EVALUATION OF THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT'S METHODS FOR ASSESSING SOCIOECONOMIC IMPACTS OF DISTRICT RULES AND REGULATIONS

VOLUME I: SUMMARY OF FINDINGS

May 1992

Prepared for the

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The research reported here is financed with funds from Contract No. C91253 between the South Coast Air Quality Management District and the Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts. The authors take full responsibility for the conclusions, which are not necessarily those of the sponsoring agency.

ACKNOWLEDGMENTS

This was a large project, which could not have been accomplished without the help of countless individuals on both coasts and between. First and foremost, we thank the people of Southern California who, despite their own recent traumas have unselfishly taken an interest in our work and offered their suggestions and time freely. We also thank the air-pollution officers in California and other states and the staff in several related agencies who took the time to respond to our survey and to discuss with us, the academics, what they do and how they do it. We owe a special debt to our colleagues in the economics profession with whom we shared ideas and who provided us with many comments on our reports, often providing valuable insights into particular issues. We especially thank George Fulton, Donald Grimes, Linea Hazen, Brian MacDonald, Ben Stevens, and George Treyz. We received important help and cooperation from the staff of the South Coast Air Quality Management District. Among these colleagues, we especially appreciate the efforts of Francis Goh, who had the difficult job of communicating between the District staff and our team, and who showed the maturity of a man twice his age and experience, and whose commitment to intellectual honesty made this work possible. Finally, as always, we are deeply grateful to our colleague Pat Murray for production support, especially with regard to the many versions of the numerous tables and figures.

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EVALUATION OF THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT'S METHODS FOR ASSESSING SOCIOECONOMIC IMPACTS OF DISTRICT RULES AND REGULATIONS

VOLUME I: SUMMARY OF FINDINGS

This report presents the findings of our one-year evaluation of the methods used by the South Coast Air Quality Management District (District) to assess the socioeconomic impacts of its rules and regulations. The purpose of our evaluation has been to determine whether the methods used by the District's socioeconomic staff are technically sound and substantively useful.[1] Some of the specific questions we will answer include:

- Do the socioeconomic staff use appropriate economic models for conducting their analyses?
- Would the quality of the analyses be improved if they were conducted by an outside contractor rather than by the socioeconomic staff?
- What are the needs and capabilities of the District regarding its socioeconomic impact assessments, and how are these likely to change?
- What alternative methods are available to the socioeconomic staff and at what cost?

The report is organized into two volumes. The first volume is a summary of findings, in which we frame the main issues, discuss the District's activities, and make our recommendations. The second volume consists of Appendices I through VIII, which contain our technical reports and other background information in more detail than most readers may desire, but which give supporting evidence for our findings.

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[1] Throughout this report, we will use the term "District staff" to refer to the overall staff of the District and the term "socioeconomic staff" to refer to those five members of the District's Planning and Rules staff who conduct socioeconomic analyses. We are aware that a recent revision of the divisions within the District has altered the current Planning and Rules division, but we have not taken the proposed revisions into account in our assessment.

Early in our study, we decided that the various tasks to be undertaken could be grouped into two major categories. First, we had to conduct a technical evaluation of both how the socioeconomic staff make their assessments and whether these methods meet standards of peer review. Second, we needed to determine whether the socioeconomic staff are asking the right questions, and if they are institutionally equipped to do so both now and in the future. In practice, these questions are not entirely separate; the quantitative methods the socioeconomic staff uses, for instance, limit the types of questions that they can ask. Nevertheless, it is a useful categorization. Beginning with these two major categories of tasks, we present three main sets of findings.

First, we evaluate the technical aspects of how the socioeconomic staff conduct their assessments, examining how they do what they do, taking what they do as given. Overall, we determine that the staff are exceptionally well-qualified to undertake the complex economic analyses they currently conduct. Furthermore, the regional economic model they use, which they purchased from Regional Economic Model, Inc. (henceforth called the REMI model), is technically sound. A more important issue is whether a model as sophisticated, complex, and expensive as REMI is necessary. We conclude that it is, but that the socioeconomic staff could make far better use than they do of its flexibility and detailed output. We also make a series of detailed technical recommendations.

Second, we evaluate the substance of what the socioeconomic staff actually do. We conclude that, if socioeconomic reports are to contribute to the goal of improving air quality, the socioeconomic staff need to examine a much larger range of issues than the partial-cost analyses they currently undertake; i.e., their socioeconomic analyses need to be significantly improved. Some of these issues, such as the need for a more careful examination of small business impacts, have been raised by others, and the socioeconomic staff are already taking steps to expand the analyses in these directions. In other instances, the changes needed are very far-reaching. We recommend, for example, that the District's socioeconomic staff should do more than at present to identify potential obstacles to compliance as well as strategies whereby businesses might avoid those obstacles. Similarly, we recommend that they identify potential areas of new entrepreneurial opportunity. As with analyses being conducted elsewhere in the United States, the Districts' socioeconomic staff conduct very little analysis of the social impacts of pollution controls.

Third, we discuss the current institutional structure and the changes in it that we believe are necessary before the substantive and technical questions can be answered in full. One critical question we explored was whether the socioeconomic analyses should be conducted by the District or by an outside contractor. To help answer this question, we made a survey of firms who conduct regional economic modeling, details of which are provided in Appendix II. From our own experience in economic modeling, we know that building a competent staff of socioeconomic analysts takes considerable time and substantial funding. The District is able to benefit from its size and diverse staff, and the organization is more than the sum of its parts. Although we make many recommendations concerning major changes that are needed to the current institutional structure, to the scope of analyses the socioeconomic staff conduct, and to the way in which they conduct them, we recommend that those changes be undertaken within the District. Our full rationale for this decision is given in the section on "Institutional Structure for Conducting Socioeconomic Analyses."

We determined that some of the debate about whether the District should contract out its socioeconomic analysis is misplaced. Regardless of where the analyses are conducted and who does them, means must be made to assure that biases are minimized and that the staff conducting the analyses are accountable not only to the District, but also to the public-at-large. In general, we believe that the types of analyses required by the District are likely to become more, not less, complex over time. To answer the varied questions raised under different rules, regulations, and alternative regulatory strategies, the socioeconomic staff need to build an organizational capability to combine resources from many sources. We recommend that the socioeconomic staff should continue to conduct the analyses, but they should make significant changes in (a) the scope of their analyses, (b) analytical tools they use for the studies, and (c) methods of obtaining information and types of information obtained from other divisions within the District administration, from outside contractors, and from the public. In addition, we recommend the establishment of a permanent Socioeconomic Analysis Review Committee to help keep the socioeconomic staff on the leading edge of analysis and to provide a means for keeping it accountable to the District and to the public-at-large. We also recommend that the District consider hiring a contractor who would be available to help members of the public construct their own policy simulations (refer to Appendix VI).

Our overall recommendation is for the socioeconomic staff to adopt what we will call "a flexible method of analysis." Under such a system, the staff would "pick and choose" methods based on the particular type of analysis needed. Instead of concentrating on upgrading a specific model, they would work on improving their own abilities to work with many different techniques and to move data between software packages. Rather than trying to gain proficiency in all fields, they would work to identify areas where in-house know-how is most needed, and where they should rely on expertise from other departments or from outside sources. Finally, such a system would embody "institutional learning," whereby the socioeconomic staff try to plan what organizational, personnel, and computational needs they are likely to have in the future and ways to meet those needs. Additional details on the institutional structure are provided in the last section of our report. We outline there the problems of creating an organization capable of adjusting to the rapidly changing demands placed on it.

OVERVIEW OF THE DISTRICT'S SOCIOECONOMIC ANALYSES

By almost any measure commonly used, Los Angeles has the dirtiest air in the United States. The costs of this poor air quality are not shared evenly, many of them falling disproportionally on poor communities, but virtually all residents of the region pay some of the costs (Arndt, et al. 1991; Brajer and Hall, 1991; Mann et al., 1991). The negative effects on public health, visual quality, building integrity, and agricultural productivity are felt almost universally in the South Coast.[2] In addition, the remedial measures now being put in place to bring the region's air up to legal standards are likely to be so widespread and to change everyday behavior so fundamentally that no one will be unaffected. Recognizing the potential for their regulations to

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[2] We will use the term "South Coast" to refer to the four counties (Los Angeles, Orange, Riverside, and San Bernardino) that are part of the South Coast Air-Quality Management District.

have far-reaching socioeconomic impacts, the District's administration decided many years ago to begin incorporating assessments of these potential impacts into the rule-formulation process. This reporting effort was institutionalized on March 17, 1989, when the District Board passed a resolution requiring the staff to prepare socioeconomic reports as a standard practice ". . .for proposed rules with emission-reduction potential" (SCAQMD, 1989).

The socioeconomic staff have undertaken an unusually large and sophisticated socioeconomic reporting effort. Unlike many air districts, the District has a special socioeconomic staff to conduct its analyses. Furthermore, most of these staff members have specialized training in the field of economic modeling. Without question, this highly trained staff is the most valuable asset the District has available to it for conducting socioeconomic assessments.

In 1989, the District purchased REMI, a regional econometric model, which significantly changed the nature of the staff's work, adding both considerable complexity and much greater flexibility in the type of analyses possible. Today, the general framework of how the socioeconomic staff uses REMI to conduct its assessments can be described as follows: they first collect data that describe the costs of a proposed rule to regulated firms. The staff then determines how best to enter those data into the model. This is an inherently subjective task, because the data can usually be entered into the model in several different ways, each of which may affect the socioeconomic impact estimates differently. Once the data are entered, they use the model to generate a forecast of how the costs of the proposed rule will be spread throughout the local economy. The final job of the staff is to interpret the results of the model's forecast, present the results to the public, and finally to the District Board.

THE REGULATORY CONTEXT

The District administration and staff must respond to a tremendous variety of demands when formulating policy and writing their socioeconomic reports. These demands have important implications for how socioeconomic impact analyses are undertaken. The task of satisfying these demands would make the District's socioeconomic reporting effort difficult under any circumstances. The situation is made even more onerous because the regulatory environment is changing extremely rapidly.

First, and foremost, the District is subject to both federal and state laws. Most obviously, this means bringing the region into compliance with air-quality standards. In several recent cases, the District Board or state legislature have actually intervened by imposing new requirements on the socioeconomic reporting process as well. These interventions include the requirement to develop an Air Quality Management Plan once every three years, to study the impacts of the rules and regulations on small business, and the legislation (State Bill 1928) that required our study to be made.

Second, the District must respond to economic pressures. This, of course, is a primary reason for conducting socioeconomic analyses. Many analysts, as well as the general public, assume, however, that economic goals are inherently in conflict with environmental objectives. A simple truth, too often neglected, is that healthy industries are much more able to invest monetary and human resources toward improving air quality than are industries in crisis. The most immediate problem is trying to identify how pollution controls actually affect the economic conditions of local businesses, governments, and residents. This is an immense task, given the large size and extreme diversity of the local economic base. This problem is made even more difficult because Southern California's economy is being subjected to heightened competition, forcing businesses to adopt new strategies to compete in the market place. Not all socioeconomic impacts are felt just by directly regulated businesses. Local governments, public sector institutions, and communities are also affected. Moreover, given the unprecedented economic distress being felt in the region in recent years, many of these economic impacts have taken on new significance.

Third, the District must respond to public demands for policy that is both credible and relevant, even though much of the information the District needs to make informed policy is either unavailable or highly uncertain. In the many cases where it is very specialized, the socioeconomic staff must obtain it directly from the regulated community. From a forecasting standpoint, they operate in an environment of rapid economic change, making it less likely that they can use old rules and patterns of behavior as reliable indicators of future economic activity. In addition, the staff rely upon a great variety of sources and estimate a diverse set of economic impacts, both of which require them to place high priority on maintaining data systems that make the socioeconomic analyses reproducible and understandable to others. Over time, these reports must also exhibit enough consistency in method and definitions to allow comparisons of the effects of the rules; therefore, the socioeconomic staff must develop procedures and guidelines for their work and maintain up-to-date data sets. In addition, they must make the output of the reports understandable and informative to a tremendously diverse public.

Fourth, there are complex organizational and institutional requirements internal to the District itself. The particular type of regulatory strategy used makes a tremendous difference in determining the appropriate type of assessment method. Not only does the District have jurisdiction over a wide variety of different pollution-control problems, but the preferred regulatory strategies are in rapid flux, seen most obviously in the shift toward the Regional Clean Air Incentives Market (RECLAIM) program, which will establish an incentive program to allow companies "to achieve their required emission reductions of Reactive Organic Gases (ROG), Nitrogen Oxides (NO_x), and, potentially, sulfur oxides (SO_x) through their choice of add-on controls, the use of reformulated products, and/or by purchasing excess emission reductions from other sources" (SCAQMD, 1992, p. EX-1).[3]

Finally, and perhaps most important, the capabilities of the socioeconomic staff have grown tremendously, encouraging them to ask new types of questions based on lessons learned from past efforts and on the availability of new analytical resources. This increased complexity means that the socioeconomic staff need to produce reports using a common format for presentation of findings. Although the reports, where appropriate, will have a common base of information, they will almost inevitably contain diverse types of information.

Few things characterize the socioeconomic staff's effort more than change. In the short time we have been conducting this evaluation, they have begun work in new fields, such as the RECLAIM program, and with new tools, such as linear programming. They have also hired four contractors to help

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[3] Rulemaking for the RECLAIM program was approved by the District Board on March 5, 1992.

them with small business and general socioeconomic impact analyses. In addition, by the time this report is published, we expect that several of our recommendations will already have been implemented in one form or another. In other cases, they may have been made less valuable by changes in the District's goals and policies. In part because of this, many of our comments focus less on detailed changes than on helping the District to create a system of economic reporting capable of adapting to rapid change.

STANDARDS OF COMPARISON

One of the first problems we faced in this project was to determine some standard against which the District's socioeconomic reports could be compared. In fact, there is no single set of generally agreed upon guidelines for socioeconomic analyses. Consequently, we have used several parallel sets of standards. First, we have assessed whether the socioeconomic staff use methods that are consistent with professional standards. These tend to be informal and often leave tremendous room for disagreement. As an example, all economists agree that, for most studies, intertemporal comparisons of outputs should not be made without first deflating output values to constant prices to account for inflation; however, these experts might disagree on which price index to use for the deflation.

Second, we compared the District's socioeconomic analyses with those conducted by similar agencies. We surveyed three groups of government agencies: (1) air-pollution control agencies in 50 states and the District of Columbia, (2) air-pollution control districts in 40 county or multicounty groups in California,[4] and (3) four California state agencies: the California Energy Commission, the Department of Forestry and Fire Protection, the Department of Transportation, and the State Water Resources Control Board. In addition to the formal surveys, we interviewed staff in some agencies and read published reports to determine methods they employed. We also reviewed several studies, conducted by researchers outside the District, on economic impacts of the District's air-pollution rules and regulations. We also conducted an extensive literature review on regional economic impact models. Details about these surveys and literature review are provided in Appendix II.

We paid particular attention to two agencies: the Bay Area Air Quality Management District (BAAQMD) and the Illinois Department of Energy and Natural Resources (DENR). The BAAQMD, the second largest air-quality management district in California, is probably the closest peer to the District. They have conducted a comprehensive study on economic impacts of their proposed Clear-Air Plan on consumers, commuters, businesses, and local governments in the Bay Area (BAAQMD, 1991). The Illinois DENR staff use their own version of the REMI model--the Illinois Forecasting and Simulation Model--to calculate the impacts of air-pollution controls on the state and regional economy (Illinois DENR, 1986; Illinois DENR, 1991; Bonardelli, 1991). This provides us with a unique opportunity to compare the analyses the District's socioeconomic staff conduct using the REMI model with the analyses conducted with the use of models in two other air-pollution control agencies.

Although the socioeconomic staff can clearly learn several lessons from the efforts of other pollution-control agencies, comparisons with their peers

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[4] Several of California's air-pollution control districts serve more than one county.

have certain limitations. The reason is that the District is widely perceived as being a leader in policy formulation and analytical methods. Throughout our study, we found many air-pollution regulators throughout the country waiting to see what the District would do next. Holding the District to a higher standard may seem unfair. It is a role, however, that the District administrators have already accepted by pursuing the most aggressive set of pollution-reduction policies in the United States.

The third, and final, standard we used for evaluating the District's methods was more subjective. It consisted of asking why the District needed to conduct socioeconomic analyses and then trying to determine if the methods used are appropriate to meet those needs. The specific standards we have used represent our best estimate of the District's and the public's need for information, based on extensive interviews, applicable legislation, and published sources. We need to make a "best estimate," because we found no precise, stated objectives for why the District is performing socioeconomic analyses. Even if the objectives were clear, the District would have to make considerable modifications to them as the regulatory environment changes. As a result, the standards for our study have evolved almost constantly in the course of our investigation, as we continue to learn more about how air-pollution regulations affect local communities and businesses.

One goal has not changed: the analyses performed by the socioeconomic staff should contribute positively to the design of policies for cleaning the air. This can be done in several ways. First, analyses can help the District formulate better policy, both by enhancing the probability that its policies will be implemented in a timely manner and by allowing it to revise its policies so as to maximize their net public benefits. Second, analyses can help private citizens and firms comply with the law in the most economically constructive manner. In addition to helping the District establish effective policies for cleaning the air, the socioeconomic reports provide the public with an up-to-date accounting of the economic benefits and costs of air-pollution regulations. This information is necessary for the public to make informed political decisions about whether or not to support continuing pollution-control efforts.

ISSUES OF TECHNIQUE

In this section, we investigate how the socioeconomic staff determine economic impacts from a technical perspective. We do not consider in-depth the types of economic impacts they study, because we will discuss those in the next section. Issues of technique include (1) choices of method of analysis, (2) appropriate use of methods selected, and (3) choice and maintenance of data. We include the latter because data concerns are so central to the use of any analytical method.

Framework of Analysis

Before we consider the specific types of analytical tools used by the socioeconomic staff, we place the use of those tools in context. Traditionally, economists have used formal and structured approaches, such as benefit-cost or cost-effectiveness analyses, as a primary means for conveying information about economic benefits and costs of policy decisions. These methods usually result in an estimate of net benefit, or dollar cost per ton of pollutant reduced, respectively. In our survey of pollution-control agencies, we found that 6 county agencies in California and 20 U.S. state agencies use either cost-effectiveness or benefit-cost studies as their primary framework of analysis.

Although analysts who use the cost-effectiveness technique obtain useful information for comparing costs, they usually do not consider any benefits that may accrue to pollution-control strategies. From our literature review and agency surveys, provided in Appendix II, we find that many U.S. air-pollution control agencies seem to rely excessively on the cost-effectiveness technique for policy decisions. We recommend that, in most cases, it should be used only as one of several tools for deciding policy.

Benefit-cost analysis is most useful as an accounting framework to obtain a consistent method of analyzing complex data. Analysts use this method inappropriately when they try to oversimplify the accounting into a single numerical estimate of net benefits, which they then use to determine important policy. In cases where data are extremely uncertain, benefit-cost analyses may be particularly misleading for two reasons. First, because benefits tend to be less easily quantified than costs, the method can lead to biased results. Second, the formality of the method can mislead all but the most experienced members of the public into believing that the results are more significant than they really are. For either method, the criteria used for determining complex policies, such as air-pollution control, are multidimensional and not easily reduced to the simple calculus of maximizing dollar benefits or cost-effectiveness (Friedman, 1991; Lents, 1991; Miller, 1991).

Although the socioeconomic staff routinely present cost-effectiveness data, they only use them for one part of a more complex analysis. We commend the staff for deciding not to use either the benefit-cost or the cost-effectiveness technique as their primary method of accounting for the benefits and costs of air-pollution control. One major advantage of the District's use of REMI, compared with cost-effectiveness techniques, is their ability to assess regional macroeconomic effects. They can determine the economic impacts on the entire South Coast economy, by sector, and can obtain not only direct economic impacts, but also indirect effects on both producers and consumers. In most of our recommendations to follow, we will try to identify ways in which the socioeconomic staff can improve upon and expand their current approach as they design an analytical procedure that is not structured around any single technique and that provides a comprehensive description of policy impacts.

Use of Economic Models

We shall refer to modeling as the use of some set of numerical techniques to estimate socioeconomic impacts of air-pollution controls. The use of such quantitative techniques is only one part of the overall socioeconomic assessment system, but it is a key part, and the part that is least well understood by many members of the public. In Appendix II, we review many of the key issues surrounding the use of economic models in more detail. Briefly, however, there are several reasons why analysts need to use such models. First, modeling provides a consistent and explicit framework for estimating socioeconomic impacts, helping to clarify assumptions and identify causal links. Second, computerized modeling allows the analyst to process large amounts of data and perform complicated calculations rapidly that might otherwise be impossible or take an unreasonably long time. Third, once the data used in computer-based modeling are collected and coded into machine-readable form, they become considerably more accessible. This makes further analyses much less expensive and allows public agencies to disseminate their data and results to the public easily and quickly.

There are also certain costs of modeling. Many of these are problems specific to individual models, but there are generic issues as well. First, most models are proprietary. Because they have a limited market and usually take considerable effort to create, they tend to be expensive. Obviously the severity of this depends on the individual model and the resources of the agency in question. Second, and related to the first issue, models usually have very specific data requirements. These data must be collected and maintained over time. Third, because all models are based on theories of socioeconomic behavior, responsible modeling requires that users have some understanding of these underlying theories. This is especially an issue as models become more complex, because the ability to generate results quickly through mechanization can hide many of the critical assumptions that lie behind those results.

The socioeconomic staff use an economic model mainly to forecast future economic behavior with and without some set of air-pollution control policies. This is not the only option available. On the one hand, they could choose not to use a model at all, relying instead on descriptive or qualitative analysis. In fact, this is the approach taken by the vast majority of air districts. Of the 40 California districts we surveyed, only 1 (in addition to the District) actually used any formal model to estimate economic impacts, and of the 51 U.S. state-level agencies, only 3 used economic models (Appendix II).

On the other hand, the socioeconomic staff could use multiple models, or subject the output from the REMI model to various forms of secondary analysis that the model cannot provide. They could, for instance, use other models to estimate specific kinds of economic impacts not possible with their current model. In at least one instance, Rule 1135, Emissions of Oxides of Nitrogen from Electric-Power Generating Systems, the staff have used information from an energy model to estimate how its rules might affect electricity production in different power plants. Similar models exist to study detailed effects of policies on land use, transportation patterns, and similar areas of concern. Many nonenvironmental groups routinely link these models with economic-impact models. At the fall REMI user's conference, for example, we talked with staff from several agencies who link REMI with energy-forecasting models, in particular with the Energy 2020 model (Backus, 1991) to study the impacts of changing economic structures on future energy demand. These are then further extended to include an air-pollution component (Reed, 1991).

Selecting a Model: REMI

One of the questions most frequently asked about the District's socioeconomic analyses is whether the REMI model is appropriate and sufficient for the District's needs. Not surprisingly, this is a complex question that must be answered at many different levels. First, let us briefly describe what REMI is.

REMI

REMI is a regional econometric model made up of a large number of linked mathematical equations.[5] Each equation describes some detailed economic

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[5] The District's socioeconomic staff use a microcomputer version of REMI, although the model was originally designed for mainframe computers. They have a four-county multiregional version of the model.

relationship. These equations are created using conventional economic theories to describe the structural relationships between variables. The parameters of each equation are then calibrated (estimated) using historical data. Originally estimated using national data, some parts of REMI are further calibrated using local data to account for differences between the national and South Coast economies. To identify the effects of a policy on the economy, REMI users generate two forecasts. The first, or "control" forecast, is a prediction of what future economic behavior would look like without any change in policy. The second forecast is a "simulation" in which the user changes one or more policy variables in the model to reflect such varied economic impacts of pollution controls as changes in production costs, energy rates, or employment in specific industries. The analyst then compares the two forecasts to estimate the economic impacts on the local economy. Included in the forecast are estimates of economic impacts associated with "indirect" and "induced" economic behavior encouraged by the policy changes. The user can print REMI's results directly or copy them into other software packages for further statistical analysis, graphing, or mapping. We provide a more detailed description of the model in Appendix I.

Special Features of REMI

Just as the socioeconomic staff need not use models at all, they also do not have to choose REMI as the model to use. There are other models available. Nevertheless, REMI has many features that recommend it as a powerful regional economic forecasting tool. First, and most important, REMI is available on a microcomputer, which makes it especially accessible. Compared with mainframe computers, microcomputers have a wider array of software tools available, and data are easier to move between packages. In addition, many people have access to the technology, making it possible for the socioeconomic staff to share data and analytical resources with other agencies and nongovernmental groups.

Second, as a regional model, the results reflect differences between local and national economic activity. REMI has the following seven features often unavailable in many other microcomputer-based regional forecasting models:

- it is calibrated to local conditions using a relatively large amount of local data, which is likely to improve its performance, especially under conditions of structural economic change.
- it has an exceptionally strong theoretical foundation.
- it actually combines several different kinds of analytical tools (including economic-base, input-output, and econometric models), allowing it to take advantage of each specific method's strengths and compensate for its weaknesses.
- it allows users to manipulate an unusually large number of input variables and gives forecasts for an unusually large number of output variables.
- it allows the user to generate forecasts for any combination of future years, allowing the user special flexibility in analyzing the timing of economic impacts.
- it accounts for business cycles.
- it has been used by a large number of users under diverse conditions and has proven to perform acceptably.

In addition, the vendor provides good customer support and incorporates many of the clients' requests into annual revisions of the model.

Overall, REMI is a relatively flexible and detailed regional forecasting tool, which gives analysts considerable power to generate a wide variety of analyses. Still, this flexibility does not come without certain costs.

First, the immense detail of the model can make it technically difficult to use. This suggests that users of the model need to be relatively well trained in advance. A novice user can make a forecast easily; however, s/he may have a very difficult time sorting through the extremely detailed results of the model. In addition, if the novice is not careful, s/he may easily change variables that should be left unchanged. Another potential problem is that, although the theory behind the model is more detailed than in many of the competing regional models, this complexity can mask many of the assumptions and relationships of importance. To the average observer, REMI seems very much like a "black box" pouring out forecasts.

Uses of REMI

The socioeconomic staff are exactly the sort of expert analysts that can get the most out of REMI. Three of the five staff members who conducted the socioeconomic analyses and wrote the reports we reviewed hold doctoral degrees in economics or closely related disciplines--a luxury that smaller air-quality management authorities can rarely afford. Even among experts, however, the extreme flexibility of REMI can lead to disagreements regarding how certain policy initiatives should be modeled. Mills (1992), for instance, specifically noted REMI's absence of budget constraints on the government sector. Yet, the vendor excluded budget constraints on purpose to give the analyst greater flexibility. There is no inherent reason to believe that regional governments are subject to a balanced-budget requirement. Fiscal expenditures can be financed in a number of different ways: as reduced expenditures in other areas, as bond sales, or as increased taxes. Clearly, this flexibility requires that users give extra thought to modeling and interpretation and that they provide more thorough documentation of their work than with simpler models.

Another tradeoff in having a model as sophisticated as REMI is that it is expensive. Less sophisticated models may cost a small fraction of what REMI does. To justify the added cost of REMI, analysts should use the full detail and flexibility REMI provides. This does not appear to be occurring at present among the socioeconomic staff. In many cases, the only model outputs used by them are changes in jobs and output, given as totals and broken down by sector. Yet, REMI provides information on a large number of other variables as well. In addition to the output, income, and employment estimates that the staff currently calculates, we recommend that, for particular rules, they make more use than they do at present of other REMI variables of particular interest, such as information on consumer prices, detailed employment data, proprietor's income, and details of gross regional product. We are not recommending that the socioeconomic staff just give the public more numbers to digest. They will need to select and then summarize this increased amount of information very carefully. Presumably the socioeconomic staff have thus far assumed that most of the other variables are of too little significance to include them in the socioeconomic reports. If that is true, then they may not need a model as sophisticated as REMI.

Although the socioeconomic staff can benefit from using a highly flexible model, we recommend that they use the model in different ways than at present. They should be able to show, for example, how modeling a similar policy with different assumptions can change the outcomes. By this, we mean more than showing several alternatives, as the socioeconomic staff do now. Rather, we mean modeling a single alternative policy in different ways. To follow up the example given earlier, the staff might assume in one model run that fiscal expenditures are paid for by a tax increase, whereas in another run the same expenditures might be assumed to be paid for by a bond sale. The results of these analyses might provide valuable information about which financing method is preferable. Specifically, the socioeconomic staff could assume that there are two ways to control, say, emissions from gaseous combustion engines. One option is to impose a large sales tax on the purchase of these engines. This will, in turn, affect the demand for these engines. To model the economic impacts of this option, the staff would use specific REMI policy variables that allow the user to change the demand for the products of selected industries. The second option is to require certain modifications of the combustion engine that will lead to fewer emissions. This will affect the cost of producing these engines. To model this option, the staff would use REMI policy variables that allow the user to change the cost of production for selected industries. The socioeconomic staff could then use the results of these two simulations to decide which option is preferable.

We know from our discussions with the socioeconomic staff that they do some of this currently, but they tend to present only the results from what they consider to be the preferred choice. We recommend that they identify the opportunities available to the public and the District administration and let them decide which is preferable. Even within a single industry, different firms often respond to similar economic challenges in very different ways, depending on their particular competitive strategies. A more thorough portrayal of different options could be informative to firms, individuals, and local governments trying to decide how to comply with rules and regulations.

Sensitivity Analyses

We recommend that the socioeconomic staff examine more carefully than they presently do how their results may be influenced by relatively minor changes in key model parameters and assumptions, including the following:

1. Data error analyses. Because data sources are often unreliable, the staff need to show how data errors are likely to affect the analyses.

2. Significant variable determination. They need to indicate which variables are most important in influencing the costs and benefits of a given proposal, because this might prove useful in reforming policy.

3. Timing of economic impacts. They need to show what effect different timing of economic impacts has on determining the success or failure of a policy.

In each case, we recommend that the staff conduct various forms of sensitivity analyses, whereby they test the model results for stability over some predetermined range of values for the input variables.[6] What we are suggesting is that the socioeconomic staff can use the REMI model more creatively than they currently do. Because this would be a major change in the way the socioeconomic staff currently conduct their analyses, they must be given more time and/or staff to do their analyses. In addition, we recommend that they use their analyses to test alternative ideas, rather than principally examining the costs of a proposed policy *ex post*. We also recommend a number of minor changes.

The socioeconomic staff can significantly improve the way they describe the ethnic and racial distribution of economic impacts in the reports. First,

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[6] We have performed selected sensitivity tests for Rule 1135, which we present in Appendix I.

they usually conclude that most job impacts will be among whites. They, for example, provide identical racial distribution of job impacts (56 percent white, 29 percent Hispanic, 8 percent Asian, and 7 percent black) for Rule 1135A, Rule 1142, Rule 1146.1, and Rule 1171. We should expect this conclusion, given that whites hold most jobs and that the socioeconomic staff usually use existing census data to determine racial impacts. The issue is whether job impacts are distributed in a manner that is consistent with the ethnic or racial distribution of the affected workforce.

Second, the District staff frequently (such as for Rule 1135A, Rule 1142, Rule 1146.1, and Rule 1171) assume that the racial composition of jobs gained and lost is the same as for the general population. The assumption here is that "virtually all sectors in the economy are affected." Even if this is true, however, it does not necessarily follow that jobs will be gained and lost by all racial groups proportionally. Different industries often have very different racial compositions, and the various sectors of the economy rarely gain or lose jobs in a similar fashion. Together, these features imply that job losses and/or gains may have strong racial biases, even if all sectors of the economy are affected. The staff tend to use racial job impacts as a proxy for social impacts, but social impacts may include many other types of effects as well.[7]

Fulton and Grimes' Adjustments to the REMI Model

The socioeconomic staff do not use the REMI model in its "pure" form. Rather, they use a version that is modified by Fulton and Grimes, two

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[7] The socioeconomic staff have indicated to us that they are attempting to improve both the data and the methods used to conduct this part of their analyses.

researchers from the University of Michigan. This "F&G REMI," as we shall refer to it, differs from the standard REMI model, mainly in that the control forecasts for the years 2000 and 2010 have been modified.

Rationale for F&G Adjustments

Fulton and Grimes were selected by the District to make adjustments to the base-line employment and population forecasts in REMI, so that the control forecasts used by the socioeconomic staff are consistent with those used by the Southern California Association of Governments (SCAG). According to the California Health and Safety Code, Article 5, Section 40460, SCAG and the District are to generate cooperatively the ambient air-quality plan for the region. According to the statute, SCAG

> shall have responsibility for preparing and approving the portions of the plan relating to regional demographic projections and integrated regional land-use, housing, employment, and transportation programs, measures, and strategies (Section b).

The District is to prepare and analyze

> sections of the plan elements relating to existing air-quality, emissions data, results of air-quality modeling, and stationary source control measures. The south coast district shall combine its portion of the plan with those prepared by the Southern California Association of Governments (Section c).

Based upon this statute, the District has decided that in their socioeconomic reports, they must adjust their own population and employment baseline data and forecasts to match SCAG's. The biggest inconsistency comes from the fact that SCAG and the socioeconomic staff (through use of the REMI model) use employment data from different federal government agencies (the U.S. Bureau of Labor Statistics and the U.S. Bureau of Economic Analysis, respectively), each of which has its own employment data sources. In addition, SCAG uses a shift-share method for its forecasts while the District uses the multiregional econometric model, REMI; consequently, even if the data were identical, the forecasts might differ because of the different methods used by the two agencies.

We raise two points about the District's way of responding to the statute. First, we believe that the District could get the statute changed if they deemed it appropriate to use a different set of projections. Second, if the District decides to continue to adjust the REMI forecasts, the staff must decide the degree to which the two sets of estimates must be made consistent. We will leave to the District's legal staff and administration the decision as to whether the District is legally required to replicate SCAG's forecasts and to what degree the estimates must be "consistent."

Issues with F&G Adjustments

As implied by the above comments, the task Fulton and Grimes were given was not well-designed. They did a reasonable job of fulfilling the task. We focus on two main questions about the F&G adjustments. First, do they maintain the integrity of the forecasts generated by REMI? Second, are the adjustments made appropriately--that is, do they result in making the REMI forecasts consistent with SCAG figures? We summarize here the more detailed findings reported in Appendix I.

1. Integrity of forecasts. In order to maintain the integrity of the model, Fulton and Grimes make their adjustments mainly by modifying the data files in the model. Their first round of changes brings the REMI control forecast within about 66 percent of the SCAG estimates (Fulton and Grimes, 1991, pp. 7-8). They then make another two sets of adjustments to the REMI model to eliminate most of the remaining discrepancy. For these latter two

adjustments, they do modify the equations in the model, thus affecting the model. (Refer to Appendix I for details.)

As expected, because of differences in the BLS and BEA data bases, when we tested the two models, we found that the forecasts of total job impacts obtained from the original REMI model and the F&G REMI model show major differences. The differences are significant for the early years of the forecast, but for later years, the differences are in a more reasonable range for overall planning purposes. For individual sectors, especially for the nonmanufacturing sectors, however, the differences are relatively large in all years, and this may create issues for particular industries affected by a given rule.

The REMI and the SCAG forecasts are based initially on different data sources and forecasting methods (refer to Appendix I for details). The real issue, nevertheless, is that, even if the socioeconomic staff make the control forecasts agree with SCAG figures through the adjustment process, the simulation forecasts will not be consistent. This inconsistency occurs because the parameters of REMI's internal equations are estimated using a different data definition than that used by SCAG, and these parameter estimates are not changed by the F&G adjustment. Thus, the task assigned to Fulton and Grimes, namely, to adjust the control forecast, (partially) achieves the important purpose of maintaining the integrity of the original REMI model, but the District's forecasted results are still not consistent with SCAG's. We propose three options below for dealing with these issues.

2. **Appropriateness of adjustments.** Recognizing that Fulton and Grimes were assigned a poorly designed task, we recommend the following three short-

term improvements that they could make to their adjustments (refer to Appendix I):

a. Provide additional documentation as to the rationale for use of particular values they use in their adjustments.

b. Give the criteria they used in selecting the values for all of their adjustments.

c. Continue to try to develop separate adjustment factors for each of the four counties for the self-employed persons. (We understand that the adjustments that they tried to make for the 1989 version of the F&G REMI model did not seem reasonable to them).

In addition, some long-term improvements are needed. After extensive consultations with Fulton, Grimes, Treyz, and the socioeconomic staff, we recommend consideration of three options:

1. The District should review their interpretation of the law to determine what exactly their responsibility is: If they determine that they do not need to have similar population and employment forecasts, they may decide to use the original REMI model without any adjustments.[8]

2. Using their own knowledge of the subject and our analysis in Appendix I, the socioeconomic staff should decide whether the SCAG or the REMI data base best suits their needs over the long term. If they decide to employ SCAG's, and if they continue to use REMI, they should negotiate with the vendor for a modified version of the REMI model using the BLS data. Given the expense of this option, a less-expensive alternative for adjusting to BLS data would be for the socioeconomic staff to request that only the FPD adjustments be made to the original REMI model. The FPD adjustment does not alter the historical data files therefore, it may be a less desirable alternative than using BLS data throughout.

3. Based upon our analysis in Appendix I, the socioeconomic staff could decide that they should continue to use the F&G model, with all the adjustments that are currently made. If this is the

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[8]In their report to the socioeconomic staff (Fulton and Grimes, 1991, p. 22), Fulton and Grimes state that "in many areas, particularly manufacturing, it is our judgement that the REMI forecast is more credible [than SCAG's]."

decision, many of the issues we raise in Appendix I will have to be considered.

