA
75-80	U.S. total resident population (excludes Armed Forces abroad) (see Card 27) (in thousands)	F6.0	

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*Includes notorcycles and taxicabs.

**Includes buses, as well as passenger cars.

+Includes roads in state highway systems, the Interstate System, and other mileage on Federal-aid systems and major toll roads.

CARD 25

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 25		
	RATE OF RETURN REVIEWS PROCESSED BY STATE REGULATORY COMMISSIONS (1960-1972 only)		PUR
10-11	Electric utilities	F2.0	
13-14	Gas utilities	F2.0	
	CREDIT		FRBul
16-21	Installment consumer credit, total (millions of current dollars)	F6.0	
23-27	Automobile paper, total (millions of current dollars)	F5.0	
29-31	Aaa corporate bonds, yiled	F3.2	
33-35	U.S. government 3-month bills, yield	F3.2	
	APPLIANCE DATA - NUMBER OF UNITS SOLD AT RETAIL		MW
37-40	Electric ranges (1960-1973 only)	F4.0	
42-45	Room air conditioners (electric) (1960-1973 only)	F4.0	
47-50	Electric dishwashers (1960-1973 only)	F4.0	
52-55	Electric refrigerators (1960-1973 only)	F4.0	
57-60	Electric water heaters (1962-1973 only)	F4.0	
62-65	Gas water heaters (1966-1972 only)	F4.0	

CARD 26

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 26		
	GOVERNMENT EMPLOYMENT (see also Card 7) (Sources: 1960-1970, Historical Statistics; 1971- , Statistical Abstract)		
10-13	Number of local government employees (in thousands)	F4.0	
15-18	Number of state government employees (in thousands)	F4.0	
20-23	Number of federal government employees (in thousands)	F4.0	
25-27	Per cent of federal government employees employed outside Washington, D.C. SMSA (1960-1970, 1972-1973)	F3.1	
	FAMILIES - CHILDREN (Sources: 1960-1970, Historical Statistics; 1971-1974, Statistical Abstract)		
29-33	Number of families in U.S. (in thousands)	F5.0	
35-37	Per cent of families having 0 children*	F3.1	
39-41	Percent of families having 1 child*	F3.1	
43-45	Per cent of families having 2 children*	F3.1	
	FAMILIES - AUTOMOBILE OWNERSHIP* (Source: 1960-1970, Historical Statistics)		
50-51	Per cent families owning 1 car (1960-1970 only)	F2.0	
53-54	Per cent families owning more than 1 car (1960-1970 only)	F2.0	
	WORKPLACES (1960-1970 only)		HS
56-60	Number of U.S. workplaces (in thousands)	F5.0	

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*For these items, Fn.1 expresses each variable as per cent (e.g., 32.1% is coded as 321 on the data card).

CARD 26 (continued)

Columns		Format	Source
	VOTING*		SA
62-64	Per cent of voting age population casting votes in Presidential election	F3.1	
66-68	Per cent of voting age population casting votes for U.S. Representative	F3.1	

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*For these items, Fn. 1 format expresses each variable as per cent (e.g., 32.1% is coded as 321 on the data card).

CARD 27

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 27		
	EDUCATION		FHWA
10-15	Number of school buses, U.S. total	F6.0	
18-22	School age population (5 to 17), U.S. total (in thousands) (Sources: 1960-1970, Historical Statistics; 1971-1974, Statistical Abstract)	F5.0	
	MISCELLANEOUS POPULATION AND HOUSEHOLD DATA (see also Cards 23, 24, 26)		
24-29	U.S. total civilian population (see Card 24) (in thousands)	F6.0	SA
31-35	Total number of females, age 20-44, in civilian population (in thousands)	F5.0	CPR (p.25)
37-41	Total number of households headed by female (in thousands)	F5.0	CPR (p.25, #244)
43-47	Total number of households consisting of a single person (in thousands) (1960-1970 only)	F5.0	HS