We strongly support efforts by SCAG and the District to adopt consistent analysis methods and data sources. Furthermore, we recommend in a later section of this report, entitled "Cooperation with Groups Outside the District Administration," that the two agencies should increase their cooperation, especially as the District moves into nontraditional areas of pollution regulation that have a strong potential to affect SCAG's land-use and other planning roles. The development of consistent analysis methods, however, requires a more serious and long-term commitment than the current adjustment process. Toward this end, we strongly recommend that the District and SCAG set up a permanent working group to obtain more consistent methods by the two agencies on all their work, not just on this particular issue.

Other Adjustments to REMI

Regardless of whether or not the socioeconomic staff use REMI or the F&G REMI, the base of any of the calculations that they presently conduct is the original REMI model. We have several recommendations concerning that model.

First, the REMI staff currently produce the regional input-output data in the model by "regionalizing" a national 53-sector table, which is aggregated from a U.S. 466-sector table. They, therefore, implicitly assume that technologies do not vary from region to region at the 53-sector level. Although "technologies" may not vary significantly from region to region for detailed sectors, represented by the larger table, we believe that they do vary at the 53-sector level because of the different mix of output produced in each region and different regional prices (Polenske, 1980). We therefore recommend that the regionalization be done to the larger, rather than the smaller, table. The vendor should then aggregate the regionalized 466-sector table to a less-aggregated level.

Second, we recommend that the vendor consider ways in which more detail can be provided for specific sectors that are especially prone to be affected by the District's air-pollution rules and regulations. To say, for example, that 60 workers in the Electronic & Other Electronic Equipment sector are affected by a given rule is not nearly as helpful as to say that 60 workers in Household Appliances (a subsector of Electronic & Other Electronic Equipment) are affected. The socioeconomic staff may want to ask for additional sectoral detail in the REMI model that is provided to them, or they may want to do studies of specific subsectors of the 53-sector model.

Third, in REMI, there are 49 tables from which the user can print results. We recommend that the vendor should suggest to users which tables are particularly informative for different types of analysis. This will save the user considerable time in selecting and printing appropriate tables.

Fourth, the vendor has made significant improvements since the mid-1980s in the quality of the documentation of the model. Even so, additional work is needed to improve the documentation still more. It is a complex model, and we found many cases in which the specifics of the variables used and the rationale for particular specification of the equations was incomplete. Refer to Appendix I for additional details.

Fifth, the vendor and the socioeconomic staff should consider whether some of the estimates can be provided with additional geographic detail, such as by zip code or census tract, as direct output from the model. An alternative is for the socioeconomic staff to disaggregate the final estimates through proxies. In either case, the staff probably need additional detail for use in geographic information systems and other place-specific models.

The modifications would impose additional costs on the socioeconomic staff in terms of increasing the time required to run a model with a larger data base, augmenting the number of results they need to review, and requiring them to present more data in an understandable way. We believe, however, that all interested parties will find the additional data useful.

Quantification of Analyses

One of the greatest difficulties in conducting socioeconomic analyses of environmental policies is that so many of the economic and environmental impacts are difficult to measure or to assign a numeric value. Methods do exist to quantify items such as health, visibility, and various environmental quality changes. These are reviewed in Appendix III. Still, they are laden with difficulties. These items are rarely marketed. Furthermore, the synergistic nature of environmental systems often makes it impossible to isolate the effects, and many of the relationships between environmental quality and human activities are uncertain or poorly understood. Finally, people's valuation of environmental quality is often inconsistent, failing to meet neoclassical economists' assumptions of consumer rationality. Overall, different analysts' estimates of environmental quality impacts may vary by several orders of magnitude, even when they all use similar methods to make the estimates. In many instances, the expected errors are large relative to the estimated effect.

To handle such poorly quantified socioeconomic impacts, an analyst must first recognize them as such. In the AQMP, for instance, the District staff carefully classify economic impacts into either quantifiable or nonquantifiable categories. This is a good start, and we recommend that the socioeconomic staff use this system more than they have in the past in evaluating rules and regulations. We recommend going even further. For their analyses, the socioeconomic staff should use quantitative methods only as one of several types of analytical tools. Often, they will be able to describe qualitatively important economic impacts on the environmental system and give a general sense of how serious these are, even when exact, reliable numbers cannot be attached to the economic impacts. We strongly recommend that the staff make more extensive use of such qualitative analyses in their reports.

Currently, the socioeconomic staff's estimates of health benefits accruing to improved air quality rely heavily on the research of Hall, et al. (1989). Not surprisingly, the results of this research have been highly controversial. We have reviewed the Hall research carefully. Our review can be found in Appendix III.1. We conclude that, in general, the study does not overestimate the value of pollution control--although it may not assign "accurate" costs to any one variable. The research is based on an extensive review of epidemiological and clinical studies, economic-valuation methodologies, and South Coast ambient-air data bases for six criteria pollutants. Their work is well-documented and attempts, in a complex situation with wide ranges in valuation results, to find a middle ground. The authors correctly acknowledge that benefits estimates are incomplete and conservative. Although critics have some valid questions about the Hall study (Harrison and Nichols, 1990), the Hall research provides illuminating information about human exposure to pollution and about the distribution of health costs across segments of the population (Brajer and Hall, 1991). In the end, the debate surrounding the Hall study illustrates more about the uncertainties and complexities of the issue than about the strengths or weaknesses of the research.

Presentation and Interpretation of Results

The usefulness of modeling is as much determined by how the results are presented and interpreted as by how accurate the model is. In general, the socioeconomic staff do a very good job of presentation. They are especially good at summarizing important points succinctly. They also use graphics very effectively. Many of the decisions they must make regarding presentation are very difficult. As an example, because REMI is so flexible, the REMI user can obtain output either as aggregate figures or as differences from the control forecast. This can become extremely confusing, especially when results are given as percentages or when the analyst is comparing the numbers to some alternative other than the base forecast. Generally speaking, the socioeconomic staff are sensitive to how confusing this can be for the reader and present the numbers well. There are several places, however, where we believe the socioeconomic staff need to be more precise in their descriptions.

Multiplier Effects

When discussing primary and secondary economic impacts, the socioeconomic staff need to differentiate between direct (first-round), indirect (second-round and higher), and induced (those due to additional rounds of household spending) economic impacts. In most cases, the staff equate "primary" economic impacts with direct spending. They usually equate "secondary" economic impacts to indirect and induced spending; however, it is not always clear if and how household spending is included. Although regional analysts have not been consistent in their use of multiplier terminology for these various effects (Polenske, 1982), we recommend that the socioeconomic staff adopt a standard set of definitions for multipliers and use them throughout their reports.

Transfers Between Groups Versus Changes in Total Economic Activity

Another area where the socioeconomic staff need to be more technically precise is in differentiating between real changes in total economic activity and transfers between members of society. In general, if the user obtains figures as a difference from the control forecast, REMI's figures give real changes in economic activity. "Direct" or "primary" costs, however, may just be transfers between individuals in the four-county area served by the District.

Likewise, the economic impacts that they calculate with REMI may not be actual economic costs to residents of the region, but may be transfers with other residents elsewhere in California or the United States. We realize that the District's main concern is for the residents of the South Coast; however, we are concerned that the socioeconomic staff omit economic benefits and costs occurring outside the four-county area as a result of the District's policies. As an example, a great deal of Southern California's electricity is generated outside the basin, so that policies that call for greater reliance on electricity are bound to have significant economic and environmental effects elsewhere. Also, the vast majority of toxic wastes generated by stack controls in the basin are exported either to other regions in California or out-of-state. Yet, the socioeconomic staff never mention this in their socioeconomic reports. We recommend that they acknowledge as precisely as possible the potential impact of the rules and regulations on regions other than the South Coast.

Size of Economic Impacts

The precision of the REMI model can be misleading at times. A number of the District's rules have relatively small economic impacts, in terms of outputs, jobs, or income decreases or increases. In 6 out of the 14 rules we reviewed for which the socioeconomic staff used REMI to estimate job impacts, the estimated employment impacts were fewer than 50 jobs lost or gained annually, relative to the control forecast. In such cases, the staff may forecast economic impacts that are small relative to the expected error of the model. This is especially true when they must forecast five to ten years into the future and those future impacts tend to be even smaller than the current ones. Consequently, the staff present results that make the estimates appear to be more significant statistically than they really are. We recommend that they set some minimum economic impact below which the results would be considered as being too unreliable to use. In the case of jobs, for example, the socioeconomic staff might disregard employment impacts less than some set percentage of either the control forecast or the total industry employment in the initial period.

Closely related, the socioeconomic staff tend to rely heavily on the number of jobs lost (gained) rather than on these numbers relative to some benchmark. We recommend that the socioeconomic staff give more attention to relative economic impacts than they currently do. First, they need to indicate what percentage the estimated job impacts are relative to total employment in the industry. Second, they should also show the economic impacts relative to some alternative policy options, in terms of both number and percentage changes. Third, when the estimated job impact number is extremely small, they should use the number as an indication of scale of impacts, rather than interpret it literally as the exact number of jobs lost or gained.

Another factor in determining the size of estimated impacts is the choice of a control forecast against which the future is compared. In keeping with standards of the California Environmental Quality Act (CEQA), the socioeconomic staff compare all simulations against an alternative in which no policy change is assumed. We can provide two different interpretations of this. In one case, "no-policy change" means using whatever policy is currently in place; in the other case, "no-policy change" means the absence of any policy. The District's legal staff have determined that the "no-policy change" or "no-project change" alternative must refer to whatever policy is currently in place. From a technical standpoint, this is the correct procedure, since prior policy decisions have already been made and are not the subject of debate. Nevertheless, this procedure tends to give lower economic-impact estimates than would be obtained otherwise, because it does not account for cumulative economic impacts of the series of rules and regulations on individual firms. We recommend that the socioeconomic staff take account of the cumulative impacts or, at a minimum, that they should clearly explain what the basis of comparison is in their reports.

Quality of Jobs Affected

The socioeconomic staff need to be more careful than at present in distinguishing the quality of jobs affected. Unfortunately, economic analysts frequently neglect to do this. Yet, the person getting a job cares whether it is only a temporary, part-time, low-paying, or nonunion one. The United States has had much faster job creation in the past decade than most other advanced industrial nations. According to Harrison and Bluestone (1988), real income has failed to grow and income distribution has become worse, in large part due to the fact that so many of the new jobs created are lower-quality jobs than the jobs being destroyed. We recommend that the socioeconomic staff indicate in detail the types of jobs being lost (gained).

Presentation and Interpretation

Many of the areas where we believe presentation and interpretation could be improved are not serious issues, but they still need attention. We have the following specific recommendations.

1. Standardize measures. We often found it difficult to identify the precise time frame or population to which the economic impacts applied. In some cases, for instance, employment impacts were presented as a total over the entire study period; in other cases, they were given as average jobs per year; and, in yet other cases, they were given as jobs per year--but not averaged over the study period. This occurs, for example, for Rule 1151, Motor Vehicles and Mobile Equipment Nonassembly Line Coating Operations. We recommend that the measures be standardized to the extent possible, perhaps as average jobs per year. This is especially important if the user wishes to make comparisons across rules or measure cumulative economic impacts. We realize that there are times when the staff will find it desirable to break from the standard, for instance if there is a very uneven distribution of job

impacts over time. The standard need not apply each time, but should be a default that is always provided to allow for comparison among reports.

2. Provide time period. Where average job impacts are used, the staff need to be extremely clear regarding what time period is used. Otherwise, the interpretation becomes confusing, and future reviews will become more difficult, because the study period for reports will not always end in 2010 as they do presently.

3. Place results in context. We also recommend placing the units used in presenting figures in some context. We were especially impressed with the methods used by the BAAQMD in their reports. When discussing output changes, for instance, they always gave them as a percentage of the industry's normal output. Likewise, income changes were given as a percentage of annual family, household, or personal income. Fiscal impacts were usually translated into dollars per capita, and costs to employees (for commuting, etc.) were usually given as dollars per worker per year. These all help to make the figures more easily understood.

4. Show distribution of economic impacts. In its Air Quality Plan, the BAAQMD staff provides an extended discussion of how the distribution of both policies and economic impacts over time can be very important. In key instances, such as transportation planning, they conclude that timing is critical, which covers the following factors.

a. Economic-impact timing. By using REMI, the socioeconomic staff actually have a much greater ability than their Bay Area counterparts to forecast the timing of economic impacts. Yet, they rarely discuss the importance of timing to policy. We believe they would benefit from considering these timing issues more carefully.

In the BAAQMD socioeconomic analysis of the 1991 Clean Air Plan, for example, the BAAQMD staff examine possible implications of changing the timing of proposed market-based incentives. The analysts conclude that, if these measures are implemented before transportation improvements are made, transportation costs to workers will increase significantly, making it difficult for local businesses to recruit high-quality labor. In other words, inopportune timing of the regulation would significantly constrain the ability of local businesses to expand. This poorly timed rule would also result in costs being imposed more on poor commuters than on richer ones (BAAQMD, 1991, p. 72).

b. Discount rates. To our knowledge, none of the air districts actually discount future benefits and costs. Because they are not attempting to conduct actual benefit-cost analysis and sum dollar figures over time, this is probably not a serious problem, and it prevents policy makers from becoming distracted by technical issues, such as what the appropriate discount rate is. Still, to the extent that they make intertemporal comparisons of the dollar value of output, we recommend that the socioeconomic staff take some account for the time preference of money. In general, we recommend placing all economic impacts that are far into the future in some context of what the economy is expected to look like at that time.

5. Mix of qualitative and quantitative analyses. One of the difficult presentation tasks the socioeconomic staff has is to mix the results from qualitative and quantitative analyses. We recommend that they follow the practice of the BAAQMD staff and incorporate in the District's socioeconomic report a classification of economic impacts by categories in order to describe the degree to which the economic impacts are quantified. In their report on

the local Clean Air Plan, the BAAQMD staff, for example, present a chart in which economic impacts are broken down by rule and by affected party. For nonquantifiable economic impacts, they replace numbers by a simple, but effective, system of pluses and minuses. Under this schema, they indicate a strongly beneficial economic impact by (+++), whereas they show a weak positive economic impact by (+), and vice-versa with costs. In the text, they then substantiate each economic impact by a more thorough explanation.

Accountability of Staff for Results Presented

In order for socioeconomic reports to be useful, the people using them must have confidence in their results. In part, this means using a technically sound model; however, it also means that the analysts conducting the studies must be accountable for their results.

Explanation and Justification of Assumptions

An analyst must be able to explain and justify the assumptions used in any particular analysis. This explanation should be as readily accessible as the socioeconomic report itself. Currently, the staff includes most discussion of the underlying economic assumptions in appendices to the socioeconomic report. They give a brief description of the REMI model and its major assumptions, followed by a description of the modeling assumptions used for the specific rule in question. By and large, this approach is fine, and represents a significant improvement over earlier approaches, where they often did not explain important underlying economic assumptions. The use of appendices is particularly appropriate for highly technical discussions that might confuse the basic issues, or where the economic assumptions make little substantive difference to the analysis. In cases where the assumptions are important and may influence the reader's interpretation of results, however, we recommend repeating them in the body of the report. To make it more obvious which assumptions are important, we also recommend that the discussions include a description of the alternative assumptions that were not used, why they were rejected, and how they might have altered the results.

Reproduction of Results by Others

A second requirement to ensure credibility in the socioeconomic analyses is that they be reproducible by others, even years after the initial analysis was completed. Currently, the socioeconomic staff do not use standardized procedures for documenting and archiving their analyses. This means that the integrity of data is left to the discretion of individual analysts. We strongly recommend that they institute a standardized data-base management system and that the staff document their work very carefully, describing exactly which variables were adjusted, how they were changed, which version of the model was used, etc.

1. Data-base management system. In Appendix IV, we describe a prototype database-management system that could be used, although it would require refinement to be implemented. There are several components to this system, many of which seem dull and uninteresting, but which are critical.

a. **Establish audit trail.** First, the socioeconomic staff need to establish and maintain an audit trail of their work. In essence, this means keeping a record of every time a REMI variable is changed from the control forecast values.

b. **Develop a standardized file structure.** In addition, they should have a standardized file structure for archiving model runs and other materials. They also should provide for some redundancy in the archiving by retaining paper copies of final model results or, at least, duplicate disk copies stored in another location.

2. <u>Storage of material and other issues</u>. Of course, model runs are only one part of any analysis and are likely to be augmented by many other types of materials. Currently, this includes spreadsheet files and text. In the future, it could mean many other types of material as well.

a. **Storage of material.** The socioeconomic staff need to give serious attention to the very real challenge of how to store these materials in a manner whereby they are meaningful to people examining the records several years later. There is no simple rule here. To the extent possible, the staff should place records in machine-readable form, because these can more easily be transferred between different media and software programs. Storing information on disk also reduces the volume of material needed, making it more feasible to keep duplicates.

b. **Usage of standard data protocols.** Where possible, we recommend use of standardized data protocols, such as the American Standard Code for Information Interchange (ASCII).

Thus far, we have focused our attention on technical and procedural issues that influence the quality of the District staff's socioeconomic reports. Some of these items are mundane, but they are important. We believe that unless the District staff maintains a high level of competence in such technical matters, the public and District administration cannot have confidence in their reports, and there is no point in discussing more engaging matters. Although we have made many recommendations for improvements, we have found the socioeconomic staff to be competent. Having established this competence, let us now proceed to consider more substantive topics, such as what is actually contained in the socioeconomic reports, what additional information is needed, and how to improve the current system where necessary.

TOWARD A MORE FLEXIBLE METHOD OF ANALYSIS

The District's socioeconomic analyses are technically sound in most areas. Many of the criticisms we have made so far are relatively minor and regard subjects with which informed people might disagree. Nevertheless, we believe that the District's socioeconomic analyses could be significantly improved. The greatest problems are not technical, but substantive and institutional. Even though the socioeconomic reports generated by the socioeconomic staff compare favorably with those of their peers in similar agencies, they often fail to provide the types of information most needed by District administrators and the public. As a result, those individuals designing new rules are unnecessarily handicapped in their effort to create rules that can be fully implemented in a timely fashion. Likewise, members of the public are needlessly impaired in their ability to comply with the law. In any case, the socioeconomic reporting process fails to contribute its utmost to the District's primary goal of improving air quality in the South Coast.

In the following sections, we describe the types of information most needed in order to support air-quality improvements in the District. This leads us to the conclusion that the socioeconomic staff need to expand their current analyses into new areas. These include impacts of regulation on product quality; future technological change; and nonindustry groups, especially consumers, local government, and communities. Within the areas they already consider, the socioeconomic staff need to make more detailed estimates of the economic impacts of regulation than they presently do. Most important, they need to evaluate the benefits and cumulative economic impacts of the District rules and regulations much more thoroughly. Finally, the staff need to plan ahead to determine what their reporting needs will be in five or more years--something that they seem not to do at present.

Given the considerable complexity of the information needed by the District and the changing regulatory environment in which they operate, we believe that the key to creating improved socioeconomic reports is to create a more flexible method of analysis. "Flexibility," in this case, means the ability to ask different questions as needed and the ability to identify and gain access to different resources needed to answer those questions. This flexibility does not come primarily from using a new model or better computer tools, although acquiring a bigger "toolbox" is certainly part of the process. The greatest contributions to improving flexibility in the reporting process must come from fundamental institutional changes, including how the socioeconomic staff use the tools available, how departments within the District relate to one another, and how the District as a whole relates to the outside world.

Our flexible alternative meets three important criteria that we believe the District would be wise to consider in any alternative it may follow.

<u>Criterion 1. Promote Improvement of Air Quality</u>

First, and foremost, socioeconomic analysts must actively promote the District's goals of improving air quality. Socioeconomic analyses are not just bureaucratic requirements that must be fulfilled. Throughout this report we show that, although recording economic benefits and costs is important, socioeconomic analysts can make other, more positive, contributions to improving environmental quality. Some of them are nontraditional roles, such as identifying

- parties especially vulnerable to job or income impacts of regulation due to their specific position in a rapidly changing regional economy.
- compliance opportunities and strategies for those businesses and individuals who have the hardest time satisfying the law.
- means of keeping decision makers and the general public well informed about the ways they may be affected by different rules and regulations.
- mitigation strategies that will not hinder, and may even promote, economic development.

Criterion 2. Improve Capacity to Analyze Complex Problems

In order to contribute to improving air quality, socioeconomic analysts must meet a second criterion: they must be capable of analyzing highly complex problems. The severe air-quality problems of Los Angeles and its surrounding regions affect millions of people in very different ways. The socioeconomic staff have a difficult task to provide even a partial picture of these impacts that is accurate. One major problem for the District is to determine which economic impacts of air-pollution rules and regulations have the greatest potential to help or hinder its cleanup effort at any given time. In some cases, progress may be impeded by the high costs of control equipment to local firms, inequitable distributional impacts, or fiscal costs to local government. In other cases, the clean-air effort may assist local firms by encouraging potential efficiency gains from technology improvements or by creating opportunities for new entrepreneurial activity. In still other cases, the multiplicity of rules in effect may even work at cross purposes. What is clear is that socioeconomic analyses cannot become a routine. Many effects cannot easily be captured using a rule-by-rule approach at all and require either a cumulative study of the economic impacts and/or separate (often ongoing) studies of important quantitative and qualitative issues. Similarly, some of the economic assessments that are most important may not even focus on the rules themselves, but on obtaining a better understanding of the economic and social environment in which the District operates.

Criterion 3. Operate Effectively in a Rapidly Changing Environment

The complexity of the socioeconomic impacts of pollution controls would make analyses difficult to undertake under any condition, but the socioeconomic analysts must also be able to operate within an environment that is rapidly changing. These changes include political, economic, legal, and organizational shifts, as well as an evolution in the District's own policy objectives and talents. We indicate here only five of the most important current changes to which the District staff have been asked to respond:

1. Recently, several new laws, including Senate Bill 1928 and Assembly Bill 2061, have been passed that direct the District to conduct enhanced socioeconomic analyses and to take careful account of what its policies mean to small businesses and underrepresented members of the community.

2. The South Coast region has faced deteriorating economic conditions formerly unheard of for that region--actually posting a net decline in economic output in 1991. The current situation is not caused just by business-cycle activity that can be expected to improve if the District only waits long enough. Local producers today are faced with much greater domestic and international competition than previously. This has encouraged a major restructuring of local industry, causing major shifts in industrial composition, the geographical distribution of jobs, and in income distribution. From the perspective of the worker, jobs have become less stable than in the past, and real wages for most workers have failed to increase in over a decade.

3. In part because of the weak economy, the District's efforts have come under unprecedented public scrutiny. First, the public wants a greater say in rulemaking. Second, even with the strong national mandate from the 1990 Clean Air Act, the public expects the District staff to justify the costs of the air-pollution effort more thoroughly than in the past.

4. Realizing the difficulties of reducing pollution by traditional controls, the District staff have moved into considering possible new areas of regulation, including marketable permits and broad-based controls, such as Regulation XV, with important implications for land-use and traffic patterns.

5. The socioeconomic staff have increased in size and talent. It may seem odd to place this in the same category as the other changes listed; however, as their capabilities expand, the staff are frequently their own strongest critics and greatest source for new ideas. One of the greatest challenges before the District administration is how to encourage and integrate these new ideas into their program for socioeconomic analyses while maintaining a smooth operation.

These are the three criteria that we believe are most important for the District's socioeconomic assessment efforts to be successful. The District staff must account for such tremendous complexity and rapid change and still keep the goal of improving air quality as its number one priority. We now describe the types of information most needed from socioeconomic analyses and how these informational needs demand that the socioeconomic staff alter the way they operate.

INFORMATIONAL DEMANDS ON THE SOCIOECONOMIC REPORTING PROCESS

District administrators require information that can help them design rules that are legal, can be implemented fully, and can take effect as quickly as feasible. Socioeconomic analyses can promote these objectives in several ways. First, such analyses can help administrators minimize the costs and maximize the benefits of proposed rules, making it easier to maintain political support for aggressive and continuing air-quality improvements.

Second, analyses can provide information that can help administrators create rules that the public perceive to be fair; consequently, they are less likely to be delayed or even overturned in court. Finally, and most overlooked, socioeconomic analyses can improve the possibility that rules will be fully implemented by providing information that can be used to restructure rules so that they are easier to comply with, and by providing the regulated community information on their compliance alternatives.

Accounting for Aggregate Benefits and Costs

Over the long-term, air-pollution policies are determined, at least in part, by public opinion. Members of the public require information to make informed political choices concerning whether or not to support proposed environmental policies.[9] For this reason, one important task of a socioeconomic analysis is to provide an accounting of the aggregate benefits and costs of air pollution control. Historically, many economists have assumed that formal benefit-cost analysis was an inherently superior way to portray such information (Krupnick and Portney, 1991). Above, we explained why we believe the socioeconomic staff made a good choice when they decided not to use benefit-cost analysis as a decision tool. This does not detract from the desirability of having a consistent accounting framework in which benefits and costs can be described. Such an accounting method, however, must explicitly recognize areas where estimates are unreliable or unavailable. In

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[9] Many of these policies, such as the 1990 Clean Air Act (42 U.S.C. 7401 et seq.) and the Polanco small business act that was recently passed by the California state legislature (California Legislature, 1991, SB 2061), are not actually made by the District. In addition, many of the District's rules result from the California Air Resource Board mandates. Because the District is ultimately called upon to implement these policies locally, the public looks to the District for information.

addition, it must facilitate the sort of multiple-objective decision making that is inherent in pollution-control policy.

Distributional Information

Providing information about aggregate benefits and costs of air pollution control, although important to aid the political process, is of much less use to designers of pollution-control policy. To determine whether one policy is preferable over another, policy makers need more detailed information. One area where added detail is especially valuable is in evaluating the distribution of benefits and costs between groups.

Which communities, city governments, or consumer groups are most likely to be hurt by regulation? Are these groups that are already disadvantaged or vulnerable to such changes? A regulation that unnecessarily hurts disadvantaged parties is not only undesirable in its own right, but is also likely to be challenged in court. At best, this results in costly delays in implementing pollution-control policies. At worst, proposed policies may be abandoned altogether or disregarded. It is equally important to understand how the benefits of pollution control are distributed. Even if they have significant net benefits, regulations may be widely ignored if those benefits are viewed as a means of economically favoring a relatively small segment of the population.

In the past, one common response to this compliance issue has been to exempt certain types of businesses from compliance--most notably small firms. Clearly, it is poor environmental policy to make such blanket exemptions without first confirming that those businesses are actually threatened. Policy makers need to be able to identify communities and industries that are likely to carry the greatest burden and that are genuinely endangered. They also need to know what the precise nature of the threat is.

Information that Encourages Compliance

Almost all of the people we interviewed strongly support efforts to clean up the air. What members of the public want to know more than anything else is how they can comply with the District's rules and regulations while simultaneously improving, or at least not reducing, their standard of living. There are several aspects to compliance. First, the public need help navigating the maze of regulations that govern pollution control. This is especially important for firms or individuals who do not have access to resources for monitoring the District's activities.

Second, the public need information concerning how they can fulfill their obligations in the most economically sound fashion. One of the best ways to make the District's policies more effective is to make compliance as easy as possible. Economically healthy firms and communities are most able to afford investment in clean technologies and work practices. To provide this type of information to the public, socioeconomic analysts must recognize that different individuals, governments, organizations, and firms may comply with the law in vastly different ways. These people need to know which options are available for compliance and the conditions under which each is most appropriate.

EXPANDING THE SCOPE OF ANALYSIS

In order to pursue air-quality objectives, both the public and the District administration need detailed information on a large and changing mix of subjects. In the following sections, we critique the job the socioeconomic staff are currently doing at obtaining this information and make suggestions for improvements. To summarize our conclusions: the approach the staff uses today is best described as a partial cost-accounting. They do a relatively good job of estimating direct costs associated with expenditures on pollution control and the indirect and induced costs they generate. They do not, however, provide sufficient detail about the benefits of pollution control or the distribution of impacts. In addition, there are whole categories of impacts that they either deal with in a cursory fashion or not at all.

We note that the socioeconomic staff's coverage of these diverse subjects is comparatively about the same as the coverage in reports of similar agencies elsewhere--and, as we indicated above, in some cases it is better. Using the current state-of-the-art in socioeconomic analysis, the staff cannot provide the information that is most needed. The responsibility for this lack of information lies with many parties: the District staff, legislators, administrators, and other groups, such as the academic and business community and nongovernmental organizations (NGOs).

We believe that the District has the personnel and financial resources to improve the state-of-the-art in socioeconomic analyses and to conduct studies of the very highest standards. If the socioeconomic staff are to use those resources effectively, however, they will need to make serious modifications to the types of analyses conducted. In the following sections, we describe the informational requirements and modifications needed for flexible analysis in more detail, focusing on three substantive areas: (1) types of information collected, (2) analytical tools, and (3) the role of planning.

TYPES OF INFORMATION COLLECTED

The first step in creating flexible analysis is to expand the types of questions asked by the socioeconomic analysts. In 1990, the Public Health and Socioeconomic Task Force recommended that the District move beyond economic-impact analysis to mitigation (SCAQMD, 1990). We agree; we also go further, recommending that the reports should help identify ways the public can reduce pollution economically and even profit from that activity. We also place greater emphasis than the Task Force did on the fact that the analytical needs of the District are changing. Based upon our assessment to date, we recommend the following extensions and expansions of the socioeconomic research:

1. Expand the types of studies conducted to include (a) product quality issues, (b) technology change issues, (c) comparisons of how economic impacts are likely to vary across different sizes and types of firms, (d) occupational, ethnic, race, gender, and class economic impacts; (e) economic impacts on consumers as well as producers; and (f) fiscal effects on business, local and state governments, public agencies, and consumers.

2. Extend current analyses to provide the regulated community with information concerning ways they may comply with the rules and regulations.

3. Include studies of cumulative, as well as rule-by-rule, impacts.

4. Conduct social-impact analyses.

We discuss a few of these suggestions in detail in order to illustrate the wide range of possible analyses that we recommend the socioeconomic staff undertake.

Product Quality and Technology Information

Pollution-control equipment costs are only one type of economic impact that can discourage firms from adopting state-of-the-art pollution-reduction methods or control equipment. The District's socioeconomic reports are less comprehensive than they should be for showing how controls will affect product quality and the effects of changing technology. We recommend that the socioeconomic analysts use industry case studies to consider these issues and to complement their current economic modeling efforts.

Product Quality

Many firms compete as much on quality as on price, and many economists believe that such quality-based competitive strategies will be more common in the future than they have been in the past because of the difficulty U.S. workers have in competing on cost against low-wage foreign labor (Piore and Sable, 1984; Best, 1990, Reich, 1991, Thurow, 1985). From an environmental perspective, these strategies may be particularly important, because firms engaging in quality-based competition are more likely to be able to afford pollution controls than are firms engaged in cutthroat price cutting.

None of the 30 rules we reviewed included an analysis of changes in product quality caused by the proposed rule.[10] In one rule, however, the issue of whether products and the use of a product would be severely restricted or phased out was briefly discussed.[11] In other cases, such as

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[10] We have been told that product-quality changes are occasionally discussed in the reports prepared under environmental impacts reporting requirements of the California Environmental Quality Act. We did not review these as part of our project; however, the economic impacts of product quality changes clearly deserve attention in the socioeconomic reports.

[11] Rule 1410, Hydrogen Fluoride Storage and Use, involved the phaseout of hydrogen fluorides for large users. The only affected facilities were four refineries and one chemical plant. Small users were exempt, but had to comply with strict record-keeping requirements (SCAQMD, 1992).

coatings in the aerospace industry (Rule 1124A, Aerospace Assembly and Component Coating Operations), the staff treated changes in product quality as changes in the cost of doing business. Yet, we learned in our interviews that some members of the regulated community feel that the real effect of the rules was to hurt demand for the product. Specifically, they maintain that the rules on coatings resulted in a product that does not last as long, making it difficult for aerospace firms to meet government standards for coatings' longevity. Because the federal government is a major market for these firms, they felt that this was potentially serious for their businesses. Indeed, under cost-plus contracting, the U.S. Department of Defense has historically been much more sensitive to quality changes than to price changes.

The District's socioeconomic analysts cannot describe many types of product changes using the REMI framework, an input-output model, or any other quantitative model. In these cases, they need to use alternative methods to evaluate the negative and/or positive employment and other economic effects. These alternative methods are needed, because, in many cases, the manner in which an economic impact is measured may determine whether a whole category of costs is adequately incorporated into the analysis. We are not suggesting that all benefits and costs need to be quantified; rather, we are recommending that the socioeconomic staff explain the qualitative aspects of the socioeconomic impacts and how these effects will tend to inflate or depress the estimated net benefits of pollution control.

Technology Changes

A similar set of difficulties is posed by changes in technology. Like changes in product quality, changes in technology have the potential to propel industries along significantly different economic paths than in the past. These technological effects are often impossible to capture as cost changes, yet are becoming increasingly important to consider as the District implements a growing number of technology-forcing rules.[12] A number of the people we interviewed expressed the belief that the District had inadequately considered the economic risks of such rules, particularly the risks associated with the potential failure of a new technology.

In addition, we have not found a sufficient assessment by the socioeconomic staff of the potential economic benefits of new technologies. Ironically, in their current employment-impact estimates, they may be severely underestimating the benefits of pollution control by overlooking this type of analysis. It is commonly recognized, for instance, that part of the success of Japanese automakers in the United States was their early commitment to making fuel-efficient vehicles. As economic analysts, we are not in a position to judge whether the specific technologies the District proposes are realistic; however, we believe that the socioeconomic assessment staff should include more detail than they do at present regarding potential economic risks and benefits of new technologies.

Consideration of Benefits

We recommend that the socioeconomic staff expand their consideration of benefits wherever possible by augmenting the definition of benefits, by enlarging their use of qualitative analysis, and by continuing to fund studies

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[12] These include Rule 1136, Wood Products Coatings, and Rule 1151, Motor Vehicle and Mobile Equipment Nonassembly Line Coating Operations, because finishes with required Volatile Organic Compound limits were unavailable at the time (SCAQMD, 1992).

that can improve benefit quantification. They currently tend to think of benefits strictly in terms of amounts of pollutants reduced even though two alternative strategies for reducing similar amounts of a pollutant may result in very different levels of economic benefits.

Our recommendations for improvements to the benefit estimates should not detract from the otherwise good job the socioeconomic staff has done and continue to do. We believe that they do a better job than many comparable agencies in accounting for the benefits of pollution control. The format used in the Air Quality Management Plan, in which the benefits are separated into quantifiable and nonquantifiable impacts, is a reasonable beginning and should be extended to the analysis of individual rules and regulations. The staff also need to consider the precise nature and distribution of these benefits more carefully, as we will now consider in detail.

Consideration of Distribution of Economic Benefits and Costs

As we have emphasized, policy makers need knowledge of the specific economic benefits and costs of pollution control to design the best policies possible; however, they also need information on their distribution. Just as policies that provide similar pollution reductions may have very different benefit levels, it is also true that policies with similar benefits and costs may have those impacts spread very unevenly. Policies that the public (businesses, consumers, environmentalists, etc.) perceive to be unfair, arbitrary, or capricious can be undermined in an endless number of ways. They can be stalled in the formulation stage; they can be taken to court; and, they can be ignored or avoided, making implementation impossible. In each case, we believe that rules designed to account for distributional issues have a better chance to be implemented quickly, at least cost, and in their entirety than those designed without taking these issues into account.

On the cost side, the socioeconomic staff have typically treated distributional impacts as being synonymous with impacts on specific ethnic or racial groups. Ethnicity and race, of course, are often proxies for vulnerability to economic hardship, because particular ethnic and minority groups are often disadvantaged. Although, they do not correspond precisely, in Los Angeles, both pollution and job loss tend to be concentrated in communities of color; nevertheless, race (and ethnicity) is only one measure of vulnerability. We believe that the more significant issue is whether negative impacts are falling on distinct neighborhoods and population subsets least able to cope with them. The District should know, for instance, both the places and the persons affected by specific rules. Will the job losses from the rules be concentrated in neighborhoods where there already are high unemployment rates, low incomes, and/or where workers have great difficulty being rehired due to low skill levels? Are specific industries or subsectors of industries more threatened by cost increases than others?

Distribution also matters on the benefit side. Clearly, pollution is not evenly distributed throughout the region; consequently, a given reduction in pollution may affect distinct communities differently. In poor communities where access to health care is limited, improvement in air quality may mean much more for increasing the socioeconomic well-being of people than a similar improvement in air quality in a more affluent community. In the past, the District has tended to think in terms of aggregate pollution reductions, without considering where those pollution reductions can do the greatest good. Similarly, some groups in society are much better poised than other to reap the potential new business opportunities of pollution control. The District should know which industries are most likely to benefit from new investment, which groups of workers are most likely to experience increased employment opportunities, etc.

Once again, although the socioeconomic staff compare reasonably well with their peers around the nation, or, for that matter, with the U.S. Environmental Protection Agency (EPA), in incorporating distributional analyses, these are critically important economic-impact aspects of their regulations that need to be considered more systematically than they presently are. One possibility, for example, would be to map exposure levels and a series of indices of economic vulnerability. Various overlays of these maps could then be used to determine the degree to which specific neighborhoods were suffering both from excessive pollution and from any negative economic impacts.

Economic Impacts on Nonindustry Groups

Overall, the socioeconomic staff are best at counting costs that accrue directly to industries being regulated, but they conduct far less complete analyses of other affected groups. For supplier firms, for example, they determine many of the changes (direct, indirect, and induced) in employment and output, where the induced changes in this case are those affecting household expenditures. They do not usually examine the economic impacts on consumers themselves. In cases where utilities were involved, such as Rule 1135 (Emissions of Oxides of Nitrogen from Electric-Power Generating Systems), the socioeconomic staff usually included electricity rate changes; however, this was one of the few consumer impacts regularly considered. Indeed, the socioeconomic staff considered consumer impacts for only 8 out of 30 rules we reviewed, and they made these consumer studies on rules prior to the use of REMI. We found no instance in which they conducted an assessment of control costs on local price levels, even though these are provided as a normal output from REMI. Similar points could be made regarding other groups as well. We found no regular assessment of the economic impact of the rules on local government, on public sector agencies or institutions, on immigrants, on women, or on any other of a large number of groups that conceivably have special needs. In all fairness, many of these economic impacts are probably very small when taken on a rule-by-rule basis, but they may be much more significant when accumulated across the entire set of rules imposed by the District.

Cumulative Versus Rule-by-Rule Assessments

Even when the socioeconomic staff include important nontraditional economic impacts in their assessments, the incremental nature of the rule-development process tends to create socioeconomic reports that may systematically underestimate the full economic effect. Assessments that are made on a rule-by-rule basis fail to capture the important fact that firms, workers, and the general public feel the cumulative effects of many such rules. We find that the District has begun to make progress toward solving this problem by analyzing the cumulative impacts of its rules in the Air Quality Management Plans (AQMP), but these plans are only scheduled to be updated once every three years, and, as far as we can determine, this is the only place where such cumulative impacts are considered. In theory, we could look at the economic impacts in the socioeconomic report for the rule and compare them to the forecasts included in the AQMP. In practice, however, the numbers may not be comparable because the economic impacts of individual rules will not usually sum to the total impact provided in the AQMP.

We recommend that the socioeconomic staff perform cumulative socioeconomic impact assessments on several rules that were adopted within a given time period in order to look at the whole range of rules affecting selected industries for which the cumulative impacts are suspected to be severe. The total job impact of several rules will certainly be larger than those of a single rule. We found the lack of cumulative assessments to be one of the greatest deficiencies with the current method of socioeconomic analysis.

Social-Impact Analyses

One of the greatest deficiencies of socioeconomic impact analyses in the United States to date is that analysts focus almost entirely on economic impacts to the near exclusion of social impacts. The District staff and our own analysis of their work are equally at fault for not giving more priority to the social dimensions of the air-pollution issue (see, also, Hulett, 1989). In our public workshop in April, we learned that this is not the case in all countries. In Canada, for example, social-impact analyses presumably are much more comprehensive than in the United States. We recommend that the District extend its explorations of this field.[13]

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[13] We are grateful to Mr. David Diaz, an urban planner from the University of California at Los Angeles, for his comments on this point during the workshop, although our recommendations do not necessarily reflect his views.

Scope of Questions Asked

Within each expanded area of analysis identified above, there are a series of specific questions that need to be asked more frequently than in the past. These are summarized in Table 1 and in Appendix V, "Guidelines for Socioeconomic Reports," but the list is far from exhaustive. For any particular policy proposal, the relevant questions will vary considerably; consequently, the tools required will also change. There are no preset rules that we can recommend for which tools are most appropriate for which kinds of questions. The socioeconomic staff are well-qualified to answer such technical questions. Econometric modeling will continue to play an important role, and REMI is a very viable candidate for that role. Providing the vendor continues to support REMI, we see no immediate reason to abandon it. At the same time, ongoing reviews of available models are needed because the modeling options are rapidly changing. The socioeconomic analysts should use REMI for tasks where it is most effective, especially forecasting indirect and induced economic impacts, and for accounting for changes in the competitive position of the South Coast industries versus those in other regions, states, or countries that are brought about by recognizable cost changes. For many of the other tasks we have identified, the staff needs to supplement the REMI model with different, but complementary, analytical techniques.

Qualitative Analyses

Most important, we recommend that the socioeconomic staff make greater use than in the past of qualitative analysis. One of the difficult problems of expanding qualitative analysis is how to make the results as credible to

Table 1

SELECTION OF ANALYTICAL QUESTIONS

Issue	Analytical Questions
Consumer impacts	How are general price levels likely to be affected by pollution regulations (especially by their cumulative impacts)?
	In cases where consumers are affected negatively, do these costs accrue mainly to types of spending that constitute a larger share of poor people's income (i.e., are they regressive)?
Distributional impacts	Which populations are most vulnerable to the expected economic impacts?
	What are the relevant dimensions of vulnerability (job loss, income impacts, access to health care, prior state of environmental quality, etc.)?
Fiscal impacts	What are the costs and benefits of regulations accruing to local governments?
	How are these costs and benefits altered by recent patterns of fiscal federalism (decentralization) and privatization of public services?
New business opportunities	What are the entrepreneurial opportunities provided by new technologies of pollution control, and what is required to make them achievable?
	To what extent are apparent new opportunities actually transfers of existing activities?
	How do these new opportunities add or detract from overall regional competitiveness?
Alternatives for compliance	How are compliance alternatives likely to vary by firm size?
	What are the conditions that make one compliance alternative superior to another?
	What resources would most help those firms having difficulty complying?
	What resources are available to help firms make the necessary adjustments?
General tradeoffs	What tradeoffs are implied by the proposed policy?
	How much of one goal must be traded off against another?

the public as numerically based results. In fact, qualitative assessments may become increasingly important if the public becomes more skeptical of "black-box" risk estimates, benefit-cost ratios, estimates of jobs lost or gained, etc. Qualitative analyses often take the form of case studies. A particularly effective case study of the effects of air-pollution regulations on East Los Angeles and Santa Fe Springs was conducted by a group of UCLA students (Arndt, et al., 1991).

The socioeconomic staff should use quantitative analyses from the REMI model and other analytical tools to support and deepen arguments or observations, but they should not use them as the only socioeconomic-analysis tool. Numerical results are not inherently more credible than properly conducted qualitative analyses--they just serve different purposes. If readers of socioeconomic reports are not provided adequate information, it is very easy to give numerical results greater credence than is justified. Models are based on theories, which incorporate important assumptions. Results usually apply to fairly small ranges of values in key variables and parameters. In a period of rapid structural economic change, the socioeconomic staff cannot use econometric models based on historical data to forecast as well as they would in relatively stable times. In fact, REMI probably makes such adjustments better than most models (Cassing and Giarratani, 1990). Even so, we recommend that the socioeconomic staff conduct sensitivity tests. Even if the economy is not changing rapidly, results are not absolute, but only a forecast of what will happen some percentage of the time. Moreover these probabilities are often unknown. Finally, the interpretation of the results depends heavily on the data coverage (as we see in the differences between BLS and BEA employment coverages).

ANALYTICAL TOOLS

Currently, the socioeconomic staff rely almost exclusively on the REMI model for the analyses they conduct, and most of the information they collect for incorporation into the REMI calculations focuses on the pollution-control costs to the businesses being regulated, i.e., the costs of purchasing, operating, and maintaining pollution-control equipment.

We recommend that the socioeconomic staff develop a "toolbox" of quantitative and qualitative analytical tools that they can use for their analyses, including the following:

(1) An econometric model, such as REMI.

(2) Other specialized quantitative economic and physical planning tools, such as land-use, air-dispersion, energy, health, and transportation models.

(3) Other generic tools, including database management systems, spreadsheets, graphics packages, basic statistical analyses, linear programming, and geographical information systems.

(4) Qualitative methods of analysis, such as case studies, sample surveys, and interviews.

Among the quantitative tools, the socioeconomic staff will not find one, or even several, socioeconomic models that do everything they want, because their needs are so diverse and are constantly evolving. They cannot even use a model as sophisticated as REMI to answer all their questions. Although we assume they will continue to use REMI for some of their analyses, overcommitment to a single model can discourage the type of innovative questioning that is absolutely critical. The socioeconomic staff must be able to recognize and adjust to the deficiencies of any particular analytical method for a specific need.

This will be especially important for nontraditional rules, such as the Regional Clean Air Incentive Market (RECLAIM) program and New Source Review. In the case of the RECLAIM program, for example, the District staff need some way of modeling the potential market for tradeable permits to determine who will buy and sell pollution rights, before any detailed economic forecasting can be done. The District, in fact, has already begun such an effort. In the case of the New Source Review, the economic impacts of pollution control may be imposed on industries or sectors of industries that do not yet exist; consequently, the results of the analyses made with an econometric model like REMI may not incorporate these effects.[14]

The answer is not to abandon economic modeling, but to concentrate on developing a new analytical "environment" in which analysts are capable of answering varied types of questions and responding to change. As we suggest above, within this new environment, we envision a style of analysis that we can refer to as being highly "flexible," combining different tools in different ways as needed to answer specific questions.

The approach we advocate is a logical outgrowth of recent trends in the field of regional socioeconomic modeling, described in Appendix II; however, we should contrast the "flexible" approach that we are advocating with the idea of "integrated modeling." In practice, integrated modeling tries to bring the capabilities of many different models into a single modeling structure. We believe there are several important weaknesses of this approach. First, integration into a single framework tends to require that data meet very specific format requirements. This can prove limiting and

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[14] We are grateful to the California Energy Commission for their very thoughtful comments on this issue, although our recommendations do not necessarily reflect their views.

inflexible, making it difficult for users to move data between the integrated model and other software tools. In addition, integration usually prevents the user from easily customizing their work environment to meet their own needs. Similarly, when users want to upgrade one part of their system to take advantage of technological improvements, they must upgrade everything, even if they are satisfied with the rest of it. This is unnecessarily expensive.

Under our more flexible approach, rather than trying to do everything with a single model (even a large integrated one), we recommend distributing specific tasks to the people best suited to conducting them, using the most appropriate methods. These tools need not necessarily reside in-house. In some cases, the resources used might come from other public-sector organizations, such as the Southern California Association of Governments (SCAG), the California Air Resources Board (CARB), local governments, or public utilities, and even nongovernmental organizations. In other cases, the District might contract with universities, private consulting firms, or other private-sector experts to conduct specialized analyses, such as that currently being done for small business and health impacts.

Flexible analysis is not primarily an issue of computerization, even though improvement in computers and data standards certainly make it more feasible than in the past. The real key to flexibility lies in building expertise in-house to manage this more complicated analytical environment. This includes developing the following three specific capabilities: (1) understanding different kinds of analytical models and theories; (2) combining and interpreting analyses from different sources, which also, in part, requires maintaining an "information infrastructure" built over time to allow widespread data-sharing; and (3) creating, maintaining, and overseeing relationships with agencies and firms outside the District in order to expand the pool of resources available to the socioeconomic staff.

Developing these type of skills that form the basis of flexible analysis requires an ongoing process in which the socioeconomic analysts constantly ask new questions and develop new capabilities. There is no simple or easy path to this type of "institutional learning;" nevertheless, we propose several specific suggestions. First, the socioeconomic staff need to expand the types of analysis they undertake, initially expanding the way in which they use REMI to answer new questions and then incorporating other analytical tools to answer questions REMI is not designed to answer. Second, they need to ask what organizational forms are most conducive to more creative forms of analysis and to support learning-by-doing. Third, they need to plan several years ahead where they wish their analytical capabilities to be.

INSTITUTIONAL STRUCTURE FOR CONDUCTING SOCIOECONOMIC ANALYSES

The institutional structure within which the District's socioeconomic analyses are conducted may either aid or hinder the effectiveness of obtaining appropriate data, conducting relevant analyses, and implementing results of the analyses. We considered five options for how the District might modify this institutional structure. Three of these options rely on the District staff to conduct the socioeconomic analyses in-house, and the other two rely on others outside the District to conduct the analyses.

1. **Status Quo**. Have the District's staff continue to conduct the socioeconomic analyses, with few, or no, changes in the institutional structure and methods of analysis being used.

2. **Altered District Structure**. Have the District's staff continue to conduct the socioeconomic analyses, but make major alterations to the District's institutional structure and methods of analysis.

3. **Altered District Structure with Significant Input from External Governmental and Nongovernmental Institutions.** Have the District's staff continue to conduct the socioeconomic analyses, but (a) make major alterations to the District's institutional structure and methods of analysis (b) establish a Socioeconomic Analysis Review Committee, and (c) provide a means to enable governmental and nongovernmental institutions to make significant inputs into the analyses.

4. **External to District--Governmental or Quasi-Governmental Institution.** Have most or all of the socioeconomic analyses conducted by staff in a governmental or quasi-governmental agency, such as the Southern California Association of Governments (SCAG), the California Air Resources Board, etc.

5. **External to District--Nongovernmental Institution.** Have most or all of the socioeconomic analyses conducted by a private consultant or staff at a private consulting firm, academic institution, or other nongovernmental institution.

In selecting among these options, we kept in mind that the District has a legislative mandate to achieve dramatic air-quality improvements in the District by the year 2010. We made extensive inquiries concerning alternative institutional arrangements that could achieve this target in order to determine which one might best meet the needs of the District and the many interested members of the public. We reviewed some of the alternative institutional arrangements in other pollution-control agencies. We also surveyed 22 groups throughout the United States who conducted regional economic modeling to document what they might determine to be major advantages and disadvantages of having such analyses conducted by the District versus an outside contractor. (Refer to Appendix II.)

After careful consideration of all the major advantages and disadvantages, we recommend that the District adopt Option 3. Although this option maintains the core of the socioeconomic analysis within the District, the changes we suggest under that option will require a greater involvement than at present of (a) other departments within the District, such as the Small Business Assistance Office (SBAO) and staff from the District's engineering, other technical, and enforcement departments; (b) governmental organizations, such as SCAG; and (c) nongovernmental groups, such as private consulting firms, academic organizations, community groups, environmental groups, and business organizations (refer to Appendix VI).

We have indicated throughout this report that there are many major changes that will be needed, regardless of who conducts the analyses. The District, however, has already invested large amounts of money and time in assembling a competent, well-trained group of socioeconomic analysts, and the District administration appears to us to be unusually committed to trying to incorporate socioeconomic analyses into its overall activities and to extend its current expertise. Building a staff of analysts to handle such a complex set of issues effectively takes considerable resources, both in terms of money and time. We believe that the District should not discard the investment already made, because a large number of the most important changes we recommend can be made just by reallocating existing resources, modifying (sometimes drastically) the types of analyses being undertaken, and changing the existing institutional structure to meet some of the most serious objections to having such analyses conducted in-house.

Our consideration was not just one of cost control. If the current practice of conducting socioeconomic analyses within the District did not yield useful results, we would more easily have recommended a different option. The District is a large and diverse organization, rich in talent and resources that, in key ways, is more than the sum of its parts, and which would be nearly impossible to recreate by an outside organization. The broad and complex types of problems studied by socioeconomic analysts are well served by this depth of resources. The District needs to integrate inputs from a large number of different offices within the District organization, a task that would be very difficult for an outside contractor to do. This does not preclude using contractors, but they should be hired for specific needs--in cases where the District has insufficient internal resources to meet large and temporary work demands, or where specialized skills are required that the District cannot easily justify investing in and maintaining (Kelley and Harrison, 1989; Holmes, 1986), or to help with the proposed public modeling. (Refer to Appendix VI.)

Many of the problems we mention in this report are difficulties that might occur regardless of who conducted the analyses. We believe that almost all of the problems that result from the District's current institutional structure can be overcome by making strategic changes to that structure. During our interviews, one of the most frequently voiced objections about having the District conduct socioeconomic analyses concerned biases that may occur in such analyses given that people working for the same agency propose rules, analyze the socioeconomic effects of these rules, and then implement and enforce them. Even if the overall cost-assessment functions were removed from the District, the District's staff would still need to undertake analyses to help them design new rules. In addition, there are economies of scope associated with performing the different categories of analysis in one place--since they can use common data sources.

We suggest below a number of ways in which the potential for these biases in the socioeconomic analyses can be mitigated. We also indicate the most critical of many improvements required in the current institutional structure. Even in areas where we recommend changes or disagree with the District's methods, we nevertheless find that they are basically on the right track. The capacity for complex analyses cannot be created overnight, and many of the District's investments are just beginning to pay off. Keeping the socioeconomic analyses in-house also does not preclude changing the forms of analyses undertaken, but changes need to be planned to maintain consistency, so that analysts can compare current with future economic impacts, while simultaneously expanding their future analytical capabilities. What is needed most is a somewhat intangible quality--the ability for people spread throughout the organization to learn from one another and to contribute to each other's efforts.

Internal Institutional Changes

The socioeconomic staff currently uses REMI, and we assume they will continue to do so, at least during the next two years. If they were to move beyond their present sole reliance on REMI and partial-cost studies, we believe they could benefit from forming closer linkages with the SBAO and other groups within the District as well as making specific changes in the composition of the socioeconomic staff. We are confident that making these three major structural changes within the District administration will assist the socioeconomic staff in carrying out more effective analyses.

Links with the SBAO Staff

We recommend establishing much closer links than presently exist between the socioeconomic staff and the SBAO staff. Just recently, for instance, the socioeconomic staff retained four consulting firms (Booz Allen & Hamilton, Economic Round Table, Ernst & Young, and Jack Faucett Associates, Inc.)

explicitly for the purpose of improving their analyses of small businesses and (in addition to their general socioeconomic analyses). Yet, insufficient attention was given to how these consultants might work with the SBAO. Although the District needs to hire experts such as these, the District staff need to be certain that the different departments of the District cooperate during the hiring process and later as the consultants are given tasks to perform.

1. **Helping small businesses.** During our interview with a member of the SBAO staff, we learned that their staff currently meets with small business groups prior to the public workshop and tries to bring them into the rule-development process. The SBAO also holds staff meetings, to which the socioeconomic staff are invited (and usually do) attend. As we understand the process, however, the socioeconomic staff rarely have the benefit of meeting directly with small firm representatives. We recommend changing the current process by having the socioeconomic staff and the SBAO hold joint meetings at this very early stage if a rule is expected to affect small businesses. Currently, the SBAO looks for cases either in which small firms are directly affected by a regulation, or in which they may be affected by having their inputs from large suppliers interrupted. We recommend that they should also determine if and how small firms may act as suppliers of components to large firms. If large firms are affected, small firms consequently may face changing demand for their output.

2. **Improving information flows.** The SBAO performs an important function by eliciting difficult-to-obtain information that can determine the relative success or failure of the socioeconomic evaluation process, but we cannot determine how much of that information ever makes its way to the

socioeconomic staff. We recommend expanding the District's small-business activities in at least two ways that may significantly improve the economic evaluations made by the socioeconomic staff.

First, at present, the SBAO mainly works to involve small businesses in the decision-making process and to provide modest kinds of technical assistance, such as identifying potential loan pools. Given limited resources and tight time schedules, they do an admirable job at this. We recommend significantly expanding the role of the socioeconomic staff in supporting the work of the SBAO, for instance by helping small firms to identify new business opportunities and alternatives for compliance; this role should not stop after a rule has been passed. The SBAO staff can benefit significantly from better information about how small firms in various sectors compete strategically and where the firms are most constrained economically in their ability to comply with regulations.

Second, at present, the SBAO staff gather information primarily on small firms. We recommend that the District also collect information concerning local governments, consumers, and community groups. Over the longer run, the SBAO could also benefit substantially from ongoing data collection about the economic impacts of prior regulation efforts, the changing industrial structure of industries dominated by small firms, the evolving new relationships between small firms and large firms, etc. These are all jobs logically undertaken by the socioeconomic staff.

Do the above recommendations imply that the SBAO and the socioeconomic staff should be merged? That is not for us to determine. In fact, each office still has many responsibilities that do not logically involve the other. We recommend that the offices establish a closer relationship in two ways. First, they should identify areas where their jobs overlap and try to interact on those tasks. This means building explicit horizontal linkages between the two groups, so that ideas and work can flow easily between them. Second, they need to build institutional linkages that encourage cooperation, yet which also allow each office the flexibility to go its own way when necessary. As an example, in addition to joint meetings before the workshop phase, the SBAO and the socioeconomic staff might also engage in a series of joint research efforts.

Links with Engineering, Other Technical, and Enforcement Staff in the District Offices

The socioeconomic staff presently obtain critical cost data from other divisions of the organization for use as input into the REMI model. Staff from these departments also come together occasionally for joint meetings concerning rules under formulation. We recommend that they expand this type of interaction and do it on a more systematic basis.

Below, we recommend that the socioeconomic staff should have a diverse set of backgrounds. This need for diversity also extends to the socioeconomic staff's interactions with other departments within the District. We heard a number of comments from members of the public who believe that the socioeconomic staff are much less well informed about the difficulties businesses have with complying with the rules than are enforcement and engineering staff members. The District staff consists of a large group of individuals whom the socioeconomic staff have only begun to tap as a resource. Work on the air-dispersion modeling by the regional, point, and area sources modeling staff, rule enforcement by the compliance staff, permitting by the engineering staff, and source testing by the Applied Science and Technology

Division staff are a few of several examples where we recommend greater interchange may be beneficial to all interested parties.

Socioeconomic Staff Composition

The current socioeconomic staff are extremely talented, with educational backgrounds and on-the-job experience that are the envy of most smaller air-pollution control districts. By and large, they are also sufficiently well trained in modeling methods to have a strong intuitive sense concerning when one model is more appropriate than another--a critical ingredient to flexible analysis. One weakness in the staff is that they tend to have very similar talents and backgrounds.

1. **Expansion of skills of socioeconomic staff.** We recommend developing a staff with more wide-ranging capabilities. These staffing needs can be fulfilled through additional training of current employees, by hiring individuals with interdisciplinary training, or by hiring additional individuals who can cover a wide range of specialty areas. Ideally, in the long run, the staff would consist of individuals who have an excellent training in a wide number of economic and social analysis and statistical skills, with most having some specialized expertise in unique areas.

2. **Experience with small business and community development.** If the District administration adopts many of our recommendations for expanding the analyses conducted, one of the first priorities should be for them to consider how to augment the current socioeconomic staff's expertise in small businesses or community economic development, either with special training of the current staff or by hiring specialists in these fields, while avoiding redundancy with the SBAO staff.. At present, the socioeconomic staff is finding some of this

expertise elsewhere in the District's organization, such as in the SBAO staff, or, when needed, by hiring outside contractors with expertise in these areas.

3. **Time needed to think creatively.** We believe that the greatest constraints on the current socioeconomic staff are not in personnel, but in organization and procedures. Because they are so busy getting rules "through the door," the staff have insufficient opportunities to reflect on what they have done or to plan for future development of their efforts. These time constraints also make it virtually impossible to undertake any of the other types of research that we believe would strengthen their capabilities and provide different kinds of valuable analysis by moving beyond their current reliance only on the REMI model and partial-cost studies. As the District expands its regulatory scope and tackles increasingly difficult air-pollution problems, they will need to set time aside on a routine basis specifically for interstaff discussions, long-term planning, and research. They already do this to a limited extent, but we recommend allocating more time to planning and reflection activities. The determination of an appropriate staff composition needs to become one part of the long-term planning process suggested below, and we emphasize that these needs undoubtedly will change rapidly over the next 20 years.

Cooperating with Groups Outside the District Organization

Just as the socioeconomic staff can benefit under a flexible system by strengthening its links throughout the District organization, the District can benefit by cooperating more closely than they currently do with other organizations. We recommend increasing the current interchanges with other organization, such as SCAG, California Air Resources Board, California Energy

Commission, etc. These relationships need to be strengthened so as to make better use of specialized expertise in other agencies and to avoid redundant investment. Of many possible links between the socioeconomic staff and outside groups, we recommend below four that need to be either developed or strengthened.

Links with Governmental or Quasi-Governmental Authorities

Members of the socioeconomic staff can supplement their own analyses more than they are currently doing with studies being conducted, techniques being used, or data available at other agencies in California and the South Coast. One example is the maintenance by SCAG of sophisticated land-use and geographical information systems capabilities. Likewise, there may be conditions under which the socioeconomic staff would like to supplement or compare their own analyses with forecasts from SCAG's input-output model. Without further study, we cannot say that these resources are accessible to the socioeconomic staff, nor can we identify the conditions under which such cooperation would be most appropriate. Still, these are the types of tools with a tremendous potential to extend the power of the staff's current analyses. At a minimum, by working together on a wide range of investigations, staff from the two agencies will be better able to solve the difficult problems of how to develop consistent methods of analysis and data sources. This will be especially important as the District continues to expand the types of rules and regulations it implements and enforces to include those with significant implications for traffic and land use (e.g., Regulation XV, Trip Reduction/Indirect Source).

Contracting with Outside Nongovernmental Individuals and/or Groups

Above, we noted a number of additional analyses needed. If the current socioeconomic staff do not have the time and/or capability to undertake these analyses, we recommend that the District continue and expand its current practice of hiring nongovernmental individuals and/or groups to conduct them.

Establishing a Planning Committee

Extending the relationship with SCAG and external private contractors is only one example of the types of outreach we recommend. As we emphasize, flexible analysis requires ongoing planning for change. When we began our study, we were unprepared for just how difficult this task can be in an agency like the District, which is engaged in an unusually large and rapidly evolving scope of activities. Our research convinces us that it is insufficient to call in contractors periodically to perform evaluations such as ours. Instead, we recommend that a permanent Socioeconomic Analysis Review Committee be established that will meet with the socioeconomic staff on a routine basis, perhaps once every two or three months.

Some of the functions of this committee will be to (a) provide an ongoing reevaluation of the District's socioeconomic reporting goals, (b) recommend changes, (c) keep the socioeconomic staff up-to-date on changing events, methodologies, etc. (d) review the socioeconomic modeling efforts for the previous two (three) months, (e) discuss alternative ways that potential problems with a rule's implementation can be improved, and (f) gather specific concerns and recommendations from outside community, industry, and environmental interest groups and review these with the socioeconomic modeling staff, etc. Without a permanent presence, it is very difficult to keep pace with the District's activities, and planning for the changes is nearly impossible. Fortunately, the District operates in a community rich with resources. We recommend the planning committee be comprised of members of the public and the District, and include both several socioeconomic modeling experts and several noneconomists. Memberships could be rotating, to ensure that new people would come onto the group, bringing new ideas and expertise with them.

Feedback from the Public

Perhaps most important of all, flexible analysis can benefit from constant and diverse input from the regulated community, beneficiaries of the changes, and those indirectly affected (refer to Appendix VI). The 1990 Socioeconomic Task Force recommendations embraced several principles of public participation that we believe are worth restating. First, public input needs to be obtained early in rule development, and it needs to be acquired repeatedly and in a variety of ways. Second, that input needs to come from as diverse an audience as possible. Third, public participation is not just a political requirement; it should be designed to help provide specialized information not easily accessible through other channels. The point of public participation is to ensure that the District's rule-making is (1) informed by data best provided by the public, (2) democratic in its procedures, and (3) acceptable in ways that prevent noncompliance.

By and large, the District staff have made great progress in improving public input into the socioeconomic reporting process, although we recommend that they still need to incorporate more input even earlier in the decision-making process. They have made substantial gains in nearly all the areas where the Socioeconomic Task Force made recommendations. Moreover, in our public interviews, we heard repeatedly that the District staff had become much better at bringing the public into the process in the past year or so. Often, this praise came from people who otherwise had major disagreements with the District staff.

In our detailed review of Rule 1135 (Emissions of oxides of nitrogen from electrical generating systems), we found the District had engaged in a very intensive dialogue with affected parties. Nevertheless, we should point out that there were several features unique to that rule that made us question whether the District might always be so successful. The parties most affected by the rule are large electrical utilities with sophisticated planning capabilities. These organizations do not compete freely in the market, but can easily pass minor costs along to the public without fear of losing markets. Perhaps, most important, these firms all have centralized management. This meant that the District was presented with a single, identifiable, and consistent group of people making comments. Our interviews suggest that the District has a more difficult time incorporating input from fragmented parties with limited planning capacity, and/or where strong competition makes the parties more impassioned about specific positions.

PLANNING FOR CHANGE

Given the changing regulatory environment in which the District operates, the institutional and substantive changes in socioeconomic impact analysis we have recommended are not enough. The socioeconomic staff need to envision what they want their analyses to look like five years in the future and to create a plan to get there, making educated guesses as to likely future demands on their efforts and available resources. The planning committee can help the socioeconomic staff plan change, but it cannot substitute for internal, ongoing planning. We strongly recommend that the socioeconomic staff give more consideration to planning the future of their effort. Below, we discuss five categories of recommendations.

Changing the Socioeconomic Reports

We recommend that the socioeconomic staff determine at least on an annual basis how their socioeconomic reports may need to be changed in the short run (one to two years) and long run (at least the next three to five years). The staff ought to be their own harshest critics, constantly asking what new questions they can answer as outside needs and their own capabilities change. When given the chance, we have found the staff to have exciting and provocative ideas about how to improve their reports; however, given the current time constraints on their activities and certain organizational weaknesses, the staff have few opportunities to advance in new directions.

Anticipating Changes in the Political and Regulatory Environment

We also recommend that the socioeconomic staff try to anticipate changes in the political and regulatory environment in which they operate that will affect their analyses. As an example, when we were hired, we found that very little planning had been done regarding what socioeconomic analyses would look like under the RECLAIM program, even though members of the socioeconomic staff had been working on the RECLAIM proposal. We recommend that considerable care be taken to determine how the socioeconomic analyses for the current rule-by-rule and the RECLAIM option can be coordinated.

The sorts of questions we have raised about socioeconomic analyses in general will not disappear under the RECLAIM option. Small firms, for instance, do not have extensive resources to buy permits any more than they have resources to invest in control equipment. Under the current proposal, small firms are being exempted, but we recommend that the District conduct analyses of small firms' impacts to determine whether it is preferable to exempt small firms from compliance, or whether some alternative for compliance is available. Furthermore, RECLAIM will undoubtedly raise issues of its own. After all, one of the results of the marketable permit approach may be to encourage older, obsolete plants to close down. Clearly, monitoring of the job effects of such actions is in order.

Monitoring and Understanding the Local Economy

We also recommend that the socioeconomic staff expand its current scope of work in order to assess and understand long-term changes in the local economy that determine shifts in local industrial and employment composition. this may be done either in-house or by outside groups. In the absence of major strategic changes, long-term declines in defense spending and restructuring in the aerospace sector, for example, are likely to continue to force local layoffs and plant closures regardless of what air-pollution rules and regulations the District imposes (U.S. Office of Technology Assessment, 1992). Small firms are also likely to become a more important source of employment than they were in the past--further reinforcing the need for greater understanding of the impacts of regulations on small firms (Piore, 1989).

Ideally, the District staff, using the information they learned, would check their forecasts after-the-fact to confirm the accuracy of their analyses in order to improve future forecasts. In practice, this is rarely possible because firm startups, closures, and other similar economic impacts can rarely be attributed to a single cause such as the District's policies. In addition, may of these economic impacts will not occur until many years into the future. As a more modest step in this direction, we recommend that the socioeconomic staff begin making quarterly forecasts of the local economy. This would provide the staff with an opportunity to track the local economy, while simultaneously giving them a chance to calibrate their use of REMI more carefully by being able to check prior model forecasts.

Forecasting Changes in the Socioeconomic Staff's Own Capabilities

In addition to forecasting changing demands, we also recommend that the socioeconomic staff forecast how their own computational, organizational, and human resources are likely to change and need to be changed in the future. Technological changes to support flexible analysis take time. Failure to plan future hardware needs can leave the staff with inadequate computing capacity and make them spend their limited time making the calculations rather than reviewing the results. We were surprised to find, for instance, that the socioeconomic staff run REMI on relatively underpowered computers that require at least twice as long to run REMI as newer machines.

Inadequate planning can easily lead the District into a situation where it misinvests in technologies today that will be incompatible with those "in the pipeline." A decision as apparently trivial as what word processor to use can become a nightmare if no account is taken of future technology developments. The same can be said for data sources. We recommend the District begin to look seriously at how to assemble ongoing data resources that, to the extent possible, are not dependent on the continuing use of REMI (or any other specific model).

Institutional changes also require advanced planning. Investment in personnel takes time; establishing links with outside agencies can require years. In many cases, the types of changes needed are iterative and evolutionary. The socioeconomic staff should not only look for new hardware and software, they must also be able to envision how those technological shifts will influence their overall style of analysis and organizational form.

Creating an Agenda for Future Research

We recommend that the socioeconomic staff create an agenda for ongoing research to augment its rules evaluations and to help the staff in the future. To the District's credit, it already has a very aggressive research program. While applauding that program, we recommend that more resources be devoted to helping the socioeconomic staff either by expanding their in-house capabilities or by allowing more analyses to be conducted externally. Many of the types of analysis we have recommended above can be done as individual studies by outside contractors. One alternative might be to commission a series of studies of these topics. Below, we list several of the topics that we believe warrant further research:

1. Industry case studies. The California economy will continue to change rapidly over the next 10 to 20 years. A selected group of industries should be selected each year for which a case study is made to determine at least the following: (a) types of inputs purchased and from where, (b) market shares and how the marketing distribution of outputs (which purchasers and where are they located) may change over time, (c) occupational and demographic structure of employees, (d)

vintage and type of capital, and (e) potential new technologies. A uniform format needs to be used for these case studies so that they become part of the "data base" that can be used by the socioeconomic modeling staff to assess industrial, employment, income, social group impacts. For some important industries, the case study may be updated each year; for other industries, the case study would only be updated less frequently.

2. **South Coast economic study.** The case studies referred to above cannot be performed in isolation, without knowledge of the larger socioeconomic changes occurring in the South Coast, the rest of California, the United States, and the world. The current economic base of the District and the relative competitive advantage of the South Coast region to the rest of the United States and world needs to be carefully examined.

3. **Institutional expertise in socioeconomic modeling.** We have identified eight areas in which the socioeconomic modeling staff need to keep abreast of new developments in the field of modeling regional socioeconomic impacts of air-pollution rules and regulations: (a) regional and/or national economic models (e.g., REMI, IMPLAN, DRI, etc.; (b) environmental/economic models; (c) energy models; (d) generic quantitative techniques, such as data-base management systems, graphical display programs, and spatial analysis programs, such as geographic information systems; (e) demographic and occupational models; (f) environmental assessment techniques; (g) qualitative assessment techniques; (h) community assessments; (i) social-impact analyses, and (j) conflict analyses. In addition, regardless of which model is used for the socioeconomic modeling, continuous testing and refinement of the model are required.

We recommend hiring an outside group to perform this work annually. They would report their findings to the socioeconomic staff and/or the permanent planning committee suggested earlier in the report. Although keeping up with the latest developments in each area and testing of the model could be incorporated into the work schedule of the socioeconomic modeling staff by expanding the number and type of staff employed, this type of work might be performed better outside the District.

4. **Expanded socioeconomic modeling review.** Our survey conducted of socioeconomic modeling being used by California and U.S. state air-pollution boards and our review of the socioeconomic modeling literature should be extended to a review of a few major agencies who are doing this type of work in other countries. In the course of our research, we have identified what seem to be important efforts in Canada, Germany, Japan, Mexico, and Netherlands. (We have been informed that social-impact analyses are currently being conducted in Canada.) Whereas presently the District seems to be at the forefront of socioeconomic modeling efforts in the United

States, similar modeling has been undertaken in some of these other countries for a more extended period of time. Such work can inform the District of potential new directions for their socioeconomic modeling and alternative institutional structures that may be needed as their own procedures progress and change.

5. **Health impacts**. We disagree with the Public Health and Socioeconomic Task Force Report of 1990 that further study of health benefits is unwarranted. We especially recommend that the District should analyze the distribution of social and geographic vulnerability to the health effects of pollution. They should also integrate new research findings from around the United States and elsewhere so as to improve the quality of the benefit assessments.

6. **Visibility impacts**. We recommend a review of hedonic and other visibility studies from other areas.

7. **Other costs**. We recommend an expansion of the analyses of ecological costs and a better accounting of material costs and degradation.

CONCLUSION

In this report, we have made a great many recommendations concerning how the District staff might improve their socioeconomic reporting process. This should not obscure the fact that, by most standards, they are doing a good job. Their work compares favorably with that of their peers, and they are extremely competent by any reasonable professional standard. Still, they can improve their work in the ways we have recommended. We summarize at the end of this report the major recommendations we are making.

The South Coast Air Quality Management District is in a unique position among air-quality regulatory agencies in the United States. They have both the worst air quality in the country and the most extensive resources to clean up that air. The aggressive approach the District has adopted to pollution control demands a more sophisticated form of analysis than in places where air quality is not a problem. If any agency is well-positioned to take the lead and advance the current state of socioeconomic analysis of air pollution controls in this country, the District is the agency to do it.

What the District's effort demonstrates very plainly is that technical competence is not enough to provide the types of information that are most useful to promoting clean air goals. These goals require analysts to use flexible analyses, so that they will be capable of analyzing highly complex problems and adapting to frequent changes in the regulatory environment. The capacity to conduct such flexible analyses is not primarily a technical problem, although technical competence is an absolute prerequisite to success. The most difficult aspects of building a flexible analytical environment are substantive and institutional.

In this report, we do not recommend that the staff undertake a series of minor reforms to the socioeconomic reporting process, but that they must embark on a new approach to the task. We believe the District staff have the capability to make the necessary changes.

SUMMARY OF RECOMMENDATIONS

I. CHANGE INSTITUTIONAL STRUCTURE WITHIN WHICH THE SOCIOECONOMIC ANALYSES ARE CONDUCTED IN THE DISTRICT

A. Establish a Socioeconomic Analysis Review Committee

B. Strengthen linkages with the Small Business Association Office (SBAO), including support of SBAO activities.

C. Expand interactions with departments other than the SBAO, especially early in rule development.

D. Expand interactions with governmental and nongovernmental agencies outside the District administration.

E. Set up a working group with SCAG to encourage development of appropriate data and analytical methods by the two agencies.