CARD 28

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 28		
	AVERAGE HOURLY EARNINGS OF PRODUCTION WORKERS IN MANUFACTURING, BY 2-digit SIC GROUPS (see also Cards 20-22) (in current dollars)*		EE
10-12	All Manufacturing	F3.2	
13-15	All Manufacturing, excluding overtime	F3.2	
17-19	22-Textile Mill Products	F3.2	
20-22	22, excluding overtime	F3.2	
24-26	23-Apparel and Other Textile Products	F3.2	
27-29	23, excluding overtime	F3.2	
31-33	27-Printing and Publishing	F3.2	
34-36	27, excluding overtime	F3.2	
38-40	29-Petroleum and Coal Products	F3.2	
41-43	29, excluding overtime	F3.2	
45-47	31-Leather and Leather Products	F3.2	
48-50	31, excluding overtime	F3.2	
52-54	37-Transportation Equipment	F3.2	
55-57	37, excluding overtime	F3.2	
	NEGRO AND OTHER RACES IN CIVILIAN LABOR FORCE (CLF) (see also Cards 1-4) (in thousands)**		
59-62	Total number of Negro*** males in CLF	F4.0	
64-66	Number of Negro males in CLF, 16-17 years	F4.0	
68-70	Number of Negro males in CLF, 18-19 years	F3.0	

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*For these items, F3.2 format expresses each variable as "dollars and cents."

**For these items, Fn.0 format expresses each variable in thousands.

***"White" + "Negro and other races" (expressed as "Negro") = Total.

CARD 28 (continued)

Columns		Format	Source
	NEGRO AND OTHER RACES IN CIVILIAN LABOR FORCE (see also Cards 1-4) (In thousands) (continued)		EE
72-74	Number of Negro males in CLF, 20-24 years	F3.0	
76-79	Number of Negro males in CLF, 25-34 years	F4.0	

CARD 29

Columns		Format	Source
2-5	Year		
7-8	Card number - Enter 29		
	NEGRO AND OTHER RACES IN CIVILIAN LABOR FORCE (see also Cards 1-4) (in thousands) (continued)		I-3
10-13	Number of Negro males in CLF, 35-44 years	F4.0	
15-17	Number of Negro males in CLF, 45-54 years	F3.0	
19-21	Number of Negro males in CLF, 55-64 years	F3.0	
23-25	Number of Negro males in CLF, 65 years and older	F3.0	
27-30	Total number of Negro females in CLF	F4.0	
32-34	Number of Negro females in CLF, 16-17 years	F3.0	
36-38	Number of Negro females in CLF, 18-19 years	F3.0	
40-42	Number of Negro females in CLF, 20-24 years	F3.0	
44-47	Number of Negro females in CLF, 25-34 years	F4.0	
49-51	Number of Negro females in CLF, 35-44 years	F3.0	
53-55	Number of Negro females in CLF, 45-54 years	F3.0	
57-59	Number of Negro females in CLF, 55-64 years	F3.0	
61-63	Number of Negro females in CLF, 65 years and older	F3.0	

Source Code*

AWS	Bureau of Labor Statistics, Analysis of Work Stoppages, various issues
CPR	Bureau of Census, Current Population Reports
EE	Bureau of Labor Statistics, Employment and Earnings, United States, 1909-75
FHWA	Department of Transportation, Federal Highway Administration, Highway Statistics, Summary to 1965; Highway Statistics, various issues
FRBul	Board of Governors of Federal Reserve System, Federal Reserve Bulletin, various issues
HS	Bureau of Census, Historical Statistics of the United States ... to 1970
HUD,YB	Department of Housing and Urban Development, Statistical Yearbook, various issues
I	Bureau of Labor Statistics, Handbook of Labor Statistics 1973 (Arabic numerals refer to table numbers)
MVMA	Motor Vehicle Manufacturer's Association, Automobile Facts and Figures, 1975 edition
MW	Merchandising Week, annual statistical issue
PUR	Public Utilities Reports, various issues. See Paul Joskow, in Journal of Law and Economics, October 1974.
SA	Bureau of Census, Statistical Abstract of the United States, various issues
SCB,BS	Department of Commerce, Survey of Business Statistics, Business Statistics 1973
WARD'S	Ward's Automotive Yearbook, various issues

* See following page for complete reference.

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