F. Expand the breadth of the socioeconomic staff skills and expertise.

II. ESTABLISH A "FLEXIBLE ANALYTICAL APPROACH" FOR CONDUCTING SOCIOECONOMIC ANALYSES

A. Conduct cumulative as well as rule-by-rule analyses.

B. Expand scope of analyses and collect data on new kinds of economic impacts.

1. Identify potential economic opportunities associated with particular rules.

2. Identify compliance alternatives and potential obstacles to compliance.

3. Study product-quality issues.

4. Study technology-change issues.

5. Compare how economic impacts vary across different sizes and types of firms,

6. Compare how economic impacts vary across different consumer groups.

7. Include, where relevant, analyses of the following economic impacts: class, consumer, ethnic, fiscal, gender, and occupational.

8. Include discussion of economic impacts outside the South Coast.

C. Expand Analytical "Toolbox"

1. Use alternative methods: REMI, other economic techniques, qualitative analyses, industry case studies, etc.

2. Expand access to other analytical tools, such as land-use, energy, health, and transportation models.

3. Develop in-house capabilities to use: data-base management systems, graphics packages, basic statistical analyses, and geographical information systems.

III. CHANGES TO THE REMI AND TO THE REMI F&G MODEL

A. REMI staff should provide the District with a model capable of generating forecasts for selected three-digit, or even four-digit, standard industrial classification industries, instead of present two-digit level.

B. REMI staff should first "regionalize" the 466-sector national table and then aggregate it to the desired sectoral level.

C. REMI staff should continue to improve documentation of their model, especially for the available policy variables, explanations of the technical model structure, and suggestions about how to use and interpret the model.

D. The District socioeconomic staff should consider the appropriateness of the Fulton and Grimes' adjustments in light of the MIT findings.

E. The District socioeconomic staff should consider three options related to adjustments to the REMI model: (1) use the original REMI model to perform socioeconomic impact assessments, (2) request the REMI staff to build a BLS-based REMI model, and (3) continue with the Fulton and Grimes' adjustments.

F. If Fulton and Grimes' adjustments continue to be made, Fulton and Grimes should try to construct separate FPD ratios for individual counties.

G. Fulton and Grimes need to provide better documentation of their rationale for the four adjustments they make.

IV. MISCELLANEOUS CHANGES IN CURRENT PROCEDURES

A. Establish a minimum threshold, below which job or output impacts would be considered too unreliable to report.

B. Adopt standard sets of definitions and procedural guidelines.

C. Make greater use of sensitivity analyses.

D. Focus more on relative economic impacts than on actual numbers forecasted.

E. Distinguish between new economic activities resulting from District regulations and those that are transfers between existing sectors, firms, or individuals.

F. Use classification schemes similar to those used in the AQMP or by the BAAQMD to differentiate between "quantifiable" and "nonquantifiable" economic impacts.

G. Improve database management and data archiving procedures.

H. Conduct quarterly forecasts of local economic activities.

V. CURRENT PRACTICES THAT NEED TO BE CONTINUED

A. Continue to use a socioeconomic impact model for certain aspects of the analyses, with REMI being the model used in the near future.

B. Continue to limit the use of cost-effectiveness and benefit-cost techniques.

C. Continue to conduct most of the socioeconomic analyses in-house, but rely on a broader range of resources to create the socioeconomic reports.

VI. PLANNING FOR FUTURE RESEARCH

A. Establish set of industry case studies that are updated.

B. Conduct study of structural economic changes occurring in the South Coast.

C. Conduct study of new international developments in field of modeling regional socioeconomic impact of air-pollution rules and regulations.

D. Review air-pollution socioeconomic modeling being conducted in other countries.

E. Allocate greater resources to long-term planning.

F. Establish agenda for future research.

G. Refine quality of health benefit assessments.

H. Review hedonic and other visibility studies.

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Volume II

TECHNICAL APPENDICES

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The research reported here is financed with funds from Contract No. C91253 between the South Coast Air Quality Management District and the Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts. The authors take full responsibility for the conclusions, which are not necessarily those of the sponsoring agency.

ACKNOWLEDGMENTS

This was a large project, which could not have been accomplished without the help of countless individuals on both coasts and between. First and foremost, we thank the people of Southern California who, despite their own recent traumas have unselfishly taken an interest in our work and offered their suggestions and time freely. We also thank the air-pollution officers in California and other states and the staff in several related agencies who took the time to respond to our survey and to discuss with us, the academics, what they do and how they do it. We owe a special debt to our colleagues in the economics profession with whom we shared ideas and who provided us with many comments on our reports, often providing valuable insights into particular issues. We especially thank George Fulton, Donald Grimes, Linea Hazen, Brian MacDonald, Ben Stevens, and George Treyz. We received important help and cooperation from the staff of the South Coast Air Quality Management District. Among these colleagues, we especially appreciate the efforts of Francis Goh, who had the difficult job of communicating between the District staff and our team, and who showed the maturity of a man twice his age and experience, and whose commitment to intellectual honesty made this work possible. Finally, as always, we are deeply grateful to our colleague Pat Murray for production support, especially with regard to the many versions of the numerous tables and figures.

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Appendix I

THE REMI MODEL AND THE FULTON AND GRIMES' ADJUSTMENTS

May 1992

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Appendix I

THE REMI MODEL AND THE FULTON AND GRIMES' ADJUSTMENTS

The South Coast Air Quality Management District (District) is using a highly sophisticated, multiregional computer-simulation model developed by the Regional Economic Models, Inc. (hereafter referred to as the REMI model) to prepare its socioeconomic impacts of air-quality rulings. The major objective of our review is to determine the appropriateness of the District staff's existing method.[1] In this report, we focus on two specific aspects of the District's computer-modeling operation.

First, we describe the REMI model in terms of its technical features, including special characteristics, assumptions, and the structure of the model. The objective of describing the key elements of the model is to set the stage for our evaluation of the REMI model. In our evaluation, we highlight certain advantages and disadvantages of using the REMI model, and we perform sensitivity tests on selected policy variables in the model. We also propose some extensions of the model that would improve the socioeconomic staff's studies.

Second, we examine how the Fulton and Grimes' adjustments to the REMI model affect the REMI forecasts. In our examination, we compare the job-impact estimates for the Proposed Amendments to Rule 1135 (PAR 1135) obtained with the use of the standard REMI model with those from the modified REMI model (hereafter called the F&G REMI model). We also analyze in detail the four adjustments that Fulton and Grimes made to the REMI model, namely: (1)

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[1] Throughout this report, we will use the term "District Staff" to refer to the overall staff of the District and the term "socioeconomic staff" to refer to those five members of the District's Planning and Rules staff who wrote the District's socioeconomic reports that we reviewed.

FPD,[2] (2) MULTS (multiplicative adjustments), (3) population-migration regular policy variable, and (4) EPOL (employment policy). For each procedure, we raise potential issues that may affect the REMI forecasts. Based upon our review, we propose three options that the District staff may consider to resolve some of the issues related to the Fulton and Grimes' adjustments.

Finally, in the last section of the report, we summarize our recommendations concerning the REMI and the F&G REMI models.[3]

THE REMI MODEL

REMI is a multiregional forecasting and policy-simulation model. REMI users can forecast future economic performance of a designated region with and without some policy initiative, such as a construction project, or other similar exogenous event. To perform a policy simulation, the user changes one or more variables in the model to reflect such varied economic impacts of pollution controls as changes in production costs, energy rates, or employment in specific industries. They then use the model to calculate direct, indirect, and induced economic impacts throughout the economy resulting from those stimuli and to obtain a printed report, containing statistics on various economic indicators. These may be used directly by analysts to make estimates of the economic impacts of policies, or they may be copied into other software packages for further statistical analysis, graphing, or mapping. We will

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[2] FPD53 is the actual name for a FORTRAN program in the REMI model. It is not an acronym.

[3] Our analysis, reported here, was completed by January 1992. As of March 5, 1992, rulemaking for a marketable permits program, called RECLAIM (Regional Clean Air Incentives Market), was approved by the District Board. We have not evaluated the use of REMI for RECLAIM.

attempt to demystify the model by describing its key theoretical assumptions, structural relationships, and features. After the description of the model, we will discuss the advantages of using the REMI model and propose some of the possible extensions to the model that may improve the District's economic modeling.

In Volume I, we argue that a primary requirement for the District's socioeconomic reports is that they inspire public confidence. Numerous academic analysts have reviewed the REMI model to assess its technical soundness. Bolton (1985) discussed its general structure in the context of reviewing the then current development of multiregional models and modeling. Sivitanidou and Polenske (1988) compared the REMI model with two other microcomputer, economic-impact assessment software packages: ADOTMATR (a matrix-operation program) and the Grit Impact Program (GRIMP). They compared the application, ease of use, and costs of the three models. Perhaps most relevant to our evaluation, Cassing and Giarratani (1990) evaluated the structure, goodness-of-fit, theoretical consistency, and forecasting ability of the specific version of the REMI model used by the District. In addition, many analysts have described applications of the model and the successes or failures experienced in those efforts (Allmon, 1987; Campbell, 1988; Fulton and Grimes, 1991a; Lanzillo, Larson, Treyz, and Williams, 1985; and Lieu, 1991). In one of the latest articles on the REMI model, Mills (1992, p. 3) says that ". . . REMI is as good as any [regional economic model] and better than the vast majority," but he believes that it is misused in many cases.

These and other analysts and policy makers have been using the REMI model to assess the economic impacts of different government policies, ranging from energy and environmental regulations to economic development strategies.

Although most reviewers and users of the REMI model have found areas where improvements can be made, most evaluators have found the REMI model to be acceptable by any of the various standards they applied.[4] Our discussion will draw on these prior studies, summarizing important points that have been made and expanding on them where necessary.

The REMI Model in Perspective

Analysts can choose from many computerized models available for national economic-impact assessments; however, their choice is far more restricted for conducting regional (or local) assessments of the sort necessary for studying the local impacts of air-pollution control policies. Many of these models are designed specifically for use in other regions and cannot easily be adapted for use by the District. Likewise, many regional economic-impact models are designed to answer very specific questions about changes in such activities as traffic flows, water-resource demands, or housing markets, making them inappropriate for the more general economic questions in which the District is interested. The REMI model that the District is currently using has been adjusted to account for the special institutional requirements and economic characteristics of the South Coast.[5] Because of the uniqueness of the District's application and modification of the REMI model, we have difficulties finding a comparable model to the specific REMI model used by the District. In this report, we, therefore, only examine the District's REMI

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[4] In Appendix II, we discuss one recently published critique of the model by Crihfield and Campbell (1991) and the rejoinder provided by Grimes, Fulton, and Bonardelli (1992).

[5] We use the term "South Coast" to refer to the four counties that are under the jurisdiction of the District. These counties are Los Angeles, Orange, Riverside, and San Bernardino.

model and do not make any comparison between the REMI model and versions of the REMI model or other economic models used elsewhere.[6] Our evaluation of the model is related specifically to its role in the District's socio-economic-impact assessments of the environmental regulations on the South Coast economy. We may sometimes discuss the model in relation to other models; however, the purpose is to put our discussion in perspective and not to make direct comparisons.

Among regional microcomputer-based models, the REMI model is unique in terms of its complexity, size, and theoretical elegance. The model has 2,386 economic variables and 849 demographic variables. In addition, the user can alter 1,096 regular, 58 translator (final demand), and 71 demographic variables to describe alternative demographic, investment, and other policies (REMI, 1990, p. 1-4). Among these user-changeable variables, the vast majority are economic descriptors, representing everything from the final demand for banking services to the relationship between local and national markets for agricultural goods. The REMI model incorporates elements from Keynesian, input-output, economic-base, and microeconomic theories. The user can access detailed economic information for 21 manufacturing and 32 non-manufacturing sectors and simulate economic impacts for a wide range of policy alternatives.

To estimate the impacts of a policy on the future economy, the user creates two different forecasts. The first or "control" forecast describes what the future would look like without any changes in policy or other unexpected outside disturbances. In the second forecast, the user manipulates

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[6] We include a review of relevant input-output models, econometric models, and economic-base models in a separate report (Appendix II).

one or more of the model's policy variables so as to describe best the direct economic impacts of the policy being considered. The user might, for example, describe a specific investment in pollution-control equipment by an expenditure on equipment, a decline in the purchases of alternative goods and services, and an increase in business costs (Lieu, 1991). By incorporating this information into the model, the user would then generate a forecast that could be compared with the control forecast.

Relative to most regional economic forecasting models, the REMI model is based on different economic theories (cited above) that are relatively sophisticated and well reflect current mainstream thinking on regional economic behavior. The general assumptions of the REMI model are consistent with neoclassical economic theory. They include:

(1) Firms and consumers are rational profit and utility maximizers.

(2) Entrepreneurs have perfect information about the relative production costs of the industry nationally and between regions.

(3) Both factor and commodity markets are competitive.

(4) The regional and national production processes of an industry are the same, with different total factor productivity and factor intensities. These production processes can be described by a Cobb-Douglas production function with constant returns to scale.

(5) The economy has the tendency to move towards equilibrium after being disrupted by any exogenous shocks.

REMI is a "general equilibrium" model, meaning that changes in one sector of the economy are allowed to affect other sectors, which then feed back on the original sector in an iterative fashion until the disequilibrium caused by an initial policy stimulus significantly dampens. Furthermore, if the user changes prices in the REMI model, both the choice of factor inputs used by producers and the relative competitiveness of producers vis-a-vis other producers in the nation are affected, a combination of effects not captured in many models (Treyz, Friedlaender, and Stevens, 1980, p. 63).

In constructing the REMI model, the vendor incorporates a relatively large amount of local data. Like most regional models, the REMI model is derived from a national model. This feature allows the regional model to be consistent with the national one, in that, with minor exceptions, the economic activities of all U.S. regions sum to that of the nation as a whole. It also means that the vendor can easily adapt the model for use in other localities--an important concern for vendors trying to keep their models affordable to a wide range of users. The problem with this "top-down" approach is that, if the structure of the local economy is vastly different from the nation as a whole, the regional model may prove to be an inaccurate representation of reality. In the case of the REMI model, the vendor compensates for this by calibrating the regional model with a large amount of locally derived information. A user can keep the national and local data fairly current by purchasing annual updates of the model from the vendor, as the District does.

Structure of the REMI Model

The REMI model is structured into three modules--the input-output module, the demographic/migration module, and the standard module.[7] The input-output module contains detailed interindustry economic information for 466 industrial sectors. The demographic/migration module uses local birth, death, and migration information to project changes in population for 202 age and sex cohorts. These are then used by the standard module to estimate

[7] We obtained most of the information about the REMI structure from the REMI documentation prepared for the District (REMI, 1990).

impacts on labor supply and government expenditures. The input-output and demographic/migration modules are used to perform specific calculations, then the results are passed to the standard module. The standard module contains the core econometric model used to estimate economic impacts. We can explain the relationships among the three modules more precisely by looking at five different linkages, which serve to tie the entire model together. These linkages are: (1) output, (2) market shares, (3) production costs, price, and profit, (4) population and labor supply, and (5) labor and capital demand, which are explained in detail in Treyz, Rickman, and Shao (forthcoming). They are shown graphically in Figure 1.

To illustrate these relationships, we will describe a hypothetical modeling situation in which an environmental regulation increases the costs of production of an industry in a region--an approach very similar to that used in most of the District's evaluations to date. The direct impact of this exogenous shock is to raise production costs (wages and other input prices) in the industry (Block 3). This increase in production costs decreases the competitiveness of the local industry relative to the same industry nationally, lowering its market share (Block 2). The declining market share dampens the direct and indirect demand for products from the local industry. Decreasing demand is then reflected as decreases in the proportion of domestic demand satisfied by local outputs and by declines in the share of the U.S. interregional and international trade supplied by local industries. These changes are then channeled into the output linkages (Block 1) to project the economic impact on production. Declines in local production reduce the demand for factors of production, most importantly labor and capital (Block 5).

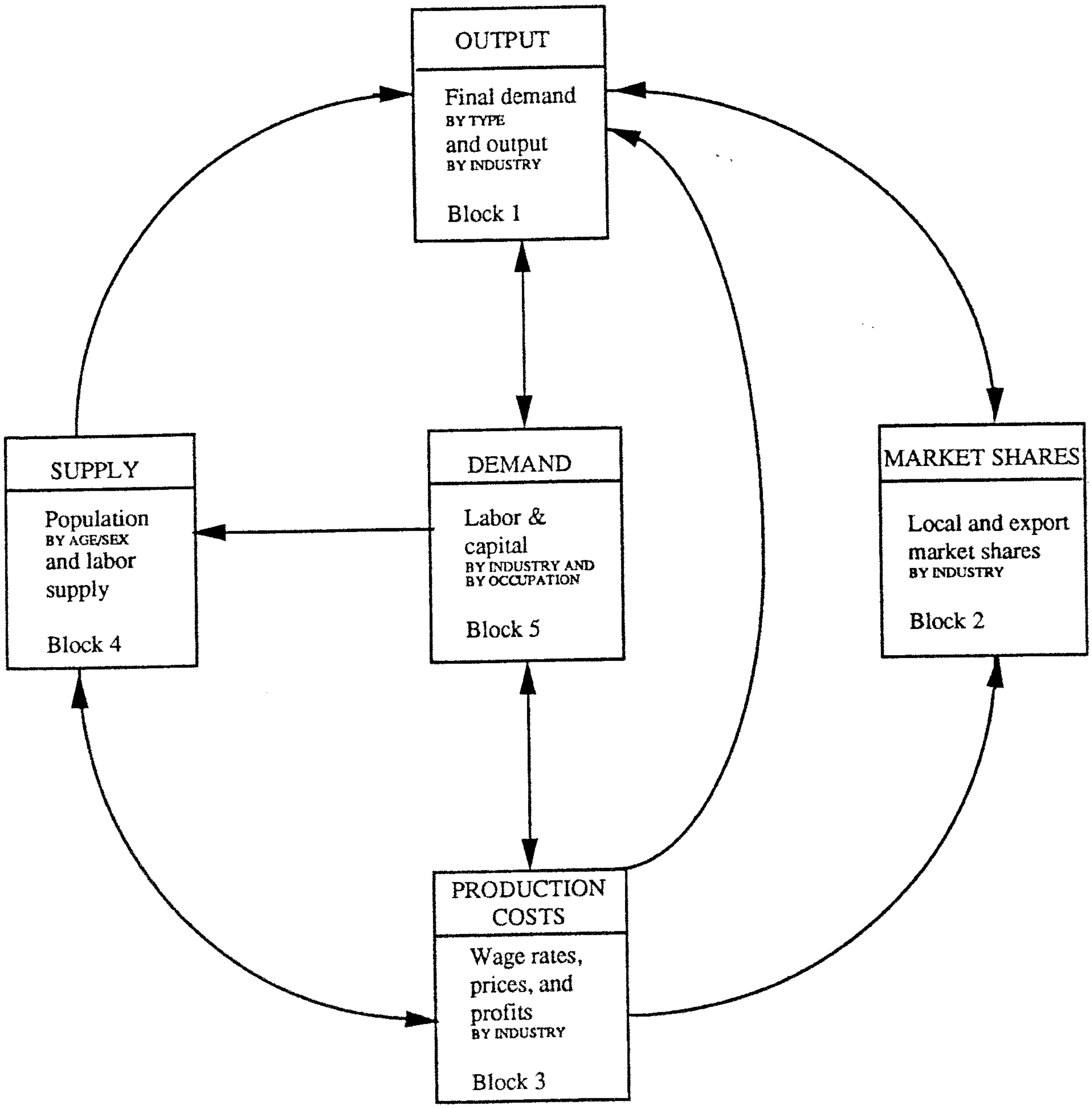

Figure 1.
LINKAGES AMONG MAJOR PARTS
OF THE REMI MODEL

Source: Regional Economic Models, Inc. n.d. "REMI Brochure."
Amherst, MA: REMI, Step 3.

The projected decrease in employment and capital-stock levels then feed back as declining wages, which tend to lower the initial adverse effect on business (although they tend to be much smaller than the initial economic impact). The declining wages also affect the supply of labor. With lower wages and less employment opportunity in the region, the number of economic migrants will decline (Block 4). The reduction of migration to the region will again lower the demand for output (Block 1). At this point, another round of economic impacts begins, with the cycle continuing until the system reaches equilibrium. We now discuss each linkage thoroughly.

Output Linkages

Output linkages (Block 1 in Figure 1) form the core of the model and are based on standard Keynesian demand functions. In order to keep calculation time and the size of the model reasonable on most microcomputers currently in use, REMI staff aggregate data from the initial 466 sectors used in the input-output module to 53 sectors, which are then used in the standard module to calculate the total effects of a policy change. Unfortunately, this means that model results are only available at a relatively high degree of aggregation--the two-digit Standard Industrial Classification (SIC) level. Outputs from the econometric model are calculated by equations representing (1) consumption, (2) investment, (3) state and local government expenditures, and (3) exports. We discuss each of them accordingly.

Consumption is a function of real disposable income, which includes total labor and proprietors income, property income, and transfer payments (including social security), after adjustments for taxes, contributions to social insurance, and inflation (Treyz, Rickman, and Shao, forthcoming, Equation (12), p. 9).[8] Incomes are deflated by the consumer price index.

Although most regional models neglect unearned income (Bolton, 1985, p. 515), the REMI model accounts for this type of income as property income and transfer payments. Property income includes dividend, rental, and interest income. Property income and transfer payments are assumed to be determined partly by the size and age distribution of the regional population relative to the U.S. population.

Implicitly, the REMI model assumes national capital markets; therefore local investment is not determined by local interest rates. Instead, national investment figures are "regionalized" by using local data to estimate the share of national investment occurring locally (Equations (15) and (16), pp. 10-13). Separate investment calculations are broken down by the type of investment being considered. Residential investment is calculated as the product of national residential investment and the ratio between national and regional real disposal income. Nonresidential and equipment investments are estimated by multiplying the national investment figures by the optimal capital-stock ratio between the region and the nation.

In older versions of the REMI model, the adjustment of capital stock to an "optimal" level was assumed to be gradual. In the 1989 version, any stimulation in investment leads to a rapid initial capital-stock adjustment, which then decreases gradually. This accelerated stock-adjustment process causes a larger stimulus to the short-run employment and output than in the earlier version as well (Rickman, Treyz, and Shao, 1991, p. 11). This also

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[8] Henceforth, we will only refer to equation number and pages, rather than provide the entire reference.

means, however, that the REMI forecasts are more sensitive than before to business-cycle activity. In Massachusetts, where recent business cycles have been both compressed and extreme, the Boston Redevelopment Authority has actually had to revise REMI's short-term forecasts downward to compensate for this rapid response time.[9]

Another important variable that affects output is government spending, which consists of federal (civilian and military), state, and local expenditures for education, health and welfare, safety, and miscellaneous expenditures. Federal government civilian and military employment in the region is determined as a share of the national total, which is exogenous and may be defined by the user. Federal military procurement is allocated to the region based on the share of total federal military spending received by the industry in the region. State government spending depends on the relative population of the region compared with the total in the United States and projected state and local government expenditures (Equation (18), p. 11).

Mills (1992) specially notes that the REMI model does not incorporate any government budget constraint. The vendor, however, says that this is intentional in order to force users to be specific about their policy descriptions. Thus, direct fiscal impacts of any new government expenditures must be entered by users through regular policy variables. These could be through offsetting declines in other spending categories, changes in the interest rate paid on bonds, increased taxes, etc. (Treyz, 1991). In their analyses, the socioeconomic staff could consider potential fiscal impacts of environmental regulations on the South Coast economy. Assume, for example,

[9] Personal communication with Bizhan Azad, Senior Economic Analyst, Boston Redevelopment Authority.

that a regulation will reduce employment and that the model will project a low influx of economic migration due to the low employment opportunity in the region. The low rate of immigration will affect the total regional population, thus lowering public health, welfare, and safety expenditures. The REMI model will automatically calculate the impacts of lowering government expenditures. At the same time, a decrease in employment and corporate profits will also lead to a reduction of government revenue from corporate and personal income tax.

Intraregional exports by industries in a county are proportional to the total industrial imports of other areas within the region. The proportion is determined by the market shares for an individual industry in the county. International and interregional exports are determined by the regional shares of the total interregional and international trade of the United States. The regional shares are approximated by the regional purchase coefficients (RPCs) and the export shares for industries in the region, which we will discuss later.

Labor-, Capital-, and Fuel-Demand Linkages

After the final demand components described above are estimated, they are passed into the labor-, capital-, and fuel-demand linkages (Block 5) to calculate the demand for factors of production. Labor, capital, and fuel demands are modeled as derived demands from industries, using Cobb-Douglas production functions with constant returns to scale. If the production functions of industries in a region do not experience constant returns to scale, users must adjust the input costs through regular policy variables to reflect the differences. Capital investment, labor intensity, and fuel consumption in production are then determined by productivities of these factors in the region and the factor shares used in production (Equation (21), p. 13).

The model does not contain disaggregated components for the factor productivities; that is, there is a single factor-productivity figure given for both capital and labor of any industry. The user can allow for the possibility of factor substitution because, in the model, the demand for factors is inversely proportional to the local factor productivity and relative factor costs. Take the case of labor as an example. Low overall productivity in a regional industry and/or low wages locally, along with the relative higher cost of other inputs will increase the demand for labor locally. After the model has estimated the capital, labor, and fuel demands, the results are combined with population and labor supply estimates to determine the production costs, prices, and profits. Before describing the production costs, prices, and profits linkages (Block 3), we first discuss population and labor-supply linkages.

Population and Labor-Supply Linkages

Labor supply in the REMI model is determined by demographic characteristics of the population, labor-participation rates, and migration. These projections are made in the demographic/migration module. Future size and demographic characteristics of the population are estimated by applying fertility and survival rates to different cohorts (Equation (28), p. 15). The population of each cohort is then multiplied by the estimated potential labor-participation rate and summed across cohorts to derive the potential labor supply.

Migration is separated into four types: international, retired people, economic migrants, and the return of former military personnel and their dependents to the civilian population. International migration is determined as a fixed regional share of U.S. international migration. Retired migrants are calculated as a function of regional amenities and the percentage of the population over age 65. Amenity attractiveness is estimated as the regional-to-national ratio of the amenity level, with no distinction being made among amenities, such as availability of private and public services, welfare programs, and public-housing services.

Economic migrants come from the part of the national population under 65 years of age who were part of the civilian population in the preceding year. Interregional economic migration is assumed to respond positively to increasing economic opportunities and better amenities (Equation (32), p. 18). Economic factors include relative employment opportunity, relative wage rates, and the relative mix of wages between high- and low-income employment. Employment opportunity refers to expected income, calculated as the relative wage rate multiplied by the probability of getting a job. Economic migrants respond to migration opportunities in the current and subsequent years based on a three-year distributed lag and an implicit assumption that prospective migrants have perfect information about relative economic opportunities, relative wage rates, the relative wage mix, and regional amenity factors in different areas. There is no restriction on migration. The demands for and supplies of factors of production are then used to determine production costs, prices, and profits.

The number of military personnel returning to the region is determined by the region's share of total population within the United States.

Production-Cost, Price, and Profit Linkages

In the REMI model, both profits and commodity prices are assumed to be related to production costs. Total production cost is the sum of all input costs, including labor, capital, fuel, and other materials (Equation (40), p. 20). These production costs are directly related to input costs and inversely related to factor productivity. The mechanisms whereby production costs affect an industry differ depending on whether the industry sells to local or national and international markets.

The demand for products sold outside the region (both nationally and internationally) is estimated to be the share of the U.S. market controlled by local producers. This depends on the level of local production costs relative to the national average. For national industries, it is possible that local production will be too small relative to the entire market to change national prices significantly. Thus, if locally based industries can maintain average costs below the national average, they may earn profits (quasirents) above and beyond normal returns to capital. These profits will then attract new firms to locate in the area. For locally marketed goods, profits are not calculated, because profits beyond normal returns to capital are assumed to disappear rapidly as new firms enter the business and drive prices down. Instead, the main direct economic impacts of local cost changes are on input substitution. For instance, when the demand for labor increases, wage rates will rise, increasing the relative attractiveness of capital. The other main effect of changing relative prices is on the ability of local producers to control some share of national markets and exports. We consider this next.

Market-Share Linkages

In the REMI model, there are two different important types of market shares. The first is the share of demand within the region met by local producers, which is approximated by regional purchase coefficients (RPCs).[10] The second is the share of markets outside the region supplied by locally based industries. The market share of a local industry is assumed to reflect its competitiveness relative to similar industries elsewhere in the nation. Industries are assumed to be homogeneous and to compete exclusively on the basis of price; other forms of competition, such as quality, service, and technological innovation, are assumed to have no effect on the market shares of local industries.

In the REMI model, initial market shares are determined for a base year. The base year is the most recent year for which complete data are available. After that, changes in market shares are influenced by changes in the relative competitiveness of local industries and by changes that cause markets to expand or contract. For national industries, the export share is calculated as the share of national final demand met by local producers, which is determined by changes in local profitability that cause local and nonlocal firms to enter the local market. For regional industries, changes in market share are calculated as the share of local demand met by local producers--the RPC. The base-year RPC estimates are taken from the cross-section equations applied to the most recent local employment data and estimates from the 1977 Census of Transportation for 466 industries, aggregated to 53 industries. The RPC may change if the national propensity to import changes. Finally, both

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[10] The RPC technique is discussed in a number of publications, including Stevens, Treyz, and Ehrlich (1979) and Stevens, Treyz, and Lahr (1989).

the RPC and export share may change if the mix of industries changes, causing the aggregation from 466 sectors to 53 sectors to weight different industries more or less heavily.

Any changes made to the REMI model through policy variables will go through these five linkages from which a new set of economic indicators, such as employment and the price level, are calculated, which reflect the estimated economic impacts of the exogenous shock to an economy.

Evaluation of the REMI Model

Policymakers often rely on regional economic models to assist them in formulating and revising important policies. Partly because of this, and partly due to their significant investment in capital and labor, users of these models often expect perfection. The designers of these models are the first to explain that such perfection cannot be attained. Models, by definition, are simplifications of reality. Accordingly, they incorporate many assumptions about real economic systems that may only be true part of the time. More often than not, these models are based on imperfect data, especially at the regional level. Besides, at the current stage of development of regional economic models, no model is designed to assess socioeconomic impacts fully, in that important variables, such as health, quality of life, wealth, etc., either cannot be quantified or are not yet available in usual statistical series at the local and regional level. Most model designers concentrate solely on quantifiable economic impacts. Users, therefore, have to keep in mind the limitations of these models in designing or assessing socioeconomic policies.

In spite of these difficulties, however, regional models do have a major value to analysts who assess policy changes. In most cases, these models represent a significant advance over prior methods of analysis where policymakers or analysts relied upon less formal tools. Although information provided by these models are only approximate projections of the future impact of policy changes, decision makers can use them as important guidelines for making difficult policy decisions in the complex world.

Given these expectations concerning regional economic models, we evaluate the two versions of the REMI model used by the District's socioeconomic staff. We first discuss some of the merits of the model. We then propose some extensions of the model that may help the socioeconomic staff to improve their socioeconomic impact analyses using the REMI model.

Merits of the REMI Model

One of the advantages of using the REMI model is that it can be operated on personal computers. As personal computers become more sophisticated and affordable to the public, the REMI model will become more accessible to wider audiences, such as public agencies and private consulting firms. The increased application of the REMI model may make it a potential standard tool for economic-impact studies.

In addition, as more economic and other types of computer models designed to run on personal computers become available, the REMI model has a very favorable development path. Users may link it with other computer software and/or to exchange information with other packages. One good example is the experience of integrating the REMI model with the Energy 2020 model (Backus, 1991; Reed, 1991). Although we cannot generalize the possibility of linking the REMI model with other models based on a single experience, the ability of the REMI model to do that seems promising. Analysts will have to conduct more research to identify any possible theoretical and technical difficulties in integrating the REMI model with other models in the future.

Another very strong characteristic of the REMI model is that it gives users many options, such as many regular and translator policy variables, to assess economic impacts of a large variety of situations. As we have mentioned earlier, there are 1,096 regular and 58 translator policy variables in the model. With these policy variables, users can translate almost any policy change into, say, changes in final demand and/or costs of operation for specific industrial sectors and assess the direct, indirect, and induced effects of these changes to other sectors and to the economy as a whole.

The drawback of providing so many options to users is the increase in the complexity of the model. To make the best use of the different options provided by the model, users may have to invest a fair amount of time and energy to get themselves acquainted with the model and to think carefully about which REMI policy variables to change. Also, they may have to compile detailed information and statistics for the primary impacts of the affected industries before running the model.

Good documentation of the operation and structure of the REMI model will definitely help users to learn how to use it. Based on our experience of working with the REMI model since 1986, the REMI staff have made tremendous progress in documenting the model in the past several years. Their current documentation of the model is relatively good for a computer model this complex, but we believe that they must continue to provide better documentation for certain aspects of the model, such as more detailed explanation of the policy variables and a less technical description of the model structure.

Related to helping users to learn to operate the model, the REMI staff also provide good technical assistance to their clients. Currently, they organize an annual conference for clients, the purpose of which is to inform the REMI users of any modification and/or update of the model. Based upon our experience in attending the October 1991 conference, we feel that the conference is an effective channel of communication between the REMI model designers and users. In the conference that we attended, the REMI staff provided training to users in interpreting the REMI forecasts with hypothetical examples. They also identified which tables among the massive printouts of the model are most informative and discussed some of the theoretical and technical issues of the model. Besides, the REMI staff also took the opportunity to get feedback from their clients on using the model. Many of the current revisions of the model are based on the comments from users expressed in past conferences.

In addition, REMI clients have relatively unlimited access to the REMI staff. Users of the model can write to or phone the REMI staff when they encounter problems in operating the model. This type of user-support system, to some extent, reduces the unfriendliness of the model and the chance of making errors in interpreting the results and/or the operation of this complex model.

Another special feature of the REMI model is that the REMI staff try to preserve the economic characteristics of the local economy by calibrating the REMI model using local data. Ideally, we would prefer a model that is designed specifically for the South Coast region. Because of the imperfection and limited availability of local data, the REMI staff calibrate a national model based on available local data and different types of proxies. Given the technical constraints, this is a reasonable attempt to make the national model applicable to the region. Most multiregional models, including the District's REMI model, do not account for interregional feedback. Clients of the REMI model can, however, ask the REMI staff to modify the model to account for this feedback. Besides, users have other means in the REMI model to improve the calibration over time. If users, for example, have special knowledge about the regional economy, they can calibrate the control forecasts of the model through the ADJREG procedure. (See REMI, 1990, Chapter 16.) Learning how to make an appropriate and efficient use of this option will, however, require a consistent and dedicated long-term effort by users. Users can also prepare regular short- or medium-term forecasts that can be compared to real data. Over time, they would probably be able to learn how biased their REMI model is under different conditions locally. There are certainly many other points about the REMI model. These are only those that appear to be particularly relevant to the current work of the District.

Sensitivity Tests of the REMI Model

When the District purchased the REMI model, it asked Cassing and Giarratani to test the simulation performance of the model. Cassing and Giarratani (1990) tested the responses of the model to changes in the cost of production and the effects of an export shock. In both cases, they found that the REMI model responded properly to these changes, both in terms of the direction and size of the forecasts.

In our study, we perform similar tests, but take a slightly different approach. We examine how sensitive the economic-impact estimates of the REMI model are to changes in the input figures of the regular policy variables and of the wage response, and we focus on the sensitivity of economic-impact estimates on jobs, real gross regional product, and real disposable income, rather than the total forecasts for these indicators, for two reasons. First, the District's socioeconomic staff use the REMI model primarily to estimate the job impacts of air-pollution control rules or regulations, not to forecast the total change of employment. Second, the employment impacts of an individual rule are often extremely small and/or negligible. We therefore conduct sensitivity analyses in terms of changes in the job-impact estimates rather than in terms of changes in the simulated forecast.

We conduct the sensitivity tests on the Amendments to Rule 1135 (hereafter referred to as AR 1135), a rule designed to reduce nitrogen-oxide (NO_x) emissions from the electric-power generating systems in the District.[11] The socioeconomic staff identified three categories of control technologies for complying with AR 1135: (1) combustion modifications, (2) flue gas treatment systems, and (3) alternative technologies (Rule 1135, p. 4-1, April 1991). They then calculated the costs of compliance based on the assumption that the utility would use the least expensive technology first. To model the economic impacts of AR 1135, the socioeconomic staff employed three types of policy variables: (1) changes in spending on the products of various sectors (DEMPOL), (2) increases in relative electricity costs for commercial users

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[11] Rule 1135 was adopted August 4, 1989 and was most recently amended July 19, 1991.

(REFPVC) and for industrial users (REFPVI), and (3) increased cost-of-living for consumers (CPI).

Based on their approach, we select three regular policy variables for our tests: Regular Policy Variable 680 (changes in demand for public utilities), Variable 941 (relative electric fuel costs for commercial users), and Variable 942 (relative electric fuel costs for industrial users). These tests help us to examine how an under-estimation or over-estimation of the input values to these variables may affect the results of the economic-impact assessment, and how the effect of an electricity cost increase for commercial customers may differ from that for industrial customers. We describe in detail our procedures of these tests in Appendix I.1.

In addition, we examine how sensitive the economic impacts are to wage-response changes. We select wage responses because the economic impacts of a rule may vary significantly depending on whether wage rates are responsive to the economic stimulants generated by that rule. In the REMI model, wage rates are assumed to adjust smoothly to changes in the labor markets. Some economists, however, argue that there is a long lag time in the downward adjustment of wages (Weitzman, 1984). We, therefore, examine how the wage response will affect the economic impacts obtained from the REMI model. We do this by comparing the REMI job estimates with the "wage response" on and off.

Tables 1 and 2 show the sensitivity of the economic impacts to changes in the input values of Variable 941, relative electric fuel costs for the commercial sector, and Variable 942, relative electric fuel costs for the industrial sector. A priori, we would expect that an increase in electricity rates increases the costs of production. This, in turn, leads to a higher job loss compared with the original estimates. The results of our sensitivity analyses indicate this to be exactly the case. An increase (decrease) in the input values of Variable 941 or 942 is associated with an increase (decrease) in the negative employment impacts of AR 1135 on the regional economy. A 20 percent decrease in the input values of Variable 941, for example, reduces the estimated jobs lost by 56 jobs (24 percent of the original job impact), with an elasticity of 1.18 (see Table 1).

The economic impacts are more sensitive to changes in relative electric fuel cost for commercial users than for industrial users. The elasticity of the employment impact for Variable 942 is about 0.4 in 1995, and this is about one-third of the elasticity for Variable 941, which is 1.2 (Tables 1 and 2). This finding is consistent with the District's results that retail and service industries are the two sectors most adversely affected by AR 1135. One possible explanation may be that, unlike service industries, most manufacturing industries have more options, such as co-generation of electricity or modification of their production processes, to cope with an electric-rate increase.

The sensitivity of the economic-impact analyses also varies with economic indicators and years examined. The changes in the input values of Variable 941 or 942 result in a relatively large change in the employment impact but little change in real gross regional product (GRP) and real disposable income. Among the four years we examined, the 1995 economic impacts, not surprisingly, are the most sensitive to changes in the input values of Variable 941 or 942. A five-percent increase in the values of Variable 941, for example, leads to a six-percent increase in jobs lost in 1995, but only to a 2 percent increase in 2010.

Table 1

SENSITIVITY TEST OF THE REGULAR POLICY VARIABLE 941:
RELATIVE ELECTRIC FUEL COSTS FOR THE COMMERCIAL SECTOR, RULE 1135
(with the 1987 REMI Model)

Economic indicator	Year	Changes in the Values of Variable 941					
		+20%	+10%	+5%	-5%	-10%	-20%
Employment (no. of people)	1995	-59	-30	-15	14	28	56 *
		24.8%	12.6%	6.3%	-5.9%	-11.8%	-23.5% **
		1.24	1.26	1.26	1.18	1.18	1.18 ***
	2000	-81	-41	-21	19	39	79
		7.4%	3.7%	1.9%	-1.7%	-3.6%	-7.2%
		0.37	0.37	0.38	0.35	0.36	0.36
	2005	-82	-41	-21	20	40	81
		9.6%	4.8%	2.5%	-2.3%	-4.7%	-9.5%
		0.48	0.48	0.49	0.47	0.47	0.47
	2010	-66	-34	-18	15	30	64
		5.6%	2.9%	1.5%	-1.3%	-2.6%	-5.4%
		0.28	0.29	0.31	0.26	0.26	0.27
GRP (millions of 1977 dollars)	1995	-2	-1	-1	0	1	1
		50.0%	25.0%	25.0%	0.0%	-25.0%	-25.0%
		2.50	2.50	5.00	0.00	2.50	1.25
	2000	-3	-2	-1	1	1	3
		9.1%	6.1%	3.0%	-3.0%	-3.0%	-9.1%
		0.45	0.61	0.61	0.61	0.30	0.45
	2005	-4	-2	-1	1	2	4
		13.3%	6.7%	3.3%	-3.3%	-6.7%	-13.3%
		0.67	0.67	0.67	0.67	0.67	0.67
	2010	-4	-2	-1	1	2	4
		8.9%	4.4%	2.2%	-2.2%	-4.4%	-8.9%
		0.44	0.44	0.44	0.44	0.44	0.44
Disposable income (millions of 1977 dollars)	1995	-1	-1	0	1	1	2
		7.1%	7.1%	0.0%	-7.1%	-7.1%	-14.3%
		0.36	0.71	0.00	1.43	0.71	0.71
	2000	-3	-1	-1	0	1	2
		10.7%	3.6%	3.6%	0.0%	-3.6%	-7.1%
		0.54	0.36	0.71	0.00	0.36	0.36
	2005	-3	-2	-1	0	1	2
		9.4%	6.3%	3.1%	0.0%	-3.1%	-6.3%
		0.47	0.63	0.63	0.00	0.31	0.31
	2010	-2	-1	-1	1	1	3
		5.1%	2.6%	2.6%	-2.6%	-2.6%	-7.7%
		0.26	0.26	0.51	0.51	0.26	0.38

Source: Calculations by the MIT multiregional planning research staff.

Notes: * Change in the estimated job impacts resulting from a one-time percentage change in the input value of Variable 941.

** Percentage change in the estimated job impacts.

*** Elasticity, which is the ratio of the percentage change in the estimated job (GRP or disposable income) impacts to the percentage change in the input values.

Table 2

SENSITIVITY TEST OF THE REGULAR POLICY VARIABLE 942:
RELATIVE ELECTRIC FUEL COSTS FOR THE INDUSTRIAL SECTOR, RULE 1135
(with the 1987 REMI Model)

Economic indicator	Year	Changes in the Values of Variable 942 +20%	+10%	+5%	-5%	-10%	-20%	
Employment (no. of people)	1995	-21	-12	-5	4	10	21	*
		8.8%	5.0%	2.1%	-1.7%	-4.2%	-8.8%	**
		0.44	0.50	0.42	0.34	0.42	0.44	***
	2000	-39	-20	-10	9	19	38	
		3.6%	1.8%	0.9%	-0.8%	-1.7%	-3.5%	
		0.18	0.18	0.18	0.16	0.17	0.17	
	2005	-45	-23	-10	10	21	43	
		5.3%	2.7%	1.2%	-1.2%	-2.5%	-5.0%	
		0.26	0.27	0.23	0.23	0.25	0.25	
	2010	-41	-21	-10	10	19	39	
		3.5%	1.8%	0.9%	-0.9%	-1.6%	-3.3%	
		0.17	0.18	0.17	0.17	0.16	0.17	
GRP (millions of 1977 dollars)	1995	-1	-1	0	0	0	1	
		25.0%	25.0%	0.0%	0.0%	0.0%	-25.0%	
		1.25	2.50	0.00	0.00	0.00	1.25	
	2000	-2	-1	-1	0	1	1	
		6.1%	3.0%	3.0%	0.0%	-3.0%	-3.0%	
		0.30	0.30	0.61	0.00	0.30	0.15	
	2005	-2	-1	0	1	1	2	
		6.7%	3.3%	0.0%	-3.3%	-3.3%	-6.7%	
		0.33	0.33	0.00	0.67	0.33	0.33	
	2010	-3	-1	-1	0	1	2	
		6.7%	2.2%	2.2%	0.0%	-2.2%	-4.4%	
		0.33	0.22	0.44	0.00	0.22	0.22	
Disposable income (millions of 1977 dollars)	1995	-1	-1	0	1	1	2	
		7.1%	7.1%	0.0%	-7.1%	-7.1%	-14.3%	
		0.36	0.71	0.00	1.43	0.71	0.71	
	2000	-3	-1	-1	0	1	2	
		10.7%	3.6%	3.6%	0.0%	-3.6%	-7.1%	
		0.54	0.36	0.71	0.00	0.36	0.36	
	2005	-3	-2	-1	0	1	2	
		9.4%	6.3%	3.1%	0.0%	-3.1%	-6.3%	
		0.47	0.63	0.63	0.00	0.31	0.31	
	2010	-2	-1	-1	1	1	3	
		5.1%	2.6%	2.6%	-2.6%	-2.6%	-7.7%	
		0.26	0.26	0.51	0.51	0.26	0.38	

Source: Calculations by the MIT multiregional planning research staff.

Notes: * Change in the estimated job impacts resulting from a one-time percentage change in the input value of Variable 942.

** Percentage change in the estimated job impacts.

*** Elasticity, which is the ratio of the percentage change in the estimated job (GRP or disposable income) impacts to the percentage change in the input values.

Table 3 displays the sensitivity of the economic impacts to Demand Policy Variable 680--demand for public utilities (SIC 49). We find that changes in the input value of Variable 680 have very little effect on the employment, real GRP, and real disposable income estimates. As shown in Table 3, the elasticity of the economic impacts with regard to Variable 680 is below 0.1 for most cases.

Table 4 shows the sensitivity of the economic impacts to the changes in the wage response. As expected, the suppression of the wage response reduces the negative impact of AR 1135 on employment in the South Coast economy. Again we find the highest change in 1995, with about 60 (25 percent) fewer jobs lost than the original job impact with the wage-response on.

Based on our sensitivity analyses, we conclude that the REMI model responds to changes in the selected policy variables and model assumptions logically and reasonably. We also find that the sensitivity of the economic impacts varies with economic indicators, different years, and with different policy variables. A small error in estimating input values of a particular policy variable may cause a large error in the economic impacts for some economic variables in some years (e.g., employment in 1995), but only a small error for others (e.g., disposable income in 2010). In addition, the economic impacts are more sensitive to changes in Variable 941 than Variable 942. This suggests that the socioeconomic staff may want to focus their attention on critical variables or assumptions, rather than to spread their resources equally in checking the accuracy and reliability of all the inputs used to estimate economic impacts.

Another major finding from our sensitivity analyses is that the economic-impact changes resulting from the changes in input values of policy

Table 3

SENSITIVITY TEST OF THE REGULAR POLICY VARIABLE 680:
AMOUNT OF DEMAND FOR PUBLIC UTILITIES (SIC 49), RULE 1135
(with the 1987 REMI Model)

Economic indicator	Year	Percentage Changes in the Values of Variable 680					
		+20%	+10%	+5%	-5%	-10%	-20%
Employment (no. of people)	1995	-5	1	0	-3	-5	-7 *
		2.1%	-0.4%	0.0%	1.3%	2.1%	2.9% **
		0.11	-0.04	0.00	-0.25	-0.21	-0.15 ***
	2000	5	2	0	-2	-5	-7
		-0.5%	-0.2%	0.0%	0.2%	0.5%	0.6%
		-0.02	-0.02	0.00	-0.04	-0.05	-0.03
	2005	5	3	2	-1	-5	-8
		-0.6%	-0.4%	-0.2%	0.1%	0.6%	0.9%
		-0.03	-0.04	-0.05	-0.02	-0.06	-0.05
	2010	7	3	1	-2	-5	-7
		-0.6%	-0.3%	-0.1%	0.2%	0.4%	0.6%
		-0.03	-0.03	-0.02	-0.03	-0.04	-0.03
GRP (millions of 1977 dollars)	1995	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		0.00	0.00	0.00	0.00	0.00	0.00
	2000	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		0.00	0.00	0.00	0.00	0.00	0.00
	2005	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		0.00	0.00	0.00	0.00	0.00	0.00
	2010	0	0	0	0	0	-1
		0.0%	0.0%	0.0%	0.0%	0.0%	2.2%
		0.00	0.00	0.00	0.00	0.00	-0.11
Disposable income (millions of 1977 dollars)	1995	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		0.00	0.00	0.00	0.00	0.00	0.00
	2000	0	0	0	0	0	-1
		0.0%	0.0%	0.0%	0.0%	0.0%	3.6%
		0.00	0.00	0.00	0.00	0.00	-0.18
	2005	0	0	0	0	-1	-1
		0.0%	0.0%	0.0%	0.0%	3.1%	3.1%
		0.00	0.00	0.00	0.00	-0.31	-0.16
	2010	0	0	0	0	0	0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		0.00	0.00	0.00	0.00	0.00	0.00

Source: Calculations by the MIT multireginoal planning research staff.

Notes: * Change in the estimated job impacts resulting from a one-time percentage change in the input value of Variable 680.

** Percentage change in the estimated job impacts.

*** Elasticity, which is the ratio of the percentage change in the estimated job (GRP or disposable income) impacts to the percentage change in the input values.

Table 4

SENSITIVITY TEST OF THE ESTIMATED JOB IMPACTS TO THE WAGE-RESPONSE (WITH THE 1987 REMI MODEL), RULE 1135

Economic indicator	Year	No Wage-Response
Employment (no. of people)	1995	60 * -25.2% **
	2000	49 -4.5%
	2005	25 -2.9%
	2010	42 -3.6%
GRP (millions of 1977 dollars)	1995	1 -25.0%
	2000	1 -3.0%
	2005	1 -3.3%
	2010	1 -2.2%
Disposable income (millions of 1977 dollars)	1995	0 0.0%
	2000	1 -3.6%
	2005	0 0.0%
	2010	1 -2.6%

Source: Calculations by the MIT multiregional planning research staff.
Notes: * Changes in the estimated job impacts resulting from the suppresion of the wage response.
** Percentage change in the estimated job impacts, calculated from economic impacts with a wage response as a base.

variables or model assumptions are very small. This indicates that the results are not sensitive to small biases or errors in preparing inputs to the REMI model, which raises a fundamental question about the appropriateness of using the REMI model to study the economic impacts of an individual rule. Because the economic impacts of some rules are very small, they can be statistically meaningless. We, therefore, recommend that, for certain cases, the socioeconomic staff should examine the economic impacts of a collection of rules rather than to conduct an economic-impact analysis on a rule-by-rule basis. Because SB 1928 and AB 2061 appear to require a rule-by-rule analysis, the socioeconomic staff may need to get the existing laws amended or perform cumulative analyses as supplements to the rule-by-rule analysis.

We believe that sensitivity analyses are underutilized by the socioeconomic staff and present an important way for them to improve their analyses. As we did for our evaluation of the estimates (Appendix VII), they can conduct sensitivity analyses to evaluate the responsiveness of the REMI model to changes in model assumptions and/or exogenous variables and to determine how different estimated input values may affect the results of their analyses. They may also perform sensitivity analyses to approximate the effects of some unquantifiable or hard-to-model variables. After determining, for example, how electricity conservation may affect the economic impacts of AR 1135 by examining the relationship between electricity conservation and electric-rate increases, they could perform sensitivity analyses of electric-rate policy variables. They can use a similar approach to examine how different options may affect the South Coast economy and help to ease obstacles in implementing air-pollution control rules or regulations.

As we have mentioned earlier, no model can provide all the necessary information for policy decisions, and the REMI model is no exception. In the process of our review, we identified possible modifications and extensions of the REMI model that may further improve the socioeconomic staff's application of the model to assess socioeconomic impacts of environmental regulations.

Extensions of the District's REMI model

We propose two major extensions of the model. First, we discuss the issues of how the REMI staff aggregate the economic information for 466 sectors from the input-output table into 53 sectors and "regionalize" this interindustry information to calculate the REMI forecasts for the South Coast. Second, from the District's point of view, we argue that they should ask the REMI vendor to supply a version of the REMI model that the socioeconomic staff can use to generate more disaggregated forecasts. We discuss each of these extensions in detail.

As we have stated, the REMI model is composed of three modules--the input-output module, the demographic/migration module, and the standard module. The input-output module contains detailed interindustry information for 466 sectors. This information is aggregated into less detailed interindustry data and passed along to the standard module for calculation of the control and stimulation forecasts. During the aggregation process, 466 industries at the four-digit standard industrial classification (SIC) level are grouped into 53 sectors at the two-digit level. The REMI staff then regionalize the national 53-sector input-output coefficient table based on the regional purchase coefficients for the four South Coast counties to get the regional input-output tables. They must make the very important assumption in this operation that industries that are aggregated into one of the 53 sectors have the same product mix, input prices, and production technology.

The degree of heterogeneity of product mixes, regional input prices, and production technologies of different industries within two-digit sectors is certainly an empirical question. We can, however, speculate that the chance of having industries with distinct structures for these three elements is very high at the two-digit SIC level. The Motor Vehicle & Motor Vehicle Equipment (SIC 371) and Aircraft & Parts (SIC 372) industries, for example, are grouped into the two-digit SIC 37 sector, Transportation Equipment. We cannot, however, assume that these two industries have similar technologies in terms of combining capital, labor, and material inputs in their production process. Besides, categories of nonmanufacturing sectors, such as the Construction and Service sectors, are so aggregate that they may contain industries that produce many different types of goods and services. Because these industries may not share common characteristics and patterns of employment, forecasting based on aggregate data for them may not produce as accurate of economic-impact estimates as desired by the District.

One way to deal with the problem, though not a perfect solution, is to regionalize the 466-sector national input-output table first, then aggregate the detailed interindustry data to a less-detailed level. This method will minimize potential errors from deriving the regional tables by using highly aggregated regional purchase coefficients (RPC) and technology coefficients. In the REMI documentation (REMI, 1990, Vol. 1, Sect. 5), the RPC data are already provided at the four-digit level for each of the four counties, so that we assume the calculation of these tables will not create a major problem.

The second related issue is the level of detail that users can obtain from the REMI model. Currently, they can obtain job-impact estimates only for two-digit industries at the county level. We feel that the District would benefit if its socioeconomic staff could obtain more disaggregate forecasts in terms of sectoral and geographical detail. To say, for example, that 60 jobs will be lost in the electronic equipment sector may not be very useful unless we can identify which specific industries within this sector and which communities within the four counties will absorb the jobs losses. Sixty jobs lost will certainly have very different socioeconomic impacts on, say, industries that are dominated by large corporations than on industries that are mainly composed of small firms. Similarly, 60 jobs lost will affect a community differently, depending on the level of income and density of population of the neighborhood. Given the current concern with job losses in defense-related industries, some of the additional sectors that should perhaps be considered for separate inclusion in the REMI model are: aircraft, computers, computer services, electronic components, missiles, radio and television broadcasting, and search and navigation instruments.

Increasing precision in terms of data used by the REMI model and outputs generated from the model, however, is not costless. If the REMI staff were asked by the District to aggregate the model from the 466-sector interindustry data into more than the current 53 sectors, we know that the running time of the model will be increased, although we do not know, at present, by how much. Besides, if the socioeconomic staff do obtain more detailed information, they may need to increase their analytical expertise to use the model wisely, and the costs of training and the time required to analyze the information may also increase. We do not suggest that a more complex and precise model will necessarily lead to "better" projections. The socioeconomic staff will have to consider the tradeoffs between having more detailed data and their ability to understand and present results of the REMI model well. We believe that the current staff is able to cope well with the increased detail. If the District decides to continue to use the REMI model, we recommend that they request the REMI staff to provide them with a model that contains more than a two-digit level of detail.

Up to this point, we have focused our evaluation of the District's REMI model on its generic features and have not examined the Fulton and Grimes' adjustments. Fulton and Grimes recalibrate the REMI baseline forecasts, thus modifying the job-impact estimates of the model. An analysis of their adjustments is, therefore, an indispensable part of our evaluation of the District's REMI model. In the next section of this report, we analyze how the Fulton and Grimes' adjustments affect the modeling operations of the District.

FULTON AND GRIMES' ADJUSTMENTS

The major objective of the Fulton and Grimes' adjustments is to make the REMI forecasts consistent with the employment and population projections of the Southern California Association of Governments (SCAG) for the years 2000 and 2010 (Fulton and Grimes, 1991b, p. 1). As we will show, the task Fulton and Grimes (F&G) was given was not very well conceived. Although they did a reasonable job in performing the task, given the constraints they were given, we have found several aspects of their work that need improvement if they continue to make adjustments to the REMI model. We focus our analysis of the Fulton and Grimes' adjustments on two issues: (1) the reasons for undertaking the adjustments and (2) whether or not the rationale and methods used by

Fulton and Grimes were appropriate. In order for the reader to understand the two issues, we must first briefly discuss the reasons for the differences between the SCAG forecasts for the South Coast and those obtained using the original REMI model.

The SCAG projections are prepared by the Center for Continuing Study of the California Economy (CCSCE). The REMI and SCAG forecasts differ mainly because the REMI and CCSCE analysts use both different sources of employment data and different forecasting methods. Specifically, for the data, the REMI analysts use employment, wage, and personal income data published by the Bureau of Economic Analysis (BEA), national employment projections from the Bureau of Labor Statistics (BLS), and County Business Patterns data to prepare their employment and population forecasts (REMI, 1990, p. 4-1). The CCSCE analysts, on the other hand, use BLS and California Employment Development Department (EDD) data (Levy, 1990, p. 1). To obtain the forecasts, the REMI staff use the REMI model, described above, while the CCSCE analysts use a shift-share procedure, explained below.

First, we try to understand the reasons for carrying out these adjustments. The District seems to interpret Section 40460 of the Health and Safety Code as a requirement that they are legally obligated to match both the employment and population forecasts of SCAG.[12] If matching the employment and population forecasts of SCAG will only complicate their procedure and not improve the performance of the District's socioeconomic studies, the District may want to ask for a modification of the law.

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[12] We interpret the statute differently. We believe that the District is required to match only the population forecast of SCAG; even so, if the District decides to match forecasts, they probably should do so for both the employment and population estimates because of their interrelationships in the REMI model.

We note that matching the REMI control forecasts of employment and population for 2000 and 2010 with the projections of SCAG does not necessarily mean that the REMI and SCAG estimates are "consistent." First, the REMI model forecasts are still based on parameters that are estimated using the BEA historical data. Second, the REMI and SCAG staff also use different methods to forecast the future South Coast employment and population growth.

It is beyond the scope of our evaluation to examine the reasonableness of the specific sections of the Health and Safety Code. Yet, it is our responsibility to explore all possible means to improve the District's modeling efforts. Assuming that laws can be changed or the interpretation of laws can be modified, we propose, at the end of this report, three options to resolve the adjustment issues.

We will now examine the rationale and appropriateness of the methods that Fulton and Grimes used to carry out their adjustments to the REMI model. In other words, we want to understand why they used certain procedures and how they derived the values for their adjustments to the model. To achieve these objectives, we begin by presenting data from a series of sample model runs to compare results from the original four-county REMI model, developed by the REMI staff for the District (REMI, 1989; REMI, 1990), with those from the F&G REMI model, developed by Fulton and Grimes (1991). We use AR 1135 to make the comparisons. We then discuss key issues that arise in using each procedure in the F&G adjustments.

Differences Between REMI and F&G REMI Job-Impact Estimates

An essential question concerning the F&G adjustments to the REMI model is: To what extent does the F&G REMI model lead to significantly different estimates of job impacts of the environmental regulations on the South Coast regional economy? If the differences are small, the socioeconomic staff may have little to gain by making the adjustments. If the differences are significant, as we anticipate they will be, we need to investigate the reasons for the discrepancies and to determine which model the socioeconomic staff should use in preparing their analyses.

At times, in fact, the socioeconomic staff may want to use the two models. If self-employment seems to play an important role in estimating job impacts, for example, they may want to check its importance by making estimates with both the original REMI model and the F&G REMI model. They can examine the estimates of the two models to understand how different assumptions may affect their projection of jobs lost or gained. They can then present these results based on a set of assumptions and alternatives to policy makers and the public so as to assist them in making policy decisions.

We first examine the job-impact estimates of all rules that we reviewed and obtain the cumulative and average job impacts estimated for those rules prepared by using different versions of the REMI and the F&G REMI model. (See Table 5.) The average of the estimated annual jobs gained or lost are 69 and 277 jobs, respectively. Unfortunately, these average figures are not particular helpful, because there are a few rules that have exceptionally small job impacts. For example, the annual job-loss estimates for the amendment to Rule 1113 and Rule 1406 were 3 and 4 jobs, respectively. Examining the job-impact estimates for each individual rule, we find that the majority of the rules have job-impact estimates ranging from approximately 148 to 554 jobs lost.

To investigate the differences in the two models in more depth, we selected AR 1135 for our analysis partly because the number of estimated jobs

Table 5

RULES ASSESSED WITH DIFFERENT VERSIONS OF REMI, F&G REMI, OR WITHOUT REMI
(From January, 1990, through December, 1991)

RULE NO.	DATE (yy/mm/dd)	TITLE	NO REMI	REMI 1987	F&G REMI 1987	F&G REMI 1988	INTEGRATED REPORT	Job Impacts Lost	Job Impacts Gained
1130A	900100	Graphic Arts	X						
108	900216	Alternative Emission Control Plans	X						
1124A	900216	Aerospace Assembly & Component Coating Operations	X						
1401	900300	New Source Review of Carcinogenic Air Contaminants	X						
301.2A	900300	Fee Schedules	X						
431.1A	900330	Sulfur Content of Gaseous Fuels	X						
431.2A	900330	Sulfur & Aromatic Hydrocarbon Content of Liquid Fuels	X						
Reg 15	900500	Trip Reduction/Indirect Source	X						
301A	900517	Permit Fees	X						
1110.2	900700	Emissions from Gaseous- & Liquid-fueled Internal Combustion Engines		X				1500	122
1162A	900712	Polyester Resin Operations	X						
1102A	900724	Petroleum Solvent Dry Cleaners	X						
1174	900900	Control of Volatile Organic Compound Emissions from Ignition of Barbecue Charcoal	X						
1146.1	901000	Reduction of NOx by Use of Low-NOx Burners		X				350	162
1405	901000	Control of Ethylene Oxide & Chlorofluorocarbon Emissions from Sterilization or Fumigation Processes	X						
1129	901000	Aerosol Coatings		X				409	
1168A	901100	Control of Volatile Organic Compound Emissions from Adhesive Application	X						
1153	901100	Control of Volatile Organic Compound--Emissions from Commercial Bakery Ovens	X						
1411	910100	Recovery or Recycling of Refrigerant from Motor Vehicle Air Conditioners			X				262
1406	910100	Control of Dioxins Emissions from Medical Waste Incinerators		X				4	
1122A	910300	Solvent Cleaners (Degreasers)			X		X	40	4
1414	910300	Asbestos-Containing Serpentine Material in Surfacing Applications	X						
1410	910319	Hydrogen Fluoride Storage and Use			X		X	293	15
1179	910520	Publicly Owned Treatment Works Operations	X						
1415	910530	Reduction of Chlorofluorocarbon Emissions from Stationary Refrigeration and Air-conditioning Systems				X	X		141
1171	910620	Solvent Cleaning Operations				X	X		4
1142	910625	Marine Tank Vessel Operations				X	X	304	53
1135A	910625	Emissions of Oxides of Nitrogen from Electric Power Generating Systems			X		X	554	69
1151A	910726	Motor Vehicle and Mobile Equipment Nonassembly Line Coating Operations						148	
1113A	910826	Architectural Coatings				X	X	3	
1130.1	910726	Screen Printing Operations				X	X	20	3
					Average job-impact estimates			302.1	75.9
					Cumulative job-impact estimates			3,625.0	835.0

A = amendment
yy = year
mm = month
dd = day
Source: Compiled by the MIT multiregional planning research staff.

lost (554) was sufficiently high that detailed results may be significant and partly because cost data are readily available from the District. Table 6 shows the differences in the employment impacts of AR 1135 for 1995, 2000, 2005, and 2010, estimated using the 1987 version of the REMI and F&G REMI models. For each model, we calculated the job impacts by subtracting the control forecast of the model from the employment forecast that incorporates the impacts on employment of PAR 1135. The numbers that are not in percentages in Table 6 represent the changes in employment between the simulation and control forecasts; the percentages are derived by dividing these numbers by the job-impact estimates of the F&G REMI model. For each of the selected years, both models project net job losses due to the amendment made to Rule 1135. If, however, the socioeconomic staff had used the REMI model (rather than the F&G REMI model) for its job-impact assessment of the rule, they would have predicted 31.5, 13.4, 14.0 and 8.0 percent larger job losses for the years 1995, 2000, 2005, and 2010, respectively.

We have two observations. First, the difference between the two models is relatively significant for the 1995 employment estimates. Second, many of the relative differences for certain nonmanufacturing industries are also rather large. The three sectors most affected are (1) Finance, Insurance, & Real Estate, (2) Services, and (3) Agriculture, Forestry, & Fishery Services.

Our concern with the large relative differences is best illustrated with an example. Assume that a rule with the same characteristics as AR 1135 would cause a decrease in employment in the services industry of 1,300 jobs instead of 130 jobs in 1995 (see Appendix I.3), which is a somewhat larger figure than the socioeconomic staff usually obtains, but is within the realm of possibility. In their economic-impact reports, the District staff actually

Table 6

COMPARISON OF REMI AND F&G REMI JOB-IMPACT ESTIMATES FOR RULE 1135

Sector	1995	2000	2005	2010
Manufacturing	2 1.5%	7 (6.3%)	10 25.0%	16 (15.1%)
Durables	1 0.7%	4 (5.9%)	6 7.3%	9 (14.8%)
Nondurables	1 (5.9%)	3 (6.8%)	5 (11.9%)	7 (15.6%)
Nonmanufacturing	(60) 19.6%	(137) 17.2%	(115) 16.0%	(107) 12.3%
Mining	0 0.0%	0 0.0%	(1) 100.0%	(1) 50.0%
Construction	(1) 7.7%	(2) 3.7%	(2) 4.1%	(1) 1.6%
Transport & public utilities	0 0.0%	(1) 3.3%	(1) 4.0%	0 0.0%
Finance, insurance, & real estate	(18) 43.9%	(35) 39.3%	(32) 36.8%	(34) 33.7%
Retail trade	(5) 4.8%	(10) 4.6%	(4) 2.1%	1 (0.5%)
Wholesale trade	0 0.0%	0 0.0%	2 (4.7%)	6 (9.4%)
Services	(32) 24.6%	(80) 23.7%	(70) 22.1%	(71) 18.3%
Agriculture, forestry, & fishery services	(4) 133.3%	(8) 114.3%	(7) 100.0%	(8) 100.0%
Total government	0 0.0%	0 0.0%	0 0.0%	3 (2.6%)
State & local government	0 0.0%	0 0.0%	0 0.0%	2 (1.8%)
Federal government--civilian	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Federal government--military	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Farm employment	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Total employment	(57) 31.5%	(130) 13.4%	(105) 14.0%	(87) 8.0%
Population	2 (2.6%)	(4) 0.3%	8 (0.6%)	48 (2.2%)

Note: Value figure is REMI minus F&G REMI. Percentage figure is REMI minus F&G REMI divided by F&G REMI. Numbers in parentheses are negative.

Source: Calculated from data in Appendices I.1 and I.2.

use average annual employment figures, rather than the figure for any given year. Based on our calculations, the decrease in jobs would be 24.6 percent, or 320 jobs, more if the estimation were done using the REMI model rather than the F&G REMI model. (See Table 6.) As expected, given the increasing importance of the services industry in the Los Angeles basin, analysts may obtain a seriously different job-impact estimate for this particular industry if they use REMI, instead of the F&G REMI, model.

Even if differences for a specific rule are small, the cumulative effects of several rules may be large. We therefore recommend that the socioeconomic staff perform cumulative socioeconomic impact assessments on several rules that were legislated within a certain period of time. Because of a larger base for the cumulative effects, even a small percentage difference in job-impact estimates between the F&G REMI and the REMI model can lead to a very large difference in projecting total jobs lost or gained. Based on these observations, we conclude that differences in the forecasts of the two models can be significant, especially for the nonmanufacturing sector. We now discuss the major causes of these differences in the forecasts of the two models.

Differences Between the REMI and F&G REMI Models

As we noted above, there are two reasons that job-impact estimates between the REMI and the F&G REMI model are different. First, the forecasts of the REMI and the F&G REMI use different data sets that do not have similar employment coverages and sources of information. Although the forecasts of the REMI model are based mainly on data from the U.S. Bureau of Economic Analysis (BEA), supplemented by ES-202 and County Business Pattern data, the forecasts of the F&G REMI are derived from recalibrating the BEA-based REMI forecasts to match SCAG estimates that are based on data from the U.S. Bureau of Labor Statistics (BLS). Partly because the BEA and BLS data sources and coverage differ, REMI and F&G REMI analysts obtain different forecasts. In Table 7, we illustrate the differences between the two sets of data. There are two major sets of data from the BLS--the household and the establishment data. We compare these BLS data sets with the BEA data in terms of their differences in treatment of self-employed, sources of information, tabulation, inclusion of military jobs, and estimated employment in the "underground" economy.

According to the BEA and BLS staff with whom we conferred, the differences between the BEA and BLS estimates of jobs are mainly due to the way in which self-employed persons are handled (U.S. Bureau of Economic Analysis, 1992; U.S. Bureau of Labor Statistics, 1992). The BEA includes self-employed persons in its tabulation of employment, using Quarterly Unemployment Insurance Contribution report data. According to the BEA staff, "a worker with two jobs will be counted twice if (1) both of those jobs are for wages, (2) one of the jobs is for wages and the other is a proprietorship (including membership in a partnership other than a tax shelter), or (3) both of the jobs are proprietorships" (U.S. Bureau of Economic Analysis, 1992). For the BLS establishment data, self-employment is excluded.

For the BLS household data, self-employed persons are included, but persons who hold multiple jobs are only counted once. The BLS staff gather the information for self-employment from the annual Current Population Survey (CPS). Because of the very small sample from which these data are gathered, the CPS data need to be used with extreme caution. For the establishment

Table 7

DIFFERENCES AND SIMILARITIES BETWEEN BEA AND BLS EMPLOYMENT DATA

Item	Data Prepared by the Bureau of Labor Statistics: Household data	Data Prepared by the Bureau of Labor Statistics: Establishment data	Data Prepared by the Bureau of Economic Analysis
Sources of data	Current Population Survey conducted by the Bureau of the Census for the BLS. (Sample size may be small at very localized geographic scale.)	Employment, hours, and earnings from payroll reports filed by a sample of non-farm establishments (From BLS 790). It is benchmarked once each year to the ES 202 data.	1. Administrative records from the: -State unemployment insurance program--ES202 -Federal income tax program of the IRS. -Military payroll systems of the Dept. of Defense. 2. Census of population. 3. Census of agriculture. 4. Association of American Railroads.
Place of measurement	Place-of-residence basis.	Place-of-establishment basis.	Place-of-work basis for industries not covered by unemployment insurance (UI); Place-of-establishment for those covered by UI.
Concept	Worker-count basis.	Job-count basis.	Job-count basis.
Definitions	Employed persons include those who: 1. work as paid employees 2. work in their own business, profession, and farm 3. work 15 hrs or more as unpaid workers in a family-operated enterprise 4. have jobs but are absent from their jobs temporarily 5. Armed forces stationed in the U.S., but not abroad.	Employed persons include those who are: 1. salaried officers of corporations 2. civilian employees of government institutions 3. persons who are on payroll, but are on paid sick leave, on paid holiday or on vacation.	1. Annual average number of jobs held by persons who work for wages and salaries, including jobs held by persons who are on paid sick leave, holiday, or vacation; 2. Number of sole proprietorships active during the year; and 3. Number of partners in partnerships (other than tax shelters) active during the year.
Level of analysis		Information at national and state level is more extensive than BEA data, being provided for 3-4 digit sectors.	Information at the national and state level is provided for 1-digit and 2-digit and at the county level for 1-digit SIC sectors.
Geographical inclusion	Data available for metropolitan areas.		Data are available for all counties and all county-based metropolitan areas.
Tabulation	Each employed person is counted only once. Those who hold more than one job are counted in the job at which they work the greatest number of hours.	Employment data, except those for the Federal Government, refer to persons on establishment payrolls who received pay for any part of the pay period, which includes the 12th of the month. Persons who are on establishment payrolls more than once will be counted multiple times.	1. For UI-covered jobs, the annual average of the monthly employment observations in the ES-202 reports; estimates of unreported ("underground economy") employment are included; 2. For civilian wage and salary jobs in noncovered industries, national estimates of the annual average number of jobs allocated to States and counties in proportion to the geographic distribution of the best available source data; 3. For the military, the average annual number of active duty personnel and reservists in monthly reports of the military service; 4. For nonfarm self-employment, the sum of the number of nonfarm sole proprietorships and active partners in nonfarm partnerships reflected in Federal individual and partnership tax returns; 5. For farm sole proprietorships, number of sole proprietors and partners counted as operators of establishments defined as farms by the Dept. of Agriculture.

Item	Data Prepared by the Bureau of Labor Statistics: Household data	Data Prepared by the Bureau of Labor Statistics: Establishment data	Data Prepared by the Bureau of Economic Analysis
Treatment of: self-employed and household workers (2)	1. Includes household workers and unpaid family workers. 2. Self-employed workers holding more than one jobs are counted only once.	1. Excludes proprietors, the self-employed, farm workers, unpaid volunteer or family workers, and household domestic workers. 2. Employees of CIA and National Security Agency are excluded.	1. Included as the available data allows. 2. Treats household workers as wage and salary jobs and proprietors as nonwage business income earners. 3. Self-employed workers holding more than one job are counted multiple times.
Part-time workers	Included and persons who worked between 1 and 34 hours are designated as working part-time.	Payroll covers earnings and hours of work for both full- and part-time workers.	Handled basically the same as by the BLS.
Military	Count armed force stations in the U.S., but not abroad.	Excludes all military personnel.	Includes all full-time miltiary personnel and the members of the military reserves; data are supplied by the Department of Defense.
Volunteer workers	Not included.	Not included.	Not included.
Sectors not covered by the unemployment insurance system	These sectors are covered in the sample of the CPS.		Adjustments are made based on other data sources or allocation procedures (See U.S. Bureau of Economic Analysis, 1991, p. M-8).
Underground economy (3)	Not included.	Not included.	Included.

Sources: Stephen Levy's memos dated July 12, 16, and 18, 1990.

U.S. Bureau of Economic Analysis. 1991. The BEA State and Local Area Employment Estimates. Washington, DC: U.S. Bureau of Economic Analysis. Unpublished draft.

U.S. Bureau of Economic Analysis. 1990. Local Area Personal Income, 1983-88. Washington, DC: U.S. Printing Office. Vol. 5.

U.S. Bureau of Labor Statistics. 1988. BLS Handbook of Methods. Washington, DC: U.S. Government Printing Office.

U.S. Bureau of Labor Statistics. 1991. Employment and Earnings. Washington, DC: U.S. Government Printing Office.

Note:

We also obtained some of the information (1) about the BEA employment data from discussions with the BEA staff and from the methodology of income estimation describedin the Local Area Personal Income, 1983-88. Based on conversations with the BEA staff, we learned that they use the same methodology in estimating employment. (2) For the BEA and BLS data, we also relied on Stephen Levy's memos dated July 12, 16, and 18, 1990, to the South Coast Air Quality Management District.

data, the BLS staff benchmark the BLS-790 data once each year to the ES-202 data.

According to Levy (1990, p. 6), the treatment of self-employment accounts for approximately 65 percent of the difference between the BEA and BLS estimates. Although we do not have details on Levy's estimation method, his estimate seems reasonable when we compare it with the values used by Fulton and Grimes to carry out their FPD adjustments. In Table 8, we show the values for the FPD adjustments. The biggest adjustments are made to industries mostly in the Service sector, such as Household Services, Real Estate, and Personal Services. These are the industries that often have a large amount of self-employment. Although in aggregate, self-employed workers comprise only a small proportion of the total workforce, for individual industries they may represent a large proportion.

Levy also argues that about 19 percent of the difference is due to the inclusion of military jobs in the BEA, but not in the BLS, data. The BEA staff count all full-time military personnel stationed in the United States and the members of the military reserves as part of employment. They gather these data from the U.S. Department of Defense. On the other hand, the BLS household data only account for military forces, rather than all military personnel, stationed in the United States; and the BLS establishment data do not include any military employees. Levy also argues that the remaining difference between the BLS and BEA data is mainly because estimates of employment in the underground economy are included in the BEA, but not in the BLS, data. Fulton and Grimes note that "the BEA counts approximately 10 percent more employees than does the BLS" (Fulton and Grimes, 1992b, p. 3).

Table 8

VALUES USED TO ADJUST REMI EMPLOYMENT DATA IN THE FPD PROGRAM

Industry	Value
Household services	0.3712
Real estate	0.4250
Agriculture, forestry, & fishery services	0.4817
Personal services	0.5831
Mining	0.7480
Legal services	0.7493
Miscellaneous manufacturing	0.7710
Auto repair	0.7811
Nonprofit	0.8179
Amusement & recreation	0.8234
Movies	0.8350
Miscellaneous business services	0.8362
Educational services	0.8729
Transportation equipment	0.8857
Banking	0.9217
Trucking	0.9372
Medical services	0.9389
Eating & drinking	0.9459
Rest of retail	0.9459
Other transportation	0.9514
Insurance	0.9591
Local transportation	0.9633
Construction	0.9636
Hotels	0.9711
Motor vehicles	0.9715
Other finance	0.9721
Wholesale trade	0.9752
Apparel	0.9758
Communication	0.9806
Printing	0.9813
Stone, clay, & glass	0.9893
Nonelectrical machinery	0.9938
Fabricated metals	0.9941
Lumber	1.0000
Air transportation	1.0000
Public utilities	1.0000
Railroads	1.0000
Leather	1.0000
Tobacco	1.0000
Furniture	1.0075
Rubber	1.0218
Food	1.0282
Textiles	1.0367
Petroleum	1.0381
Paper	1.0387
Primary metals	1.0537
Chemicals	1.0652
Electrical machinery	1.0712
Instruments	1.1245

Source: George A. Fulton and Donald R. Grimes, 1991. "Recalibration of the Control Forecast for the REMI Model of the South Coast Region." Ann Arbor, Michigan: Regional Economic Associates and University of Michigan, p. 4.

The BLS staff have provided the following explanation of the BLS data:

> There are two sets of establishment data collected by the BLS in cooperation with State Employment Security Agencies: the BLS-790 (also known as the Current Employment Statistics, or CES) and the ES-202 (also called the Covered Employment and Wages, or Insured Employment and Wages). The ES-202 data are a quarterly census of employment covered under state unemployment insurance programs and the federal Unemployment Compensation for Federal Employees program.
>
> The ES-202 establishment-level administrative records provide the primary sample frame for the monthly BLS-790 survey of approximately 360,000 nonagricultural establishments. In addition, the ES-202 data are used as the primary "all employees" benchmark to adjust the BLS-790 estimates derived from the sample of establishments.
>
> Both the BLS-790 and ES-202 programs define monthly employment as the number of employees who received pay for the pay period which included the twelfth of the month. The ES-202 data will count only those employees who are covered by state unemployment insurance laws; thus, the difference in employment levels between the ES-202 and the BLS-790 data is "presumed to be noncovered." Unlike the BLS household survey data, both the BLS-790 and the ES-202 count jobs, not persons; therefore, persons with multiple jobs will be counted for each job which meets the BLS definitions above.
>
> The BLS-790 data exclude proprietors, self-employed, unpaid family workers, domestics, and members of the armed forces. These categories are generally not in the ES-202 data, either. In some states, however, the self-employed may elect to be covered in their state UI program, in which case they are counted by the ES-202 program. Typically, only a small percentage of the self-employed choose to be covered and pay UI taxes to the state.
>
> County-level ES-202 employment and wages data are provided on a quarterly basis to the BEA and are the major source of their employment data. BEA uses additional sources [refer to Table 7] to include categories of employment not shown in ES-202. Of these, the self-employed (proprietors) are the largest single group, but it is important to note that they make up a relatively small percentage of the total employment reported by the BEA. (U.S. Bureau of Labor Statistics, 1992.)

The second reason that may explain the difference in the job-impact estimates between the REMI and the F&G REMI models is that the CCSCE and the REMI staff use different methods to prepare their forecasts. The REMI staff use their multiregional econometric model, described above. On the other hand, CCSCE staff use a detailed shift-share analysis of South Coast industries to prepare their baseline employment projections for SCAG (SCAQMD, 1991, pp. 29-31, 40-53). To prepare these regional forecasts, the CCSCE staff first divide industries in the region into basic and nonbasic industries. They then estimate the employment for individual basic industries based on the region's share of the national and state projections of employment for these industries. With the projections of employment for the basic industries, they subtract the total basic industry jobs from the projected total jobs in the region to obtain the total nonbasic industry jobs. These nonbasic industry jobs are then allocated to each nonbasic industry, based on the industry's state share of the total state employment.

Because of these two fundamental differences--data and forecasting method--between the REMI and SCAG forecasts, the job-impact estimates of the REMI and the F&G REMI models are dissimilar. In order to determine whether Fulton and Grimes handle the major differences inherent in the two forecasts properly, we have to analyze their procedures in adjusting the model.

Procedures and Issues of the F&G Adjustments

Fulton and Grimes make four adjustments to the original REMI control forecasts through the: (1) FPD, (2) MULTS (multiplicative adjustments), (3) population-migration regular policy variable, and (4) EPOL (employment policy) procedures. They carry out the four procedures in sequence in order to minimize the effect of the recalibration on the operation of the REMI model. In Figure 2, we depict the F&G adjustments and the parts ("linkages") of the

REMI model they affect. In the following sections, we first discuss the general operation of the F&G adjustments and then give a detailed description of each procedure.

Initially, Fulton and Grimes alter the REMI control forecasts by running the model and adjusting the employment forecasts for major industries through the FPD program. With the adjusted employment and population forecasts, they then eliminate almost all of the remaining differences between the REMI and the SCAG projections by using three types of policy variables in the ADJREG procedure of the REMI model: (1) MULTS, (2) the population migration policy variable, and (3) the EPOL.[13] Fulton and Grimes adjust these policy variables and run the REMI model again to produce a new control forecast. If there are still differences between the REMI model and the SCAG employment and population forecasts, they continue the above iterative adjustment process until the two forecasts ". . . are very close by appropriate professional standards" (Fulton and Grimes, 1991b, p. 20).

The FPD Adjustment

Fulton and Grimes use the FPD adjustment to convert the REMI model employment forecast from the BEA employment estimate to that of the CCSCE, which is based on the BLS and EDD employment estimates. As shown in Figure 2, the FPD adjustment does not affect the operation of the REMI model, because the FPD program modifies the data file after it has exited the computer model. It aggregates detailed two-digit SIC forecasts into major one-digit SIC industry categories and prints output tables. In this procedure, Fulton and

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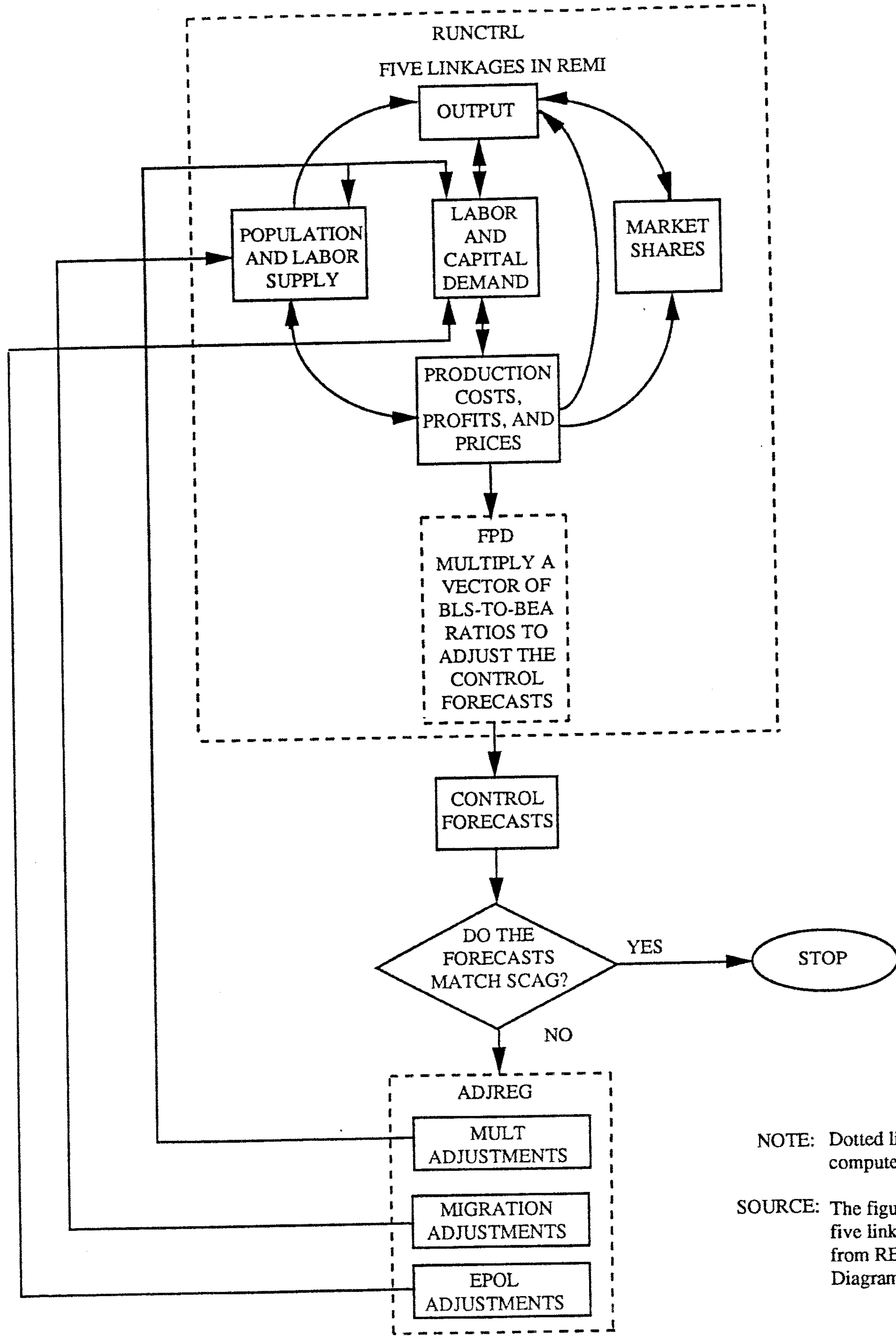
[13] For additional details of the ADJREG procedure, see the 1990 Operators' Manual published by the REMI staff.



NOTE: Dotted lines represent computer programs.

SOURCE: The figures for the five linkages are from REMI, 1990, Diagrams 2-3.

Figure 2. F & G ADJUSTMENT PROCESS

Grimes only modify the data file after it has exited the computer model, thus preserving the internal and operational integrity of the REMI model.

Table 8 above shows the vector of ratios Fulton and Grimes use to modify the data files. They first estimate the BLS-based employment for each industry, which includes the self-employed, and divide these numbers by the BEA employment for the corresponding industry to obtain the BLS-to-BEA ratios. Each entry in the vector represents the ratio of employment for each detailed industry. They then multiply the REMI control forecast by this vector of ratios and are able to reduce the differences between the REMI model and the SCAG employment forecasts by about two-thirds.

To construct the vector of ratios, Fulton and Grimes used 1987 BLS employment data for Los Angeles County, because the ". . . other [three] counties have missing information for industries, which has to be estimated, introducing potential error into the process" (Fulton and Grimes, 1992a, p. 10).[14] They then adjusted those data to include (1) estimates from ES-202 data for industries not covered in the original data and (2) an estimate for self-employed. In the FPD program, they included missing farming and military employment data directly from REMI employment forecasts, but the "REMI employment totals were calibrated to SCAG targets before the military was included . . ., so that the definitions would be consistent with SCAG's (Fulton and Grimes, 1991b, p. 8).

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[14] For the adjustments to the 1989 version of the original REMI model, they told us that they tried to obtain data for the four counties, but that the estimates made did not appear to be reasonable. Although we have not examined those estimates, we know that county employment data are sometimes rather unreliable. We recommend that they continue to work on making such estimates.

Early in 1992, Fulton and Grimes indicated that they ". . . are currently developing separate FPD ratio estimates for Los Angeles, Orange, and Riverside-San Bernardino counties for use in the 1989 version of the REMI model" (Fulton and Grimes, 1992a, p. 10). We were not able to construct separate ratios for the four counties, but we did examine how different total employment was for different industries in the four counties. We used County Business Patterns data, which is a different set of data than those employed in the model. Not surprisingly, we found that the industry structure for total employment in LA County is different from that in the other three South Coast counties. In Table 9, we show only those industries for which Fulton and Grimes made substantial adjustments in the FPD procedure (refer to last column of table). Within the manufacturing sector in LA county, the Instruments & Related Products industry is only 7.3 percent of total employment of this sector; whereas the percentage is 17.9 in Orange county. In other words, the Instruments and Related Products industry plays a relatively more important role in manufacturing sector employment in Orange County than in LA County. Similarly, the Real Estate sector employs a relatively higher percentage of workers in Riverside county (32.0 percent) than in other counties. In the Services sector, the Amusement & Recreational Services industry in all the other three counties has a higher percentage of employment than in LA County.

We assume that there may not only be large differences among the four counties in the structure of total employment, but that the structure of self-employment may also vary. If so, use of own-county employment ratios would be preferable to the current use of Los Angeles county ratios. For the 1989 version of F&G REMI, Fulton and Grimes attempted to incorporate "own-county

Table 9

PERCENTAGE OF EMPLOYMENT IN EACH INDUSTRY TO TOTAL EMPLOYMENT IN THE SECTOR FOR SELECTED INDUSTRIES, BY COUNTY

(percent)

Sector	County				Value in the FPD adjustment (Table 2)
	Los Angeles	Orange	River-side	San Ber-nardino	
MANUFACTURING					
Instruments & related products	7.3	17.9	3.9	2.0	1.12
Transportation equipment	3.4	0.3	0.1	0.2	0.88
FINANCE, INSURANCE, & REAL ESTATE					
Real estate	21.4	25.1	32.0	26.2	0.42
SERVICES					
Auto repair	0.8	0.2	0.1	0.1	0.78
Business services	4.3	1.5	0.2	0.3	0.84
Personal services	3.6	3.7	4.4	4.7	0.58
Amusement & recreation services	3.8	6.2	8.8	5.3	0.82
Motion picture	2.1	0.1	0.0	0.0	0.83
Legal services	0.9	0.2	0.0	0.0	0.75
MINING					
Oil & gas extraction	55.5	30.5	100.0	18.6*	0.75
Nonmetallic minerals, except fuel	10.9	11.7	n.a.	81.4	0.75
Administrative & auxiliary	33.1	57.8	n.a.	n.a.	0.75

Notes: * = estimated number.
n.a. = not available.

Source: Extracted from Appendix 3

FPD adjustments, but found that this procedure produced unreasonable estimates of self-employment for some of the industries in some of the counties" (Fulton and Grimes, 1992b, p. 4). We therefore recommend that they continue to try to find appropriate estimates to take specific account of geographic variations in self-employed persons for ratios used in the FPD procedure of F&G REMI.

MULT Adjustments and Population-Migration Policy Variables

Fulton and Grimes' second adjustment procedure is to adjust the industry employment growth and population migration estimates. They modify the employment growth rates by using the ADJREG procedure to reduce or increase the growth rates of the MULTS for selected industries for 1988-2010.

The use of the MULT adjustment makes the task of Fulton and Grimes more complicated. In fact, Fulton and Grimes can just use the FPD program or the EPOL procedure to adjust all the differences in employment forecasts between the forecasts of the REMI and SCAG. Although the simplest way to target a specific value is to use the EPOL procedure, it is very tedious. (We discuss the EPOL procedure in the next section.) Fulton and Grimes choose to separate the adjustments for the differences in data sources and projections of employment and population growth. The former adjustment is carried out by using the FPD program and the latter by the MULT adjustment. They believe that their adjustments should not be just to match SCAG forecasts, but to reconcile the fundamental differences between the two approaches of forecasting. We absolutely agree with them. Because of the lack of full documentation of the values used for making their projections, however, we have difficulty determining whether their adjustments are valid.

The MULT adjustment directly affects both the supply and demand for labor.[15] As shown in Figure 2, the adjustment enters into the population and labor supply and labor and capital demand linkages of the model. For population migration, they use the migration policy variable for the adjustment. Unlike the MULT adjustment, the migration adjustment changes the population figures and, thus, directly affects only the supply of labor. (See Figure 2.)

Fulton and Grimes use the industry growth MULTS for employment to "add or subtract a fixed growth rate to each of the forty-nine private sector industries . . . for each county" (Fulton and Grimes, 1991b, p. 8). The most important issue regarding the MULT adjustment is whether there are unexplained trends that result from problems of data measurement, misspecification of equations, or incorrect estimation of parameters. If they result from some identifiable and consistent source, a user can correct the problem by the MULT adjustment. In other words, if users of the REMI model have special knowledge about the economy they are analyzing that is not incorporated into the model structure, they can use the MULT adjustment to modify the control forecast in order to improve the forecast of the model.

According to Treyz and Shao, inclusion of the specific MULTs that the REMI staff include in the standard model does not necessarily improve the performance of the model.[16] They compare error statistics of REMI forecasts with and without activating the MULTS for two post sample periods, 1981-1988

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[15] We use the term "MULT adjustment" to refer to the procedure used and the word "MULTS" to refer to the numbers used in the procedure.

[16] This information is from a memo (REMI, 1991) furnished by the REMI staff and also from our discussions in the fall of 1991 with Treyz and Shao, President and Director of Development of the firm REMI, respectively.

and 1985-1988, and for 51 regions of the United States. Because they find that the mean absolute percentage errors for the forecasts of selected variables, such as total employment, personal income, real disposal income, and population, were smaller without the MULTS than with them, they conclude that there was no systematic misspecification in the REMI model across regions. Because full documentation of the research is not available, we cannot presently determine the accuracy and reasonableness of the tests used by the REMI staff. In their own baseline forecast, they do not use the MULT adjustment to account for the unexplained trends and do not recommend their clients to do so, unless the trend is expected to continue in the future.

Cassing and Giarratani (1990) express a somewhat different view in their paper. They believe that the MULT adjustment is an important procedure in the predictive function of the REMI model. In the "regular-MULT" model, the MULTS for the forecast years are estimated by two regressions, one using the historical data from 1969 to 1975 and the other using information from 1979 to 1988. If the unexplained trends captured by the MULTS will persist into the future, Cassing and Giarratani indicate that the inclusion of the MULT adjustment is fine (p. 11).

The authors also test the sensitivity of the forecast errors of the "fixed-MULT" [17] and the regular-MULT models. The fixed-MULT model uses the MULT for the last year of history as the ratio for subsequent forecast years, which is an alternative to the "regular-MULT" model (Cassing and Giarratani, 1990, p. 11). Although they find that the fixed-MULT model that uses 1980 as

[17] Cassing and Giarratani refer to this as the "No-MULT model" We believe that this term is misleading and have therefore called it the "Fixed-MULT model" instead, because MULTS are used, but are set to a fixed value of the last year of history.

the last year of history does better than the regular-MULT model, the results are mixed when they use 1985 as the last year of history. With 1985 as the last year of history, the authors find that the fixed-MULT model has smaller forecast errors for employment in the Electrical Equipment and Rest-of-Retail industries and higher forecast errors for employment in the Rest-of-Transportation Equipment and Miscellaneous Business Services industries and Gross Regional Product. Because of these mixed results, Cassing and Giarratani conclude that forecast errors are very sensitive to the choice of the MULT adjustment and believe that careful analysis should be done prior to using the MULT adjustment (p. 12).

These reactions from the vendor and researchers of the REMI model lead us to pay particular attention to the MULT adjustments made by Fulton and Grimes. Yet, we need to emphasize that the results of the above-mentioned studies do not necessarily imply that the MULT adjustment of the F&G adjustment is wrong. It only helps us to raise two basic questions: (1) Should the MULT adjustment be used at all in the F&G adjustment to the REMI forecasts? and (2) if so, do the adjustment values appear reasonable? In the F&G REMI model, the MULT adjustment is used to eliminate the differences that remain after using the FPD procedure between the REMI model and SCAG employment and population forecasts.

Fulton and Grimes assume that unexplained trends in the South Coast economy cause the differences in forecasts not accounted for by the dissimilarity in the BEA and BLS measurement and estimation of employment. According to the above-mentioned studies, analysts should only use the MULT adjustment when the unexplained trends are expected to be permanent. We think, however, that permanence is not the only criterion. Even if a trend is considered to be permanent, we would want to know the underlying structural reasons for the local trend prior to applying a given MULT.

The current determination by Fulton and Grimes of the values for the MULT adjustment to selected industries is heavily dependent on their knowledge about the South Coast economy. For their adjustments, they identify industries that will experience a different employment growth pattern than is projected by the REMI model, but in their report they do not document their selection rationale. They then modify the employment growth rates by altering the growth rates of MULTS for these industries. In order to obtain the same number as the SCAG employment forecasts, Fulton and Grimes do several trial runs.

Although Fulton and Grimes make the total number of employees forecast in the REMI model approximate the SCAG projection for 2000 and 2010, we cannot, at this point, determine whether their employment estimation in the F&G REMI model is "consistent" with it. To be consistent, we mean that both sets of estimates should not only have the same final value of total employment, but they should have a similar projection of the employment growth for industries in the economy. Without a full documentation of how Fulton and Grimes decide which industries should be adjusted, we are not able to compare the rationale and assumptions of the F&G method in forecasting employment growth for industries with the method used for the SCAG projections.

EPOL Adjustments

The last adjustment Fulton and Grimes make is to use EPOL, which are regular policy variables in the REMI model, to adjust the number of employees for selected sectors over time. The basic purpose of the EPOL adjustments is the same as for the adjustments to the MULTS and the population-migration policy variable, that is, to make the REMI and the SCAG forecasts match. Because of the rigidity of the MULT adjustment, users cannot vary it from one year to the next, thus perhaps imposing unrealistic paths of employment growth in the model. Unlike the MULT adjustments, the EPOL adjustments, in some cases, will not affect the differences between the employment projection of the control forecast and the simulation, because the modification carried out through EPOL is an additive adjustment, whereas the adjustment with the MULTS is a multiplicative adjustment. We agree with Fulton and Grimes (1992b, p. 6) that for the recalibration of the REMI employment forecast to be reflected in job-impact assessments for rules in all situations, the MULT adjustment should be used. The problem of using the MULT adjustment is that it changes the employment growth rate; this, in turn, makes the recalibration to target a specific employment numbers for the year 2000 and 2010 difficult. Besides, the EPOL adjustment will directly affect only the demand for labor. In Figure 2 above, we show that the EPOL adjustment enters into the labor and capital demand linkages in the model. The advantage of using EPOL rather than the MULTs is that EPOL allows users to adjust the number of employees of an industry with separate values for each year. This will make the matching of the employment estimates between the REMI model and the SCAG for the two targeted years simpler.

The issue of the EPOL adjustment is again related to the determination of the values of the adjustment for the selected industries. Fulton and Grimes apply the same method of deriving the values for MULTS to the EPOL adjustments, and we have discussed above the most important issues about the determination of the values for the MULT adjustment. In addition, by providing additional documentation, Fulton and Grimes will help the socioeconomic staff to understand better than at present some of the many factors that may affect particular forecasts using the F&G REMI model.[18]

Potential Options

After reviewing Fulton and Grimes' adjustments, and from discussions with Fulton, Grimes, Shao, Treyz, and the socioeconomic staff, we propose three options for dealing with some of the issues related to the F&G adjustments, assuming the District continues to use the REMI model for socioeconomic assessments. These options include (1) use the original REMI model to perform socioeconomic impact assessments, (2) request the REMI staff to build a BLS-based REMI model, and (3) continue to use the current type of F&G REMI model. There are certainly pros and cons to each option, which we will now discuss.

The possibility of using the original REMI model is, of course, based on whether or not the District has the flexibility to have the REMI employment and population forecasts differ from those of SCAG. The issues are: Do the District's employment and population forecasts have to be consistent with the SCAG estimates and exactly what does consistency mean? If variations in projections between the two agencies are permitted, we recommend that the socioeconomic staff use the REMI model without making any adjustment to it, or they may decide to make an ex-post adjustment that would not affect the use of REMI itself. The advantages of using the unadjusted REMI model, rather than

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[18] In many places in our evaluation, we recommend that additional documentation is needed. We strongly believe that well-documented studies will help the socioeconomic staff, other socioeconomic analysts, and the general public to understand the results and to make more effective inputs into the assessment process.

the F&G REMI are increased simplicity, cost savings, and ease of use of the model. Using the original REMI model will simplify the procedure of using an econometric model for the District by eliminating the F&G adjustments. Besides, the original REMI model is based upon BEA data that have a larger coverage than the BLS data. The REMI data include self-employed, military employees, and jobs created in the underground economy. If the District and the SCAG forecasts need to be similar, the question is: How close do they have to be? According to Fulton and Grimes (1991b), the conversion of the REMI forecast from the BEA to a BLS base eliminates about two-thirds of the discrepancy between the REMI and the SCAG forecasts. The question is whether this amount of difference between the two projections is acceptable to all parties involved.

A second option is for the District to request the REMI staff to build a BLS-based REMI model. The advantage of this option is that it does not require the District to request Fulton and Grimes to adjust the REMI model each time the District receives an up-dated revision of it from the vendor. It will also maintain the consistency and comparability between the baseline forecasts and the historical data of the REMI model. Although we would prefer a REMI model that is based on one single data source, the cost of doing that may be high.

An alternative formulation of this option is to have Fulton and Grimes make only the FPD adjustment to the original REMI model, which would just affect the forecasts, not the historical data base. (The BLS-data model would have all the historical data based on BLS data.) Adjusting the model using only the FPD program will eliminate some of the complications created by the

MULT and EPOL adjustments that we have identified earlier. The socioeconomic staff can ask Fulton and Grimes to perform this operation.

The final option is for the socioeconomic staff to continue using the F&G REMI model, having Fulton and Grimes make appropriate adjustments to the original REMI model. If this option is selected, we feel that the issues raised in this report must be solved. The socioeconomic staff will need to have further investigations conducted on some of the critical issues, such as the usage of the MULT versus the EPOL procedure and the determination of their values in the adjustments. These studies will be important in order for the District to substantiate to the public the rationale for adjustments to the original model.

SUMMARY

In the first part of this Appendix, we described the technical structure of the REMI model and discussed the merits and possible extensions of the model. We explained in detail the general features and the five linkages in the standard module of the model. In the second part of the report, we discussed the Fulton and Grimes' adjustments. We have examined two main issues in their adjustments.

First, we discussed the reasonableness of the values of the adjustments in the FPD, MULT, and EPOL procedures. We find that Fulton and Grimes need to document in more detail than they presently do their rationale and method of deriving the values for the MULT and EPOL adjustments. This will help the socioeconomic staff to determine whether the adjustments made to the REMI forecasts are appropriate and whether the estimates are "consistent" with the SCAG projections.

Second, we investigated the issues related to the use of MULTS in the Fulton and Grimes' adjustment. In our review, we could not determine if there is a reasonable justification for using the MULTS. We recommend that the District staff examine in detail the underlying structural reasons for the differences in the REMI and SCAG employment and population projections.

Because the REMI model and the Fulton and Grimes' adjustments of that model will continue to be subjected to public scrutiny, the socioeconomic staff will need some thorough explanations of the model and justifications of the modifications made to the original REMI model by Fulton and Grimes. We have indicated several places where additional explanations are needed or even where entirely different procedures should be considered. The following are the specific recommendations that we propose:

(1) The REMI staff should modify their procedure of aggregating and regionalizing the 466-sector national input-output table. They should first regionalize the detailed national input-output table and then aggregate the four-digit sectors to a more aggregated level.

(2) The REMI staff should modify the REMI model in order to provide more disaggregated forecasts for the District. Instead of giving job-impact estimates for two-digit industries, the model should be able to generate forecasts for selected three-digit, or even four-digit, industries.

(3) The REMI staff should continue to improve the documentation of their model, especially the explanation for the available policy variables in the model and the technical description of the model structure.

(4) The socioeconomic staff should reconsider the appropriateness of the Fulton and Grimes' adjustments, regardless of the existing legal requirement. If they think that these adjustments are inappropriate, they should propose modifying Section 40460 (c) of the Health and Safety Code.

(5) Based on the possibility of modifying the legal requirement, we propose three options that the socioeconomic staff can use to resolve some issues related to the current adjustments of the REMI model. These options include (1) use the original REMI model to perform socioeconomic impact assessments, (2) request the REMI staff to build a BLS-based REMI model, and (3) continue the Fulton and Grimes' adjustments.

(6) If the socioeconomic staff decide to continue to use Fulton and Grimes' adjustments, Fulton and Grimes should continue to investigate possibilities of constructing separate FPD ratios for individual counties.

(7) Fulton and Grimes need to provide better documentation than they presently do of their rationale for using the MULTs and criteria for determining the values in their MULT and EPOL adjustments.

To conclude, we found that the REMI model is technically sound. We also found that Fulton and Grimes have done a reasonable job of adjusting the standard REMI model, given the technical and institutional constraints that they confronted. Some of the seven recommendations may or may not affect significantly the numerical results of the job-impact estimates using the F&G REMI model. We, however, strongly believe that our recommendations, if accepted and implemented, will enhance the credibility of the District's socioeconomic analyses, both within the District and with the public-at-large.

Appendix I.1

SENSITIVITY TESTING PROCEDURES

We used the following procedure to test the sensitivity of REFPVC, REFPVI, and DEMPOL 680.

1. We started LOTUS and retrieved the worksheet for PAR 1135 that the District sent to us. Based on the numbers provided in the worksheet, we increased each individual input value for the variable we examined (e.g., Variable 941) by 5 percent. We did not change any other variables that the District used to simulate PAR 1135. With the new input values for Variable 941 and the other original variables, we created "print files" for Los Angeles, Orange, Riverside, and San Bernardino counties. These print files were used to generate input files for the REMI simulation.

2. To generate input files, we used the AUTOMR procedure. We used the command MKSIMIN to create input files for the counties and the AUTOMR EMPTY to input these files into the REMI model.

3. We used the RUNMOD command to run the simulation.

4. To get a hard copy of the simulation, we used the PTAB command. We printed the difference between the control and the simulation forecasts for the whole South Coast region for 1995, 2000, 2005, and 2010. We concentrated our analysis on the changes in the economic-impact estimates for employment, real gross regional product, and real disposable income.

5. We then repeated Steps 2 to 4 until we finished changing variable 941 by plus and minus 5 percent, 10 percent, and 20 percent.

6. With the results of the modified simulations (plus and minus 5 percent, 10 percent, and 20 percent changes to the input values for Variable 941), we compared each of the results to the original simulation (no change to the original values for Variable 941).

We conducted the same tests on Variables 941 and 942.

APPENDIX I.2

REMI JOB-IMPACT ESTIMATES FOR RULE 1135

Sector	1995	2000	2005	2010
Manufacturing	132	-105	50	-90
Durables	148	-64	88	-52
Nondurables	-16	-41	-37	-38
Nonmanufacturing	-366	-932	-835	-975
Mining	0	-2	-2	-3
Construction	-14	-56	-51	-65
Transport & public utilities	-5	-31	-26	-34
Finance, insurance, & real estate	-59	-124	-119	-135
Retail trade	-109	-227	-195	-206
Wholesale trade	-11	-59	-41	-58
Services	-162	-418	-387	-458
Agriculture, forestry, & fishing services	-7	-15	-14	-16
Total government	-4	-60	-72	-111
State & local government	-4	-60	-72	-111
Federal government--civilian	0	0	0	0
Federal government--military	0	0	0	0
Farm employment	0	0	0	0
Total employment	-238	-1,097	-857	-1,175
Population	-76	-1,218	-1,418	-2,184

Source: Differences in the employment forecasts between the simulation for Rule 1135 (using the 1988 REMI model) and the control forecast.

APPENDIX I.3

F&G REMI JOB-IMPACT ESTIMATES FOR RULE 1135

Sector	1995	2000	2005	2010
Manufacturing	130	-112	40	-106
Durables	147	-68	82	-61
Nondurables	-17	-44	-42	-45
Nonmanufacturing	-306	-795	-720	-868
Mining	0	-2	-1	-2
Construction	-13	-54	-49	-64
Transport & public utilities	-5	-30	-25	-34
Finance, insurance, & real estate	-41	-89	-87	-101
Retail trade	-104	-217	-191	-207
Wholesale trade	-11	-59	-43	-64
Services	-130	-338	-317	-387
Agriculture, forestry, & fishing services	-3	-7	-7	-8
Total government	-4	-60	-72	-114
State & local government	-4	-60	-72	-113
Federal government--civilian	0	0	0	0
Federal government--military	0	0	0	0
Farm employment	0	0	0	0
Total employment	-181	-967	-752	-1,088
Population	-78	-1,214	-1,426	-2,232

Source: Differences in the employment forecasts between the simulation for Rule 1135 (using the 1988 F&G REMI model) and the control forecast.

Appendix I.4

PERCENTAGE OF EMPLOYMENT IN EACH INDUSTRY TO TOTAL EMPLOYMENT IN THE SECTOR, BY COUNTY

	Los Angeles	Orange	River- side	San Ber- nardino	Four-county total
MANUFACTURING					
Food & kindred products	5.3	3.0	4.5	5.8	4.8
Textile mill products	1.3	0.9	0.3 *	0.4 *	1.1
Apparel & other textiles	10.6	2.6	2.1	2.6	8.4
Lumber & wood products	1.6	1.4	7.7	6.4	2.0
Furniture & fixtures	4.3	3.6	3.4	4.1	4.1
Paper & allied products	1.9	1.8	1.8	1.5	1.9
Printing & publishing	6.9	7.0	9.9	6.1	7.0
Chemicals & allied products	2.8	3.8	1.4	1.9	2.9
Petroleum & coal products	0.9	0.1	0.2	0.6	0.7
Rubber & miscellaneous plastics	4.1	7.5	7.6	8.4	5.1
Leather & leather products	0.6	0.1	n.a.	n.a.	0.4
Stone, clay, & glass products	1.8	1.3	7.3	9.4	2.2
Primary metal industries	2.3	1.4	3.5	4.4	2.3
Fabricated metal products	8.4	8.7	10.0	13.0	8.7
Industrial machinery & equipment	7.4	13.4	4.3	5.0	8.4
Electronic & other electrical equipment	7.6	13.2	9.3	4.3	8.7
Transportation equipment	20.1	7.3	17.8	20.4	17.4
Instruments & related products	7.3	17.9	3.9	2.0	9.1
Miscellaneous manufacturing industry	2.2	1.7	1.3	3.0	2.1
Administrative & auxiliary	2.6	3.2	3.7	0.7	2.7
TOTAL	100.0	100.0	100.0	100.0	100.0
TRANSPORTATION AND PUBLIC UTILITIES					
Local & interurban transit	4.3	3.9	8.5	7.8	4.7
Trucking & warehousing	24.4	26.4	34.5	40.0	26.1
Water transportation	3.9	0.4 *	n.a.	0.6	3.0
Transportation by air	17.8	15.2	4.8	5.9	16.1
Pipelines, except natural gas	0.2	0.1 *	n.a.	0.3 *	0.2
Transportation services	10.2	9.1	4.8 *	3.2	9.4
Communication	25.1	26.0	31.4	25.9	25.5
Electric, gas, & sanitary services	8.0	15.1	13.9	15.2	9.8
Administrative & auxiliary	6.1	3.8	2.1 *	1.3 *	5.3
TOTAL	100.0	100.0	100.0	100.0	100.0
WHOLESALE TRADE					
Wholesale trade--durable	58.6	66.9	53.5	58.6	60.2
Wholesale trade--nondurable	36.5	27.6	45.2	36.3	34.9
Administrative & auxiliary	4.9	5.5	1.4	5.1	4.9
TOTAL	100.0	100.0	100.0	100.0	100.0

RETAIL TRADE

Building materials & supplies	2.9	3.1	4.6	4.1	3.2
General merchandise stores	9.9	10.2	11.1	13.1	10.3
Food stores	12.9	11.1	14.3	13.4	12.7
Auto dealers & service stations	9.7	9.6	12.7	12.7	10.2
Apparel & accessory stores	6.9	6.5	5.1	5.0	6.5
Furniture & homefurnishing	4.4	4.1	3.5	3.6	4.2
Eating & drinking places	34.9	37.2	37.3	33.1	35.4
Miscellaneous retail	12.2	10.9	11.0	9.3	11.6
Administrative & auxiliary	6.2	7.2	0.4	5.7	6.0
TOTAL	100.0	100.0	100.0	100.0	100.0

FINANCE, INSURANCE, & REAL ESTATE

Depository institutions	30.6	22.7	32.9	33.7	28.9
Nondepository institutions	8.3	10.8	11.2	11.7	9.1
Security & commodity brokers	5.3	3.4	2.0	1.6	4.6
Insurance carriers	14.7	21.4	11.1	14.0	16.1
Insurance brokers, agents, & services	9.2	10.8	6.7	9.9	9.5
Real estate	21.4	25.1	32.0	26.2	22.8
Holding & investment offices	4.5	3.4	4.1 *	2.6	4.2
Administrative & auxiliary	6.0	2.5	n.a.	0.3 *	4.7
TOTAL	100.0	100.0	100.0	100.0	100.0

SERVICES

Hotels & other lodging	3.1	6.3	11.2	3.8	4.1
Personal services	3.6	3.7	4.4	4.7	3.7
Business services	20.3	25.4	14.1	15.7	20.8
Auto repair, services, & parking	3.6	3.3	4.3	5.1	3.7
Miscellaneous repair services	1.4	1.4	1.8	1.3	1.4
Motion pictures	9.8	1.0	1.3	1.2	7.3
Amusement & recreation services	3.8	6.2	8.8	5.3	4.5
Health services	21.3	21.8	27.6	31.8	22.2
Legal services	4.3	2.9	2.0	1.7	3.8
Educational services	6.6	3.5	3.9	4.7	5.8
Social services	4.1	3.7	5.1	6.2	4.2
Museums & other gardens	0.1	0.1	0.1	n.a.	0.1
Membership organizations	4.7	5.2	6.4	10.4	5.2
Engineering & management services	11.0	12.4	7.9	6.8	10.9
Services, n.e.c.	0.6	0.6	0.5	0.4	0.6
Administrative & auxiliary	1.6	2.3	0.5	0.7	1.7
TOTAL	100.0	100.0	100.0	100.0	100.0

AGRICULTURAL SERVICES, FORESTRY, & FISHING

Agricultural services	95.5 *	100.0 *	100.0 *	100.0 *	98.0
Fishing, hunting, & trapping	1.8	n.a. *	n.a. *	n.a.	0.8
Administrative & auxiliary	2.7	n.a. *	n.a. *	n.a.	1.2
TOTAL	100.0	100.0	100.0	100.0	100.0

MINING					
Oil & gas extraction	55.5	30.5	100.0	18.6 *	46.4
Nonmetallic minerials, except fuel	10.9	11.7	n.a.	81.4	23.8
Administrative & auxiliary	33.6 *	57.8	n.a.	n.a.	29.8
TOTAL	100.0	100.0	100.0	100.0	100.0
CONSTRUCTION					
General contractors & builders	23.4	23.2	15.8	17.1 *	21.9
Heavy construction, except building	9.5	8.5	11.9	14.2	10.0
Special trade contractors	66.9	67.6	72.3	68.8	67.9
Administrative & auxiliary	0.2	0.7	n.a.	n.a.	0.3
TOTAL	100.0	100.0	100.0	100.0	100.0
UNCLASSIFIED ESTABLISHMENTS	100.0	100.0	100.0	100.0	100.0

Source: Calculated from data published by the U.S. Department of Commerce. 1990. County Business Patterns, 1988--California.

Notes: * = estimated number.
n.a. = not available.

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Appendix II

ASSESSING REGIONAL ECONOMIC IMPACTS OF AIR-POLLUTION CONTROLS: A METHODOLOGICAL REVIEW

May 1992

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The research reported here is financed with funds from Contract No. C91253 between the South Coast Air Quality Management District and the Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts. The authors take full responsibility for the conclusions, which are not necessarily those of the sponsoring agency.

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Appendix II

ASSESSING REGIONAL ECONOMIC IMPACTS OF AIR-POLLUTION CONTROLS: A METHODOLOGICAL REVIEW

In this technical report, we review methods and models that are currently used for assessing economic impacts of air-pollution controls to provide a general context for our evaluation of the South Coast Air Quality Management District's (District) economic-impact assessment methods. The report consists of two parts. In the first part, we describe how economic-impact analyses are actually conducted in U.S. state air-pollution control agencies, in other California county air-pollution control districts, and in several related California state agencies. We also review several studies, conducted by researchers outside the District, on economic impacts of the District's air-pollution control rules and regulations. In the second part, we examine some of the basic methodologies of regional-economic-impact (REI) models. We group REI models into four categories: economic-base, input-output, econometric, and integrated models and evaluate their strengths and limitations for assessing economic impacts of air-pollution controls.

Throughout the report, we advance two basic arguments. First, there is no single "best" way to approach economic-impact analyses. Analysts can use many methods and models, each with strengths and limitations, and the information requirements and analytical needs may vary significantly from one air-pollution control agency to another and from one rule to another. The key to a good economic-impact analysis, therefore, is to match approaches to the task at hand and to adopt a flexible way of using the appropriate methods and models. Second, and closely related, no REI model is perfect. There will always be a long list of interesting submodels that can be added and improvements that can be made. Some of them are necessary for accurate analyses, others, however, may make only marginal contributions. Analysts, therefore, need to evaluate and select models in the real world context, rather than based on an abstract theory. The purpose of using an REI model is to help us understand complex air-pollution control problems. Modeling is a means to achieve such a purpose but not an end in itself.

ECONOMIC-IMPACT ANALYSES IN PRACTICE

We conducted four surveys to determine what methods and models are currently used for assessing regional economic impacts of air-pollution controls in the United States. First, we sent a brief questionnaire to air-pollution control agencies in 50 states and the District of Columbia. Second, we conducted a similar survey of 40 county air-pollution control districts in California.[1] Third, we sent the same questionnaire to six California State agencies.[2] Fourth, we surveyed twenty-two consulting firms and individuals who have extensive experience in regional economic modeling to determine their perceptions of the advantages and disadvantages of having the District staff perform the socioeconomic assessments versus having the equivalent work conducted by an independent contractor.[3] Forty-eight (94 percent) of the

---

[1] There are several unified air-pollution control districts that have jurisdiction over more than one county. The South Coast Air Quality Management District, which we are evaluating, was not included in the survey.

[2] We included the California Air Resources Board in the State Air-Pollution Control Agency survey. The six California State Agencies are the Department of Food and Agriculture, Department of Commerce, California Energy Commission, Department of Forestry and Fire Protection, Department of Transportation, and Water Resources Control Board.

[3] The state, county, and modeler questionnaires are included in Appendices II.1, II.2, and II.3, respectively, while the names and addresses of all the state and county air-pollution control agencies and firm respondents are included in Appendices II.4, II.5, and II.6, respectively.

state agencies, thirty-five (88 percent) of the California county districts, four California state agencies (67 percent), and seven consulting firms responded to our survey.

State Air-Pollution Control Agencies

The majority of the state air-pollution control agencies conduct economic-impact analyses in developing their rules and regulations. Among 48 state respondents, 31 (65 percent) conduct economic-impact analyses, but with considerable variations in types of analyses performed, as shown in Table 1.[4]

Twenty state agencies conduct their economic-impact analyses using the general framework of benefit-cost or cost-effectiveness analyses. Most of them focus their analyses on economic costs of air-pollution controls and only

Table 1

SOCIOECONOMIC IMPACT ANALYSES CONDUCTED BY
STATE AIR-POLLUTION CONTROL AGENCIES

Methods	Number of Respondents	Percent
Cost-effectiveness/ benefit-cost analyses	20	39
Econometric methods/models	3	6
Others (e.g., Informal studies and qualitative analyses)	6	12
Methods not specified	5	10
No analysis	17	33
Total	51	100

Source: MIT Multiregional Planning Staff. 1991. "State Environmental Protection Agency Survey." Cambridge, MA: Department of Urban Studies and Planning, Massachusetts Institute of Technology.

Note: The sum of individual categories is greater than 48 because some agencies indicate more than one method in their survey responses.

[4] Three "states"--Alaska, Pennsylvania, and Washington, D.C.--did not respond to our survey.

consider benefits qualitatively or not at all. Some states, such as Utah, include only capital and operation costs of pollution-control technologies in their cost estimates, while others, such as Massachusetts, also consider cost impacts on regulated industries and/or on consumers. For example,

> In California, the Air Resources Board (ARB) staff conduct source- and industry-specific cost analyses and small-business impact assessments to determine "best available control technology" (BACT) and to demonstrate that a proposed control program or "model rule" is financially feasible for the regulated population. The ARB's economic-impact studies are generally limited to those effects that are tractable within the scope of available data and analytical technique.
>
> In Kansas, the Air Inspection and Enforcement Agency is required to prepare: (1) a description of the cost, the persons who will bear the costs, and those who will be affected; (2) a description of any less-costly or less-intrusive methods that were considered by the state agency for achieving the stated purpose of the rules and regulations and why such methods were rejected in favor of the proposed rules and regulations.
>
> In Kentucky, the Division of Air Quality staff examine the economic impacts on the regulated community. They first identify sources that will be affected by new or modified regulations, then they estimate compliance costs (capital outlay and operating costs), and finally they determine overall cost impacts on the regulated community. The Division has their own computer data base recording polluting sources, emissions, and costs of control equipment.
>
> In Louisiana, the Air-Quality Regulatory Division staff of the Department or Environmental Quality estimate capital and operating costs of air-pollution control regulations, based on engineering analyses. They also examine the effect of the regulations on competitiveness of state industries by using data from publications and from affected industries.
>
> In Maryland, a law requires the Department of Environment to have an economic-impact analysis of each proposed environmental regulation or amendment. Their analyses are limited to assessments of direct costs based on literature surveys and industry estimates.
>
> In Massachusetts, the Air-Pollution Control Agency studies (1) cost to the regulated party, (2) how the regulated party will pass costs along to the consumer, and (3) the amount of emissions removed from the air.

In Ohio, the Environmental Protection Agency staff perform cost-effectiveness analyses for control strategies in terms of annualized costs per ton of pollutants reduced.

In Oregon, the Department of Environmental Quality staff conduct benefit-cost analyses based on available information at the time the rule is proposed. State law also requires the department to consider the specific impact on any small businesses affected by the rules.

In Utah, the Bureau of Air Quality applies a benefit-cost analysis to determine reasonable available control technologies (RACT).

In Virginia, the Air-Pollution Control Board performs quantitative analyses of costs and only qualitative analysis of benefits of air-pollution control.

The data and information used for the benefit-cost or cost-effectiveness analyses are mainly from literature reviews, U.S. Environmental Protection Agency's documents, surveys, information provided by affected industries, engineering analyses, and studies of consultants and other concerned groups.

Three states--California, Illinois, and Washington--have used econometric methods or models to assess the impacts of air-pollution controls. The California Air Resources Board (ARB) has funded or participated in projects such as estimating the economic impacts of air pollution on real estate values, modeling the integrated producer/consumer economic impacts of ozone damage to crops, studying the costs associated with material damage due to ozone and airborne acids, and assessing the economic impacts of implementing alternatives to open field burning of agricultural wastes. The Illinois Department of Energy and Natural Resources (DENR) has a version of the Regional Economic Modeling, Inc. (REMI) model, specially calibrated for Illinois, called the Illinois Forecasting and Simulation Model. They use it to examine the impact of air-pollution controls on the state and regional economy. The DENR staff also perform benefit-cost analyses. The Washington Department of Ecology (DE) staff use an econometric (regression-based) model to (1) estimate costs for different alternatives, (2) evaluate financial impacts, and (3) prepare small business impact statements. Both the Illinois DENR and the Washington DE maintain their own computerized economic data base.

The scope and emphasis of economic-impact analyses differ from state to state. Most states focus on direct compliance costs or economic impacts and largely ignore benefits and secondary or indirect economic impacts. Six states, California, Minnesota, New York, Oregon, Texas, and Washington, also pay particular attention to small firms and require small-business impact statements. Table 2 shows some variables or factors that are often considered by the state agencies, including

- compliance costs (both capital and operation costs),
- small-business impacts,
- determination of reasonably available control technology (RACT) or best available control technology (BACT),
- direct costs, industry-specific costs,
- costs per amount of air pollutants removed,
- impact on economic competitiveness of local industries,
- fiscal impacts, permit fees.

The methods and scope of economic-impact analyses often differ from case to case, depending on the characteristics of the specific rules studied. In Alabama, for example, Air Division of the Environmental Management Department staff conduct a benefit-cost analysis for each rule proposed. The depth of analysis depends on the complexity of the rule. In New York, the Department of Environmental Conservation staff conduct economic-impact analyses on a case-by-case basis and do not follow a definite formula for accomplishing the task. They normally include cost comparisons for different control strategies. Data are often derived from analyses performed either by or for the U.S. Environmental Protection Agency or from studies conducted by consultants and information provided by industry trade organizations.

Table 2

VARIABLES INCLUDED IN THE ECONOMIC-IMPACT ANALYSES

Variables	States Mentioning Them in the Survey
Compliance Costs	Kentucky, Kansas, Louisiana, New York, North Carolina
Small Business Impacts	California, Minnesota, New York, Oregon, Texas, Washington
RACT, BACT	California, Florida, Utah
Direct Costs/ Industry-Specific Costs	California, Louisiana, Maryland, Massachusetts, Texas,
$/Air Pollutants Reduced	Massachusetts, Ohio,
Fiscal Impacts/Permit Fee	Missouri, Washington,

Source: MIT Multiregional Planning Staff. 1991. "State Environmental Protection Agency Survey." Cambridge, MA: Department of Urban Studies and Planning, Massachusetts Institute of Technology.

Note: Only states that specifically mentioned the variables in their response are listed in the table.

From the survey results, we find that most states use cost-effectiveness techniques and focus their economic-impact analyses on compliance costs and direct economic impacts on regulated industries, rather than on multiplier effects on the regional economy. The Maryland Air Management Administration staff conducted an analysis of the economic impact of Maryland's proposed air-toxics regulations (Maryland AMA, 1986). Their study provides a good example on how cost-effectiveness studies are typically done in air-pollution control agencies. In 1986, the Maryland Department of Health and Mental Hygiene proposed regulations that would require businesses to submit information on the emissions of toxic air pollutants and to take certain measures to control these pollutants. To assess the economic impacts of this proposal, analysts first identified the number of installations that would be subjected to the proposed regulations. They then estimated economic impacts on businesses in terms of emission-reporting costs, costs of modeling emissions, and emission-reduction costs. The emission-reduction costs were determined in three steps: (1) review of options available for reducing emissions, (2) estimate of the costs of pollution control for new installations, and (3) estimate of the costs of pollution control for existing installations. Finally, analysts calculated the costs to the Department of implementing the proposed regulations. The Maryland AMA staff expected that only a few sources would incur substantial costs for emission controls beyond those required by other regulations. They also expected the implementation costs to the Department to be largely absorbed in the existing budget. In other words, there may be economies of scope in air-pollution controls.

Illinois Environmental Protection Agency

The Illinois Environmental Protection Agency (EPA) staff in the Department of Energy and Natural Resources (DENR) use their version of the REMI model for assessing the economic impacts of air-pollution controls. This provides us with a unique opportunity to compare the use of the REMI model in the District with that in another air-pollution control agency.

The Economic Technical Advisory Committee (ETAC), which is an arm of the Illinois Pollution Control Board, plays a central role in economic impact analyses (Illinois DENR, 1986).[5] The Illinois Revised Statutes (Section 7405) describe the ETAC as:

[5] Correspondence and communication with Mark Bonardelli, energy data analyst in the Illinois Department of Energy and Natural Resources.

> The Economic Technical Advisory committee shall be composed of seven members, appointed by the governor, with the advice and consent of the Senate, as follows: one shall be engaged in a field which is directly related to agriculture; one shall be engaged in the management of a private manufacturing concern; one shall be representative of labor; one shall be engaged in local government; one shall be a person engaged in commerce; one shall be a person engaged in public health services; and one shall be selected at large.

After the Illinois EPA proposes air-pollution control rules, they furnish all documents and related materials to the ETAC. The ETAC then reviews the documents and materials and proposes to the Director of the Department of Energy and Natural Resources that an economic impact study be conducted and published if the Committee has "reasonable cause" to believe that the rule may have an adverse economic impact. From these rules proposed for study, the Director of the Department selects the ones that s/he determines to be the most important for economic-impact studies, considering the Department's budgeting constraints.

The Illinois Department of Energy and Natural Resources usually hires professional consultants to prepare the economic studies, with a substantial amount of assistance and guidance from the Department's Project Manager and staff and the ETAC members. The Project Manager initiates the study and interacts with the consultant to ensure compliance with specified criteria and deadlines. The ETAC is responsible for reviewing and approving the designated individual or firm selected to conduct the study. To estimate indirect and induced economic impacts, the Department staff run the REMI model with the inputs prepared by the consultant. The consultant incorporates the REMI results into the final report.

The economic-impact study must be sufficiently comprehensive so that the Illinois Pollution Control Board can consider the full range of economic impacts in deciding whether to adopt the rule in question. The staff should include all health, welfare, social, and economic impacts on local residents in their analyses. For each type of impact, they should consider its effect on the general population, agriculture, local government, commerce, as well as industry. They are expected to evaluate the economic impacts in terms of changes in costs of goods, services and food; availability of goods, services, food, energy and employment; effects on aggregate price levels, local taxes, and local services; and effects on expansion of local communities, expansion of industry in Illinois, and attraction of industry.

The Department publishes and disseminates the study, with supporting data, when it is completed. The Illinois Pollution Control Board then holds public hearings to elicit comments. The Board, however, may modify and adopt any proposed regulations or amendments to existing regulations without further economic studies by the Department if the change does not significantly alter their intent and purpose. Illinois law requires that the Department study the economic impact of selected environmental regulations on a continuous basis and that it makes annual reports to the Illinois Pollution Control Board and the General Assembly.

To understand more fully how the economic impact analysis is conducted at the Illinois EPA, we reviewed their study of The Economic Impact of Proposed Regulation R82-14: Emissions of Volatile Organic Material--RACT III (Illinois DENR, 1984). The study presents an evaluation of the costs and benefits of a regulation R82-14, Reasonably Achievable Control Technology (RACT)-Group III, to control emissions of volatile organic material. It consists of four major sections.

- First, analysts provide rationales for the rule and an extensive overview of the regulatory requirements, including the requirements of the federal Clean Air Act, results of air-quality modeling, analysis of ozone air-quality data, state-wide applicability of RACT rules, and changes in the original R82-14 proposal.

• Second, analysts describe the affected plants, discuss the process and emission-control requirements, and provide estimates of the expected emissions reductions, with comments and testimony from affected industries.

• Third, analysts estimate the direct compliance costs to industry, including the capital costs, the annualized capital recovery, and operation/maintenance costs. They calculate overall costs as well as the economic impacts on each affected industry. They then use the REMI model--the Illinois Forecasting and Simulation Model--to estimate the indirect impacts of the regulation on prices, employment, and competitiveness of Illinois industries.

• Fourth, analysts evaluate benefits, generally qualitative, from reduced ozone, on health, welfare, and crop yield--primarily based on a literature review.

The Illinois analysts estimate direct costs using a combination of a model-plant approach and industry surveys. For indirect economic impacts, analysts first convert the direct cost estimates, in terms of annual costs, into a form suitable for the REMI modeling. They then use the REMI policy variables to model the impacts on directly affected industries and on pollution-control industries. Their analyses focus on the effects on the regional consumer-price index, employment, and production costs relative to the rest of the United States. The results indicate that the overall economic impacts are fairly small and do not significantly change the competitiveness of Illinois industry, although some industries may be negatively affected.

The Illinois EPA economic-impact analyses differ from those conducted by the District in three important aspects. First, the economic-impact analysis process is more decentralized in Illinois than in the District. The Illinois ETAC proposes and the director of the DENR determines which rules are to be studied and specifies the scope of the study. The Illinois DENR selects and hires consultants. The consultants then carry out the study with the involvement of the DENR and assistance and guidance from the ETAC. Finally, the ETAC and Air-Pollution Control Board review and approve the study.

Second, the REMI model plays a less important role in the Illinois EPA than in the District. In The Economic Impact of Proposed Regulation R82-14: Emissions of Volatile Organic Material--RACT III, for example, analysts devoted over half of the report to examining compliance costs and direct impacts on specific industries, using information from a model-plant analysis, industry surveys, and comments and testimony from the affected industries. The discussion of the REMI-modeling results was less detailed than that for the compliance costs and direct impacts on affected industries.

Third, while the REMI model is used almost exclusively for assessing economic impacts of air-pollution controls in the District, the Illinois DENR and the Illinois Department of Commerce and Community Affairs staff use it for a wide variety of purposes, such as assessing economic impacts of energy development, infrastructure projects, and new plant location.[6] Illinois may therefore have a larger constituency to defend and support the REMI model than elsewhere. Crihfield and Campbell (1991) used Illinois data recently to question the credibility and reliability of the REMI model. Grimes, Fulton, and Bonardelli (1992), however, maintain that the REMI model does produce reasonable and reliable results and show that because Crihfield and Campbell did not conduct appropriate experiments for their evaluation, the Crihfield and Campbell conclusions are not valid.

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[6] Correspondence and communication with Wallace Biermann, Manager of Research and Analysis, Illinois Department of Commerce and Community Affairs.

California County Air-Pollution Control Districts

At the time of our survey (fall of 1991), only eight (23 percent) of the 35 county respondents in California perform economic-impact analyses, and most of them use the framework of cost-effectiveness analyses (Table 3). The eight counties are:

1. Bay Area Air Quality Management District. The District hired consultants to prepare a socioeconomic analysis of the Bay Area 1991 Clean-Air Plan, using a variety of methods and data, including input-output multipliers to determine indirect employment effects.

2. Fresno County Health Department. The air-quality planners in the Department perform economic-impact analyses for control measures in Air-Quality Plans and for rules or regulations developed from suggested control measures, including implementation cost range (maximum, minimum, and average), using data from secondary sources and facilities that have installed required technologies.

3. Lakeport County Air-Pollution Control District. They have a workshop and public-hearing process, using state-adopted model rules where economic evaluation has occurred.

4. Northern Sonoma County Air-Pollution Control District. They look at initial cost of equipment, annual cost, and how it increases cost of production for businesses affected.

5. San Diego County Air-Pollution Control District. They perform cost-effectiveness analyses (dollars per unit of air pollutants reduced).

6. San Luis Obispo County Air-Pollution Control District. They use only standard cost-effectiveness analyses to determine cost per ton of pollutant reduced. This includes an evaluation of capital, operation, and maintenance costs to the affected party. Other benefits to society are not usually considered.

7. Santa Barbara County Air-Pollution Control District. They calculate cost of control for individual rules versus benefit in terms of pollution reduced (tons/year).

8. Yolo-Solano County Air-Pollution Control District. They estimate the cost of pollution control on a case-by-case basis.

Table 3

SOCIOECONOMIC IMPACT ANALYSES CONDUCTED BY
CALIFORNIA COUNTY AIR-POLLUTION CONTROL DISTRICTS

Method	Number of Respondents	Percent
Benefit-cost/ Cost-effectiveness analyses	6	17
Public hearing/workshop	1	3
Eclectic approach	1	3
No analysis	27	77
Total	35	100

Source: MIT Multiregional Planning Staff. 1991. "California County Air-Pollution Control District Survey." Cambridge, MA: Department of Urban Studies and Planning, Massachusetts Institute of Technology.

The staff at the air-pollution control district in the county of San Luis Obispo provided us with three examples of the cost-effectiveness studies they conducted--T-1A Employer Based Trip-Reduction Program (TRP), MP-1 Residential Wood Combustion, and N-11 Utility Fuel Combustion. Their reports have a standard format and normally contain 16 items, which are:

(1) Title of the rule or regulation.
(2) Existing regulation, indicating whether there are existing rules to control the same pollutants.
(3) Baseline emission forecast.
(4) Control measure description, which describes the basic elements of the proposed program, reporting and monitoring requirements, and different alternatives or options to compliance with the rule.
(5) Sources affected and emissions subject to control.
(6) Projected emissions reductions.
(7) Enforceability, which describes implementation strategies.
(8) Cost-effectiveness in terms of the costs per ton of pollutant removed.
(9) Health, welfare, energy, and social impact, mainly in qualitative terms.

(10) Jurisdiction.
(11) Estimated date of adoption.
(12) Implementation schedule.
(13) Resources required from the District.
(14) Recommendation for the Air-Pollution Control Board as to whether to adopt the rule.
(15) References.
(16) Supporting documents on cost-effectiveness analysis.

The Bay Area Air Quality Management District (BAAQMD) is the only county-level agency in our survey that has conducted comprehensive socioeconomic impact analyses somewhat comparable to those done at the South Coast Air Quality Management District.[7] In 1991, the BAAQMD hired Applied Development Economics, Inc., a consulting firm in Berkeley, California, to prepare a Socioeconomic Report for the Bay Area 1991 Clean Air Plan (BAAQMD, 1991), which discusses issues related to the control measures proposed in the Clear Air Plan (CAP) and their economic impacts on consumers, commuters, businesses, and local governments in the Bay Area.

The general structure of the BAAQMD's report is similar to the District's Draft Socio-Economic Report for 1991 Air Quality Management Plan (SCAQMD, 1991). The BAAQMD analysts first provide an overview of the economic structure, projected growth, labor force, and job/housing balance issues in the San Francisco Bay region. The analysts then examine potential economic impacts of the CAP on businesses, the general public, and local governments, and they summarize both direct and secondary employment impacts. Finally, they briefly evaluate several alternatives to the proposed CAP. One of the three alternatives is a no-project option, whereby no elements of the CAP would be implemented. A second alternative is to accelerate the schedule for implementing market-based transportation control measures. A third

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[7] There are nine counties in the BAAQMD.

alternative is to accelerate the implementation of certain Reactive Organic gasses (ROG) measures, while postponing the implementation of certain nitrogen oxide (NO_x) rules.[8]

The BAAQMD's method of economic-impact assessment, however, differs significantly from that of the District. First, the BAAQMD staff rely heavily on professional consultants and on information collected by other governmental agencies, such as the Association of the Bay Area Governments and Metropolitan Transportation Commission. The BAAQMD retained the firm of Deakin/Harvey/ Skabardonis to estimate costs of implementing the transportation control measures (TCMs). Applied Development Economics, Inc. staff estimated the costs of compliance for the stationary source control measures (SCMs) and determined how the total costs from both TCMs and SCMs would affect specific industries.

Second, the BAAQMD staff do not use a single modeling framework, such as the District's REMI, for their economic-impact assessments. Rather, they use an eclectic approach, applying different methods for different groups (e.g., businesses, consumers, governments) and different types of control measures (TCMs versus SCMs) and using data and information from a wide variety of sources. There is no separate section in the report for methodology and assumptions of the analyses, which are, instead, presented in the context of related economic-impact assessments.

Third, the BAAQMD staff focus their analyses on the compliance costs and direct economic impacts on affected industries, population, and governments rather than on multiplier impacts on the regional macroeconomy. An exception

[8] According to the BAAQMD report, roughly 85 percent of the total compliance costs from the stationary source control measures is associated with six measures designed to reduce NO_x emissions from the combustion of fuels.

is the estimation of job impacts, for which analysts applied input-output multipliers for the San Francisco Bay Region to estimate indirect and induced employment impacts. The results show that, in terms of quantifiable employment impacts, the CAP would have a positive impact and result in a net increase of 3,770 permanent jobs.

Fourth, the BAAQMD staff make explicit differentiations between net economic costs and social transfers, which are transfers of revenue within society to achieve the purpose of cleaner air and do not represent added costs to society as a whole. The BAAQMD staff also differentiate between permanent job impacts and temporary job impacts (e.g., construction jobs). They also make a special effort to incorporate qualitative variables and to combine quantitative estimation with qualitative analyses. For unquantifiable impacts, they use "+" and "-" to indicate whether effects are generally positive or negative. The relative severity of the impacts is indicated by the number of "+s" or "-s".

Fifth, the BAAQMD staff explicitly analyze some distribution issues. They examine the economic impacts on three main groups in the local economy--industry, the general public, and local governments--and summarize the economic impacts on major industries. They also discuss the likely impacts on low-income people. This type of analysis enables them to examine the cumulative impacts and determine the burdens on certain industries or groups.

Other Related California Agencies and Research Groups

Four California state agencies responded to our survey: California Energy Commission (CEC), Department of Forestry and Fire Protection (DFEP), California Department of Transportation (CALTRANS), and Water Resources

Control Board (WRCB). None of them assesses the economic impacts of air-pollution control rules or regulations. All of them except the WRCB, however, do conduct other types of economic- or regulatory- impact analyses. In the CEC, staff perform a complex series of analyses, in issuing power-plant certification, to assure that individual applicant facilities conform to "need for power" determinations made within the Commission's Electricity Report planning proceedings and that such facilities conform to all environmental regulations under the broad requirements of the California Environmental Quality Act. They also perform cost-effectiveness analyses in setting energy-efficiency standards for buildings and appliances. The DFEP staff do benefit-cost and cost-effective analyses and examine the employment impacts of changes in timber harvests. CALTRANS staff use the RIMS II input-output model for economic-impact analyses of transportation capital outlay programs.[9] In addition, they conduct, on an ad-hoc basis, benefit-cost, internal rate of return, and net present value analyses of specific transport projects. All three departments have their own data bases and maintain those data in data-base management systems.

The District staff provided us with some interesting studies on the economic impacts of the District's air-pollution rules and regulations. The ICF Consulting Associates, Inc. (1988), for example, conducted a small-business economic-impact study for the District in 1988. They developed an eight-step analytical process, as shown in Table 4, to examine the economic impacts of five existing District rules on small businesses in the four-county area. Their approach is flexible, allowing analysts to use a wide variety of

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[9] We examine the structure of the RIMS II input-output model in the second part of this report.

Table 4

STEP-BY-STEP APPROACH FOR ASSESSING ECONOMIC IMPACTS

Steps	Tasks
1	Determine regulatory requirement.
2	Define small business and compliance strategies.
3	Estimate the potential costs of the regulation on small businesses.
4	Assess the degree to which compliance costs vary with the size of firms and/or plants.
5	Assess the feasibility and extent of small business cost pass-through.
6	Determine the timing of small business compliance cost pass-through.
7	Evaluate contraction of industry given full compliance cost pass-through.
8	Summarize economic impacts from all sources.

Source: The ICF Consulting Associates, Inc. 1988. Small Business Economic Impact Study. A report prepared for the South Coast Air Quality Management District.

techniques--survey, literature review, model-plant analyses--and to incorporate into the analysis many unquantifiable variables, such as difficulties in acquiring information on pollution-control options. The ICF researchers indicate that it is especially useful in identifying important rules for detailed study and in defining the data needs for assessing economic impacts. Depending on the amount of information generated in the eight steps, analysts can, at a minimum, provide a qualitative assessment of the likelihood and severity of economic impacts on small business and, at best, detailed cost estimates. We note, however, that because the process the ICF staff outline is qualitative and only provides general guidelines, the quality of the results is very dependent upon the capabilities of the person conducting the analysis.

Fairbank, Bregman, & Maullin (FB&M) consultants (1990), under a contract from the Southern California Coalition for Jobs and a Clean Environment, examined how the business community and the general public perceived the potential economic impacts of the District's Air Quality Management Plan (AQMP). They employed an interlocking survey strategy, shown in Table 5.

Their study is important for at least two reasons. First, people's perceptions affect their behavior and sometimes can be self-fulfilling. If many business managers, for example, perceive that air-pollution controls have

Table 5

INTERLOCKING SURVEY STRATEGY

Steps	Tasks
1	Conduct personal interviews with executives of the 20 largest nongovernmental employers in the region and with labor organization leaders.
2	Conduct telephone interviews with executives of 50 large industrial processing companies and 25 service companies in the region.
3	Mail survey questionnaires to 2300 businesses affected by the AQMP.
4	Conduct a random sample telephone survey of 600 voters in the region.

Source: Fairbank, Bregman, & Maullin. 1990. Business Community Perceptions of Air Quality Regulation Impacts on Economic Development in the South Coast Air District. A research report prepared for Southern California Coalition for Jobs and A Clean Environment. Los Angeles, CA: Fairbank, Bregman, & Maullin.

severe negative economic impacts on their firms, they may decide to scale down the production, disinvest, or relocate, no matter what the real economic impacts will be. Second, public opinion about the economic impacts of air-pollution rules, to a certain extent, reflects the degree of difficulty and complexity in enforcing a particular regulation or rule. The results of the FB&M survey indicated that both business executives and voters believe that the District's AQMP has an adverse economic impact and that it will increase the costs of production, reduce competitiveness of Southern California businesses, and result in lower employment and income. Many see the process of air-quality regulation, both rule adoption and rule enforcement, as unnecessarily adversarial. The survey also shows the overall agreement on the need to improve air-quality and to place more emphasis on mobile sources.

The Pasadena Research Institute (PRI) staff have conducted series of studies on economic impacts of the District's air-pollution control rules and regulations. They used a direct industry survey approach to estimate the initial employment impacts. "Industry spokesmen and industry association leaders were consulted to verify the risks of job loss, to identify vulnerable industry elements, and to evaluate the extent of their plans to transfer parts of their operations to plausible locations (Mexico, Nevada, or other out-of-state plants) where they already have operational units" (PRI, 1990a, p. 6). They then applied regional input-output multipliers to convert the initial employment impacts into total employment impacts.[10] Their analyses showed that the District's proposed air quality regulations would result in 350,000 direct job loss and 1.4 million total job loss (PRI, 1990a). For the solvent

[10] In the reports we reviewed, the PRI staff do not provide any details and documentation about their regional input-output model.

use regulations alone, they estimated that there would be a 239,000 job loss (PRI, 1990b). Based on their employment impact estimates, the PRI staff estimated the tax revenue and budget impacts of the District's air-pollution control regulations (PRI, 1990c). They concluded that the regulations would have a severe negative impact on the state and local government budgets because of a loss in tax revenue and the increase in government expenditure, such as unemployment insurance and income assistance programs.

Because of the large estimated employment losses and negative budget impacts on the state and local governments, the PRI staff call for an alternative approach to air-pollution controls in Southern California. They argue that air-pollution controls should concentrate on mobile sources, rather than stationery sources, because it is more cost effective and because the mobile sources account for over 80 percent of air pollution in the region (PRI, 1990a, 1990d). In particular, they advocate a program to scrap old cars, which, according to their estimates, emit 10 to 50 times as much pollution as more modern vehicles (PRI, 1990d). They recommend that the District provide "regulatory credit" for scrapping old cars (one per every five tons of emissions reduced).

The PRI staff are critical of the District's socioeconomic impact assessment method. They argue that by using the REMI model, the District socioeconomic staff mainly rely on macro or gross regional employment figures and tend to underestimate the problems that must be faced by individual firms and employees. Methodologically, they suggest that the District (1) complement REMI modeling with industrial surveys, such as those conducted by the PRI staff; (2) examine the timing of employment losses and gains closely and provide year-by-year employment impact analyses; and (3) pay particular attention to labor-intensive industries (PRI, 1991). As we show in the next section, the job-impact estimates made by the PRI staff differ significantly from those made by the District's socioeconomic staff and from those made by researchers from the University of Southern California and the National Economic Research, Inc.

Employment Impacts of the District's AQMP: A Comparison of Four Studies

In addition to the District's socioeconomic staff, three research groups, National Economic Research Associates, Inc. (NERA, 1988), Pasadena Research Institute (PRI, 1990a), and University of Southern California (USC, 1988), have studied the economic impacts of the District's AQMP. The NERA study refers to the draft 1988 AQMP; the USC study refers to the 1988 revisions to the AQMP; the PRI study refers to the final 1988 AQMP; and the SCAQMD study refers to the 1991 AQMP. Of the three non-District studies, the NERA one, which employs a benefit-cost framework, is the most extensive analysis of the economic impacts of the District's AQMP. The NERA staff not only estimated the net economic impacts, but they also calculated the total annual burden borne by households in different income groups. The USC researchers studied output and employment impacts, but they did not assess the benefits of clean air. The PRI staff focused their analyses almost exclusively on employment impacts.

In Table 6, we show the estimates of employment impacts of the four groups. Values we provide for both the SCAQMD and USC studies are for quantifiable control measures (Tier 1) only. The differences among the

Table 6

COMPARISONS OF EMPLOYMENT IMPACTS FROM FOUR STUDIES

Study	Job Losses	Job Gains	Net Job Impact
SCAQMD	-8,295	+88,987	+80,692[a]
USC	-46,000	+29,600	-16,400[b]
NERA	-389,636	+333,945	-55,691
PRI	-1,409,162[c]	0	-1,409,162

SOURCES:

National Economic Research Associates, Inc. (NERA). 1988. Economic Impacts of the Draft Air Quality Management Plan Proposed by the South Coast Air Quality Management District. A report prepared for the California Council for Environmental and Economic Balance, Table J-2.

Pasadena Research Institute (PRI). 1990a. "Employment Impacts of Proposed Air Quality Regulations in Southern California." Pasadena, CA: PRI.

South Coast Air Quality Management District (SCAQMD). 1991. Draft Socio-Economic Report for 1991 Air Quality Management Plan. Los Angeles, CA: SCAQMD, Table 5-5, p. 5-6.

University of Southern California (USC). 1988. The Economic and Social Impacts of: the Air Quality Management Plan, the Regional Mobility Plan, and the Growth Management Plan. A report prepared for Southern California Association of Governments. Los Angeles, CA: USC, The Planning Institute, School of Urban and Regional Planning, p. 13.

NOTE: The NERA study refers to the draft AQMP; the USC study refers to the 1988 revisions to the AQMP; the PRI study refers to the final 1988 AQMP; and the SCAQMD study refers to the 1991 AQMP.

[a] Estimates for quantifiable control measures (Tier I only). The District socioeconomic staff also project job impacts of the entire 1991 AQMP. We summed all job losses and all job gains listed in Table 5-5, realizing that these represent the net job change within the category.

[b] Estimates for Tier I control measures. The USC staff also assess separately job impacts of the Regional Mobility Plan (RMP) and Growth Management Plan (GMP).

[c] Direct employment impact was 351,616 jobs.

four estimates are striking, with the employment impacts ranging from 80,691 jobs gained, according to the District staff, to over one million jobs lost, according to researchers from the Pasadena Research Institute.

At least five factors may contribute to these large differences in the employment-impact estimates.

Rule Coverage. Control measures are first proposed in the AQMP; they then are discussed by the District staff in the various stages of the rule-making process (refer to Appendix VI) prior to becoming rules. The four studies are not conducted for the same AQMP and therefore have different rule coverage because the rules and regulations are changing overtime. The District socioeconomic staff estimate economic impacts of the 1991 AQMP, which has large construction expenditures from the Southern California Association of Governments' control measures. The USC researchers include quantitative Tier I control measures, the Regional Mobility Plan (RMP) and Growth Management Plan (GMP), from the 1988 revisions to the AQMP. The NERA researchers include control measures from the draft 1988 Revised AQMP without the RMP and GMP. The PRI study, which is based on the final (1989) report of the SCAQMD, covers all District rules and regulations that "are currently in effect in the four-county area" at the time of study (p. 72).

Benefit Consideration. The benefits included in the analyses are not the same in the four studies. The District's benefits include not only job creation from the air-pollution control expenditures, but also other benefits, such as agriculture, visibility, health, and traffic congestion relief, while the NERA and USC staff account for only air-pollution control expenditures. The PRI researchers assume that job-creation from air-pollution controls would be negligible, accounting for only about 11,000 jobs in regulatory agency and law and consulting firms.

Input Data. The input data are also from different sources. The District's analysis covers all quantifiable control costs and benefits and projected costs from nonquantifiable measures. The NERA study includes the projected costs for those measures when cost data are not available, in addition to the District's quantified Tier I measures. The USC's input data are from the SCAQMD/SCAG <u>Environmental Impact Report of the 1988 Revision to the AQMP</u>. The PRI researchers estimate the direct employment impacts based on an industry survey. There is a possibility that business managers may exaggerate the job loss resulting from air-pollution rules and regulations, in part, because it may be difficult to separate effects of air-pollution controls from those of others, such as increasing labor costs and increasing international competition.

Assumptions and Methods. As shown in Table 7, the four research teams use very different assumptions and methods. The USC staff, for example, assume a 100 percent cost pass-through to consumers in the form of price increases. The NERA staff, on the other hand, differentiate between basic and nonbasic sectors. In the basic sector, the cost increases are assumed to reduce industrial competitiveness, thus its market share and profits. In the nonbasic sector, the cost increases are assumed to increase the product prices and reduce local income available to spend. The District staff use the REMI model, NERA researchers employ the Southern California (SOCAL) Gas Company model and an adjusted national input-output model, USC researchers apply the Regional Science Research Institute (RSRI) input-output model, and the PRI staff use a regional input-output model to estimate multiplier employment effects. It is possible that the differences in model structure and study methods contribute significantly to the differences in the employment-impact assessments.

Definitions and Interpretations. The differences in the employment impacts may also result from the different definitions and interpretation of employment. Employment can be defined in terms of a person, counting an individual as employed only once, even though he or she may hold more than one job. It can also be defined in terms of job-count, in which employment is calculated based on number of positions rather than persons who fill those positions. In addition, the employment estimates may vary significantly depending on whether analysts include both permanent jobs and temporary jobs, such as construction jobs, both part-time jobs and full-time jobs, and on the time period used to calculate employment impacts (e.g., point estimate, annualized estimate, or average annual estimate). None of the four studies, however, provides a clear definition and interpretation of employment.

We do not have sufficient information to determine the relative contribution of the four sources identified to the discrepancy in employment impact estimates, because to do so, in most cases, requires as detailed an examination of the methodology and data sources of the study as we conducted on the District's REMI model (refer to Appendix I). Our comparison of the four studies has several important implications for the District's socioeconomic impact analyses.

Table 7

COMPARISON OF THE EMPLOYMENT-IMPACT-ASSESSMENT METHODS

Agency	Method
NERA	Control Costs Assume that air-pollution controls increase the costs of production, having profit/sale-reduction effects on the basic sector and price-increase effects on the nonbasic sector. For the basic sector, use the Southern California (SOCAL) Gas Company Model to estimate direct employment impacts and the SCAG economic-base multiplier to estimate secondary employment impacts. For the nonbasic sector, the price increases are assumed to reduce income available to spend, which, in turn, will reduce final demand. Apply an adjusted national input-output table to estimate the employment impact of this reduced demand. Control Expenditures Assume 75 percent would be spent in local areas. Estimate employment generated based on direct and indirect demand for labor in SIC 34-38 industries.
PRI	Conduct industry survey to estimate direct employment impacts in eight industry groups; Use a regional input-output model to estimate the multiplier effects of the initial employment impacts. Assume that local job generation from the control expenditures is negligible.
SCAQMD	Estimate quantifiable control costs and control benefits, such as agriculture, visibility, and traffic congestion relief. Translate the estimates in (1) into the REMI policy variables. Run the REMI model to assess employment impacts.

Table 7 (continued)

COMPARISON OF THE EMPLOYMENT-IMPACT-ASSESSMENT METHODS

Agency	Method
USC	<u>Control Costs</u> The costs were allocated to industries at the two-digit SIC level. Assume 100 percent cost pass-through to consumers in the form of price increases. Estimate the final demand decrease based on price elasticity of demand. Use the RSRI input-output model to quantify output and employment impacts. <u>Control Expenditures</u> Assume 65:35 division between capital costs, including installation, and service costs. Allocate the control expenditures among the supply sectors at a two-digit level with the sectoral distribution reflecting the relative distribution of the final demand. Use the RSRI input-output model, which has regional purchase coefficients, to quantify output and employment impacts.

Sources: National Economic Research Associates, Inc. (NERA). 1988. Economic Impacts of the Draft Air Quality Management Plan Proposed by the South Coast Air Quality Management District. A report prepared for the California Council for Environmental and Economic Balance.

Pasadena Research Institute (PRI). 1990a. "Employment Impacts of Proposed Air Quality Regulations in Southern California." Pasadena, CA: PRI.

South Coast Air Quality Management District (SCAQMD). 1991. Draft Socio-Economic Report for 1991 Air Quality Management Plan. Los Angeles, CA: SCAQMD.

University of Southern California (USC). 1988. The Economic and Social Impacts of: the Air Quality Management Plan, the Regional Mobility Plan, and the Growth Management Plan. A report prepared for Southern California Association of Governments. Los Angeles, CA: USC, The Planning Institute, School of Urban and Regional Planning.

First, it is critical, in analyses and reports, to define clearly the key variables and measurements, to indicate what factors are included and what are not, and, whenever possible, to discuss how the factors that are not included may affect the results of the economic assessments.

Second, because of difficulties involved in quantifying some control measures and in estimating quantifiable variables accurately, the District's socioeconomic staff may consider performing sensitivity analyses on a regular basis to see how sensitive the economic impacts are to changes in the values of the input variables. For some highly sensitive economic-impact estimations, they may report the results in terms of a range of estimates, rather than in terms of point estimates.

Third, the District's socioeconomic staff may complement the REMI modeling with other types of analyses. When the overall economic impact is small and there are only a small number of firms or industries affected, for example, it may be more productive to conduct a business survey, as the Pasadena staff did, or to do simple modeling, as the USC research team did, than to do the REMI modeling. Even when the use of the REMI is warranted, a business survey and/or first-round quick analysis will help the District staff to make judgements on which policy variables or options of the REMI to use and to interpret the results of the REMI modeling.

Private Consulting Firms

Seven consulting firms responded to our survey, all of whom have extensive experience in regional economic modeling. In the survey, we asked them to estimate the relative costs of the District staff performing the socioeconomic assessments versus having the equivalent work conducted by an independent contractor. We also collected information on their modeling techniques and their views on advantages and disadvantages of having an independent contractor to conduct economic-impact analyses of air-pollution controls.

Among the seven firms, two indicate that it will cost them less than $400,000 annually to conduct socioeconomic analyses equivalent to those performed by the District's socioeconomic staff for about 20 rules and regulations. Four firms estimate the annual costs to be between $550,000 and $849,000, which is in the same range as the District costs. The other one believes that the annual cost will be more than $850,000. This suggests that there may not be a large saving if the District were to hire an independent contractor to conduct the socioeconomic evaluations.

The consultants cite five major advantages they believe would exist if they, rather the District staff, conducted the economic-impact analyses.

1. **Objectivity.** The District's rules and regulations have repercussion effects on the regional economy and affect many people, both producers and consumers. The socioeconomic impact analyses, at least in perception, are conducted in a highly politicized environment. An independent contractor may be in a better position than the District to ensure all affected parties and concerned groups that analyses are done objectively and that the conclusions are unbiased.

2. **Accountability.** An outside firm is accountable. It has incentives to do high quality work to maintain their reputation and to continue its contract. Its analyses are likely to be closely monitored by the District staff to ensure an acceptable level of accuracy.

3. **Time Efficiency.** A consulting firm is better equipped than the District to complete tasks on time and to reduce the costs of performing economic impact analyses, especially when it faces competition from other firms.

4. **Diversified Experience/Expertise.** Private consulting firms typically have many clients and may perform similar work for other

agencies. They often have diversified experience and expertise, are aware of similar and related efforts in other parts of the country, and are familiar with many data sources and analytical techniques that can be used to improve the economic evaluations.

5. **Flexibility.** As analytical needs change, a private consulting firm can adjust workloads and methods of analysis more quickly than a governmental agency. They usually can engage consultants, professionals, and specialists on short-notice.

The consultants who responded to our survey realize, however, that there are problems associated with hiring outside consultants, rather than having in-house staff, conduct the analyses. Some of the problems they cited are:

High Up-Front Costs. The District has to pay high up-front costs to a private firm to set up the system and develop the capacity to perform the socioeconomic evaluations. If the District changes consultants frequently for some reason (e.g., dissatisfaction with the work of an existing contractor, presence of better or lower-cost firms, and so on), there will be repeated start-up costs. There will also be another layer of supervision and coordination costs as the contractor is hired, the work plan developed, and the work is monitored.

Lack of Local Knowledge. Outside firms may lack detailed and current local knowledge relevant to the District's rules and regulations. Outside firms may not be aware of or have access to local data sources, costs/types of alternative control technologies, and types/distribution of pollution sources. Establishing a local knowledge and data base that is comparable to what the District has would add further to already high project costs.

Monitoring Problems. The District would need to monitor the consultants' work. Given the complexity of economic impacts of air-pollution controls, the District may have to maintain a sizable number of experts and specialists in-house just for monitoring. There may also be problems of communication between the District and an independent contractor and transaction costs, both in time and money, involved in this communication. The District, therefore, would have a strong argument for incurring additional costs just to maintain an in-house socioeconomic impact assessment capability as (1) an important oversight and monitoring function and (2) an important information source and knowledge base for urban and rural space management.

Six models or modeling approaches are identified by consultants for assessing economic impacts of air-pollution controls. They are (1) the Regional Economic Modeling, Inc. (REMI), (2) the Regional Input-Output Modeling System II (RIMS II), (3) Impact Planning (IMPLAN)/Interactive Policy Analysis Simulation System (IPASS), (4) Regional Science Research Institute Model (RSRI), (5) regional input-output model, and (6) hybrid econometric and input-output modeling.[11] We will discuss the basic structure and methodologies of these models in the second part of this report.

Several consultants commented on the District's REMI modeling approach. We summarize their comments here.

First, REMI is a versatile regional economic model that has performed well in many states. For some purposes, however, it may lack sufficient industry detail to account for changes in industrial mix (e.g., at the three-digit and four-digit industrial level) and intraindustry differences, especially for areas that experience much volatility in industry mix. This problem can, in part, be mitigated by periodically accounting for the changing industry mix in the simulation runs.

Second, the REMI model incorporates many relevant variables and parameters dealing with production costs and some transfer costs. Yet, the most critical costs affecting the location of economic activities may be

[11] Both RIMS II and RSRI are regional input-output models. The IMPLAN/IPASS modeling system consists of three components: (1) IMPLAN (528-sector) economic modeling system and county-level data bases for detailed industry assessments, with corresponding industry detail on exports and imports, (2) IPASS/Trade Model for demand-driven supply-constrained simulation of rules effects over a given planning horizon, and (3) Individual county and multi-county social accounting matrices (SAMs) for reconciling production and demand changes and deriving distribution effects of these changes in local areas.

various other infrastructure and market-access costs, which are not included in the model.

Third, the REMI model may be too complex or too "macro" to estimate economic impacts of an individual air-pollution rule. The socioeconomic staff need to complement their use of the REMI model with other types of analyses to explain employment and production cost impacts, to interpret the modeling results accurately, and to assess the significance and meaning of the results.

Fourth, the REMI model does not adequately deal with distribution issues. The socioeconomic staff need to recognize and analyze some socioeconomic factors, such as effects on specific income and ethnic groups, in addition to the REMI model results.

Fifth, current modeling approaches, including the District REMI models, focus on transitional steps and do not adequately consider long-term adjustments. Although transitional costs must be considered, the long-term adjustments must be taken into account as well. In the long term, adjustments are made by both producers and consumers, so that transitional economic impacts disappear. The consumers, producers, and work force all adjust to the new situation. Thus, the most important considerations are the efficiency gains or loss.

The results of our consulting firm survey indicates that having the District conduct economic impact analyses has both advantages and disadvantages. One major concern is the objectivity and accountability of the District's economic analyses given that people working for the same agency propose rules, analyze the socioeconomic effects of these rules, and then implement and enforce them. This is an important issue because in order for socioeconomic reports to be useful, the people using them must have confidence in their results. In our final report, we suggest a number of ways in which the potential for some of these biases in the socioeconomic analyses can be mitigated. We, for example, recommend that the District provide clear explanations and justifications for their assumptions and document their work very carefully, describing exactly which variables were adjusted, how they were changed, where data came from, which version of the model was used, and so on. We also recommend the establishment of a Socioeconomic Analysis Review Committee to help keep the District's socioeconomic staff at the leading edge of analyses and to provide a mechanism to assure accountability of the staff to the public at large.

Summary of Alternative Approaches

At the risk of oversimplification, we group the economic-impact assessment methods used by U.S. air-pollution control agencies into three categories: cost-effectiveness techniques, industry studies, and regional economic-impact modeling. The three approaches differ in the levels of aggregation. Cost-effectiveness analysis is the most disaggregated. It focuses on compliance costs, including the relative importance of unit compliance costs to total unit costs of production for individual plants and the financial impacts on specific firms. At the next level of aggregation, an industry study is used to examine the regulatory impacts on directly affected industries, including effects on product prices, output employment, input uses, and market structure as well as total industry-wide compliance costs. At the most aggregated level, regional economic impact (REI) modeling quantifies the effects of air-pollution controls on the regional macroeconomy.

The three approaches are, to a large degree, complementary and should not be viewed as competing alternatives. Cost-effectiveness analyses identify the initial impacts of the air-pollution control, which, in most cases, are an important input into the industry studies and REI modeling. REI studies extend the cost-effective analyses and industry studies to estimate indirect and induced effects or secondary impacts of air-pollution controls. In fact, the Economic Analysis Branch of the U.S. Environmental Protection Agency (U.S. EPA, 1985) has developed a general framework to integrate economy-wide, industry-wide, and firm level economic impact analyses and make them internally consistent.

Cost-Effectiveness Analyses

Cost-effectiveness analysis is used "to identify the set of emission standards that minimize the total cost of achieving a given level of benefits from environmental quality improvement" (U.S. EPA, 1985, p. 2.4-1). In other words, the cost-effective set of standards are ". . . those that minimize the total cost of a target level of total emissions reduction" (U.S. EPA, 1985, p. 2.4-1).[12] The EPA sets forth three ways of defining the control costs. The first definition is the narrowest. It includes only the annualized cost of capital equipment (including installation cost) and annual cost of operating and maintaining the equipment. The second definition extends the first definition to account for any dollar-saving from the control equipment, such as reduced maintenance, improved productivity/efficiency, or the recovery of valued residuals or by-products. The third definition includes all

[12] Analysts should distinguish the EPA method from a method that minimizes the cost per ton of pollutant reduced because minimizing total costs is not usually equivalent to minimizing average costs.

elements in the second one plus indirect costs, which are reductions in output and employment caused by air-pollution controls. The U.S. EPA recommends use of the second definition in performing cost-effectiveness analyses. The most commonly used techniques for cost-effectiveness analyses are model-plant analyses and engineering costs estimates.

Industry Studies

The central task of an industry study is to examine the impacts of air-pollution regulations on directly affected industries or businesses. There are two types of industry study: business analysis and industry analysis. Business analysis is concerned with the regulatory impacts on the business environment and/or on special groups of businesses, such as small businesses. The Small Business Economic Impact Study conducted by the ICF, Inc. researchers (1988) and Business Community Perceptions of Air Quality Regulation Impacts on Economic Development in the South Coast Air District conducted by the FB&M staff (1990) are examples of a business analysis. An industry analysis, on the other hand, focuses on the impacts on specific industries and is usually undertaken in three stages (U.S. EPA, 1985). First, analysts examine the characteristics and current conditions of the industry. Second, they project the future growth of the industry without air-pollution controls. Third, analysts examine how air-pollution controls may affect the industry and alter the pattern of growth.

Regional Economic-Impact Analyses

The regional-economic-impact (REI) analyses deal primarily with the impacts of air-pollution controls on the regional macroeconomy. The emphasis of an REI study is on the multiplier effects of the proposed air-pollution regulations or rules. One major advantage of the REI approach, compared with both cost-effectiveness analyses and industry studies, is its comprehensiveness. Analysts can use an REI model to study the impacts of air-pollution controls on the whole economy, including all sectors, and they capture not only direct effects, but also indirect and/or counter-intuitive effects on both producers and consumers. This comprehensiveness is particularly important in examining the rules or cluster of rules that have large or repercussion effects on the regional economy.

There are several other advantages of using REI models. First, the REI models provide an explicit and organized framework for the impact assessments, helping analysts to clarify assumptions and identify causal links. Second, the models institutionalize and standardize the assessment process and contribute to the accumulation of knowledge and data. Third, by using the models, analysts can process large amounts of information, estimate impacts, and make forecasts under different assumptions, thus contributing to a mutual understanding and communication among different concerned groups. Fourth, analysts can use an REI model to generate a variety of output, thus improving administrative efficiency.

The REI models, however, are expensive and may require more resources, data, and research capacity than the agencies are able to obtain. In some states, the law requires air-pollution control staff to assess only direct compliance costs and industry-specific economic impacts. Some advantages of the REI models we cite above thus become less important, and the REI models may not be cost-effective. More fundamentally, the REI models have their own conceptual limitations. To fit the complexities of the real world into the variables that can be handled in a model, the builders of regional economic models may have to make many unrealistic and simplifying assumptions. A few examples are:

Selective Attention. The influence of any factors not included in the model is implicitly assumed to be less important. By so doing, the model users may miss some important variables or factors and neglect unquantifiable issues.

Range. The parameters in regional models are usually estimated or calibrated using historical data within a range of prior experience. If there is no change in underlying economic behavior, the model should be useful in making forecasts within this range of prior experience. The reliability and accuracy of the forecast, however, will decrease dramatically if the underlying behavior changes and/or if the projection is far beyond the range of historical data.

Symmetric Relationship. The modelers often assume that the economic relationship is reversible. They, for example, may assume that wages will be equally responsive to increasing and decreasing demand for labor. This may be problematic because many studies have shown that price and wage adjustments are asymmetric. They are easy to rise, but are "sticky" in downward adjustments.

Adjustment Time. Typically, there are no historical data for modelers to estimate how fast and effective the response to certain stimuli is likely to be. Time lags, in practice, are often determined artificially using a convenience number, such as one year.

We will discuss the strengths and limitations of using REI models to assess economic impacts of air-pollution controls in detail in the second part of this report. We realize that analysts who conduct cost-effectiveness or industry studies must make many assumptions as well. The real issue, therefore, is whether or not analysts who use the REI models are more prone to hide the assumptions, thus reducing the transparency or credibility of their modeling results, than if they were to conduct cost-effectiveness or industry studies.

Selection of Appropriate Approach

From our surveys, we find that there is no single "right" way to approach economic impact analyses. The scope and methods of economic-impact analyses vary significantly across air-pollution control agencies and research teams and often also differ from one rule to another in the same agency, depending on the characteristics of the specific rules studied. The problem, therefore, is not what is the best method, but which method is the most appropriate to answer which question. Selection of the appropriate approach often cannot be determined easily a priori and depends on several factors, such as:

Primary purpose of the economic-impact analysis. If the analytical focus is on compliance costs, then analysts may select cost-effectiveness analysis, although in order to study the long-run competitiveness of the industry, they will also need to use industry studies and REI models. If analysts, on the other hand, are mainly concerned with short-term to medium-term macroeconomic impacts of air-pollution controls, they may use REI models.

Characteristics of the rule in question. The choice of the methods also depends on the size or scale of economic impacts. Researchers, for example, may conduct a cost-effectiveness analysis if the rule in question only affects a few plants/firms, an industry study if it affects a few industries, or the REI modeling if it affects a large number of industries/businesses.

Institutional capacity. How many resources--technical, personnel, time, and money--does the agency have to conduct the economic impact analyses? Among the three approaches, the REI usually has the highest resource requirements and the cost-effectiveness, the lowest.

Institutional structure and requirements. How frequently are the impact analyses performed, for individual rules or for a set of rules such as the District's AQMP? What kinds of information--e.g., cost, output, employment, and consumer impacts--are required and at what scale--e.g., at the plant level, at the industry level, or for the regional macroeconomy?

Analysts can use many methods and models to assess economic impacts of air-pollution controls, each with strengths and weaknesses. We believe that the key to a good economic-impact analysis is to match approaches to the task at hand and to mix different methods and models as needed. One path to this strategy is a flexible method of analysis--a basic analytical framework that has the capacity to incorporate other methods and models and to adopt to changing environment and analytical needs. Under such a system, analysts would "pick and choose" methods based on the particular type of analysis needed. Instead of concentrating on upgrading a specific model, they would work on improving their own abilities to work with many different techniques. Rather than trying to gain proficiency in all fields, they would work to identify areas where in-house know-how is most needed, and where they should rely on expertise from other departments or from outside sources. We discuss some methodological implications of this flexible method of analysis in the last section of this report. Details on the flexible method of analysis, including the institutional structure required for its implementation, are provided in our final report.

BASIC METHODOLOGIES OF REI MODELS

If analysts decide to use an REI modeling approach, they may have difficulty selecting an appropriate model. The number of REI models available has increased dramatically in the last 25 years because of the increased demand for such models, reduced model costs, improved data availability, and advancements in computing and data-processing technologies (Brucker, Hastings, and Latham, 1987). There is no set of "industry standards," however, governing all REI models (Brucker, Hastings, and Latham, 1987; 1990), nor any data protocols. In fact, product differentiation through the availability of options and additional features is an important form of nonprice competition in the regional model market. The REI models differ widely in their range of applicability, methodologies, data requirements, complexity, and computational procedures.

Here, we examine some of the basic methodologies of REI models to provide a general framework within which the socioeconomic staff can compare and evaluate their REMI model. Rather than evaluating a large number of individual models in the market, we focus on common structures and methodologies among diversified REI models and the advantages and disadvantages of using a certain type of model or modeling approach. We group REI models into four categories: economic-base, input-output, econometric, and integrated models. For each category, we review the basic structure and methodology and examine the strengths and limitations of the models for assessing economic impacts of air-pollution controls.

Economic-Base Models

Economic-base models dichotomize the regional economy into export and local-service sectors. The export sector is assumed to be the driving force of regional economic development and includes those economic activities producing goods and services that are sold to nonlocal markets. The service sector is assumed to serve mainly as a supporting activity for the export sector and includes all other activities that produce for the local market. Thus, export-base theorists assume that changes in the level of economic activities in the export sector will automatically lead to similar changes in the service sector. To implement the model, they also assume that the economic-base multiplier--the ratio of the total level of economic activity to the level of export sector activity in terms of employment, income, or output--remains constant in the short run.

Using an export-base model to assess economic impacts of air-pollution controls, analysts first determine how the air-pollution regulations affect the comparative advantage of export industries. They then examine how this leads to changes in the level of export activity. Finally, they apply economic-base multipliers to estimate changes in the total level of economic activities in the region resulting from initial changes in the export sector activities.

The economic-base model is most representative of regions with a highly specialized industrial structure whose economic fortunes are entirely dependent on a few export-oriented industries. It is commonly employed in economic-impact analyses, in large part, because of the model's theoretical simplicity, small data requirements, and relative ease of application.

Murdock and Leistritz (1983) reviewed 13 well-known REI models in the United States and found that eight of them were based on economic-base theory. The economic-base method, for example, was used in constructing the Social and Economic Assessment Model (SEAM). The SEAM is a computerized simulation model developed by the Argonne National Laboratory to estimate socioeconomic impacts of energy and industrial development (Stenehjem, 1978). The model can provide economic and demographic information for any county or group of counties in the continental United States, including (1) population by age, gender, and race; (2) direct employment requirements of energy-related facilities; (3) secondary employment generation; (4) locally available work force from affected and adjacent counties; (5) number of immigrating workers; (6) housing and public-service requirements (Carley, 1983). Another similar model is the Community Level Impacts Projection Systems (CLIPS), which was written to help assess the impact of energy development in Texas (Carley, 1983; Murdock and Leistritz, 1983). Table 8 shows the structure and characteristics of these two models and six other economic-base models that are widely used in economic impact analyses.

The economic-base model, however, has four important limitations. First, it relies exclusively on exports as the determinant of economic expansion and decline and fails to consider the role of the local service sector and other aspects of the regional economy. Air-pollution controls, for example, may force businesses to import pollution-abatement equipment from other regions, thus reducing the regional income.

Second, the economic-base multiplier may change because of the proposed air-pollution regulation. The regulation, for instance, may increase the costs of producing local goods and divert resources from the export activities to the service sector.

Third, it fails to distinguish between the linkages of different export activities. Air-pollution controls may affect different export industries very differently because production functions and input requirements vary across industries. In addition, changes of equal magnitude in different export activities may produce markedly dissimilar impacts on the regional economy due to disparate sets of backward and forward linkages between the export activities and the rest of the economy.

Finally, and most important, the economic-base model oversimplifies the regional economic structure. It fails to account for the complexities of global production strategies in which goods are produced with components from

Table 8

CHARACTERISTICS OF EIGHT ECONOMIC-BASE IMPACT ASSESSMENT MODELS

Model	Geographical areas included	Time interval and total projection periods	Total # of area units	Methodologies						Validation	Transferability to other areas
				Eco-nomic	Demo-graphic	Inter-face	Subarea Distri-bution	Service	Fiscal		
BOOM1	City only	Yearly, NLS	Any given city	E-B	E-P	E-P-1	NA	P-B	per capita	sensitivity	yes-Texas
BREAM	Region, county cities	Yearly, NLS	2 counties maximum	E-B	CC-S	E-M-1	% share & gravity	P-B	NA	INP	untested
CLIPS	Region, county cities	Yearly, 20 yrs.	INP	E-B	CC-S[a]	E-M-1	% share & gravity	NA	per capita	INP	untested
HARC	Project county	5 yrs. 30 yrs.	INP	E-B	CC-S	E-M-1	gravity	P-B	NA	sensitivity	untested
MULTI-REGION	BEA area	5 yrs. NLS	All BEA regions	E-B	CC-S	E-M-1	NA	NA	NA	historical	untested
NAVAHO	Reservation districts	5 yrs. NLS	9 reservation districts	E-B	CC-S	E-M-M	gravity	NA	NA	INP	untested
SEAM	County, cities	Yearly, 30 yrs.	INP	E-B	CC-S	E-M-M	LP	P-B	per capita facility	sensitivity/ historical	untested
WEST	Region, county cities	Yearly, NLS	INP	E-B	E-P	E-P-1	% share	P-B	per capita	sensitivity	untested

Sources: Steve H. Murdock and F. Larry Leistritz. 1983. "Computerized Socioeconomic Assessment Models." in Social Impact Assessment Methods, edited by Kurt Finsterbusch, Lynn G. Llewellyn, and C.P. Wolf. Beverly Hills, CA: Sage Publications.

NOTE: Explanation of abbreviations: NLS = no limit specified; INP = information not provided; NA = not applicable. *Economic:* E-B = export base. *Demographic:* CC-S = cohort component survival; E-P = employment-population ratio. *Interface:* E-M-1 = employment-migration-one phase; E-P-1 = employment-population-one phase; E-M-M = employment-migration-multiphase procedure. *Subarea Distribution:* % share = distribution to subareas on basis of employment or population ratio; LP = linear programming model. *Service:* P-B = population-based projections. *Fiscal* per capita = per capita costs and revenues; facility = projections of facility requirements also completed.

a. Cohort component survival method used at the regional level only.

all over the world. In fact, the whole concept of regionally based production is changing partly because of economic globalization and increasing competition (Dertouzas, Lester, and Solow, 1989; Piore and Sabel, 1984; Reich, 1983, 1991). There are, in practice, no methods for easily, unambiguously, and accurately distinguishing between export and service activities. Analysts, depending on what methods they use to identify export activities, may reach different conclusions regarding the economic impacts of air-pollution controls.

Regional Input-Output Analyses

Input-output analysis is perhaps the most widely used regional economic-impact assessment method. It is a powerful tool for use in describing an economy empirically and has played a dominant role in regional modeling throughout the world (Nijkamp, Rietveld, and Snickars, 1986). It stems from the double-accounting principles employed in the national income and product accounts. Gross output can be accounted for either by adding the total purchases (outlays) of intermediate inputs, labor, capital, and imports, or by tracing the flows of output from sectoral sources to destinations of intermediate and final uses. The empirical basis of the input-output analysis is the transactions table, which can be expressed in either monetary values or physical units (Polenske and Fournier, forthcoming).

A major advantage of the input-output approach is its ability to provide sectoral-specific multipliers under different assumptions (Sivitanidou and Polenske, 1988). Using the transactions table, regional analysts calculate direct input requirements--inputs required by each industrial sector to produce one unit of the gross output in that sector--and total input requirements--inputs required by each industrial sector to produce one unit of the **final output** in that sector. Analysts typically assume that direct and total input requirements remain stable for about 5 to 15 years and use them to estimate the economic impact multipliers, which are the economic effects that a change in the final demand for one or more sectors will have on regional output (output multipliers), income (income multipliers), and employment (employment multipliers) for each sector. In calculating multipliers, analysts can treat all final demands exogenously to account for only direct and indirect effects; or they may treat one or more of the final demand components endogenously to account not only for direct and indirect effects, but induced effects as well. The former is often referred to as an open input-output model (or Type I multipliers) and the latter as the partially closed model (or Type II multipliers) (Polenske, 1982; Sivitanidou and Polenske, 1988; Miller and Blair, 1985).

The input-output technique has frequently been used to incorporate environmental variables into regional economic models (Miller and Blair, 1985; Brouwer et al., 1983; Briassoulis, 1986). Leontief (1970), Leontief and Ford (1972), Isard (1969, 1972), Kneese et al. (1970), Cumberland and Korbach (1973) were among the first to integrate economic and environmental variables into a unified modeling system based on the input-output framework and the materials-balance principle. Del Duca (1978), Pai (1979), and Polenske (1986) extended Leontief's environmental model to a multiregional level and used it to examine the regional economic impact on outputs of implementing the 1974 Clean Air Act. Miernyk and Sears (1974) constructed an air-pollution input-output model to study the impacts of the 1970 Clean Air Act on the West Virginia economy.

Analysts use three basic techniques to include air-pollution variables into traditional input-output tables: (1) augmenting the technical coefficients matrix with additional rows and columns to reflect air-pollution generation and/or abatement activities; (2) extending the interindustry framework to include "air-environment" sectors to record flows between the economy and the air-environment; (3) expressing air pollutants as "commodities" in a commodity-by-industry table (Miller and Blair, 1985). The input-output analysis, then, can be used to determine the amount of air pollutants associated with certain levels of economic activities, to estimate the impacts of air-pollution controls on the regional economy, and to identify various ways in which air pollution can be reduced.

Several input-output models are widely used in regional economic-impact analyses. They are the Regional Input-Output Modeling System II (RIMS II) developed at the Bureau of Economic Analysis of the U.S. Department of Commerce, ADOTMATR developed at the University of Nebraska, the Impact Planning (IMPLAN) model developed for the U.S. Forest Services, RSRI developed by Benjamin Stevens at the Regional Science Research Institute, and SCHAFFER developed by William Schaffer at the Georgia Institute of Technology. All five models were developed for use in determining economic impacts at the state or county levels. Brucker, Hastings, and Latham (1987; 1990) provide an excellent review and comparison of these models (see Table 9).[13]

[13] REMI, which is discussed below under integrated regional economic models, has an input-output model module.

Static input-output models, however, have three major limitations: constant coefficients, linear relationships, and data intensiveness.[14] First, analysts assume that technical coefficients in the static input-output model remain unchanged over the period of analysis. This implies that, within the study period, there are no changes in production technologies, in the relative prices of any of the inputs, or in product mix--all of which may alter technical coefficients. This assumption is particularly problematic in assessing economic impacts of air-pollution controls because one principal way industries comply with pollution-control regulations is to change production technologies (e.g., using cleaner and more efficient electric-generation systems) and substitute pollution-related inputs (e.g., use fewer or cleaner inputs). Second, a static input-output model is fundamentally a set of simultaneous linear equations. Analysts assume that there are no economies of scale, discontinuities in the production functions, threshold effects, irreversibilities, or other violations of smooth linear functions (Davis, 1990). Finally, input-output models are data-intensive and expensive to construct. As a result, most regional input-output tables in the United States are not based on local survey data, but are derived from national input-output tables using so-called "regionalization" techniques, ranging from simple location quotients, regional purchase coefficients, to the RAS computational algorithm. Empirical evidence shows that regionalization techniques are limited in their accuracy and the derived regional technical coefficients may not reflect characteristics of the regional economy to the

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[14] Many analysts now use dynamic input-output models, in which case the first two limitations are overcome, but the third limitation becomes more restrictive (Duchin, 1988).

TABLE 9
Comparison of Five Regional Input-Output Models

	Regional Model				
Characteristics	RIMS II	ADOTMATR	RSRI	IMPLAN	SCHAFFER
I. General Characteristics					
Base Year	1977	1977	1977	1977 (1.1), 1982 (2.0)	1977
Update	Yearly (LQ earnings)	Price index	Emp./wages 1983	Not regularly	CBP PI tapes/yearly
Reference Model	Nat'l tech. coefficients	Nat'l or other	Nat'l tech. coefficients	Nat'l transactions	Nat'l tech. coefficients
II. Sectoring Scheme					
Disaggregated	531	531	494	538	533
Same as National	Yes	Yes	No (Retail more detailed)	No (Mining more detailed; const. & ag. more aggregated.)	Yes
Aggregated	39	150 (maximum)	1-digit or 2-digit	User choice	13 or 80 or user chooses
When Aggregated	After inversion	Before inversion	After iteration	Before inversion	After iteration unless adjusted
Defined	By modeler	By user	By modeler (SIC-based)	By user	By modeler
III. Definitions and Data					
Matrix Definition	Industry-by-industry	User choice	Industry-by-industry	Industry-by-industry Commodity-by-commodity	Commodity-by-industry (during construction) Industry-by-industry (in use)
Data Used:					
Physical Labor Coefficient	BEA emp./earnings	CBP emp./output (user choice)	Wage/output ratio Wage/employment ratio	CBP employment	CBP employment
Consumption Column	National PCE, savings rate State tax data	User choice	BLS, regional CES	Regional personal consumption Regional population	Regional Personal Income ratios
Household Income Row	Residence data	User choice	Residence data Out-of-state spending	Gross Factor Income	no change
Trade Pattern Adjustments	BEA 4-digit wage & salary	User supplies	Census of transportation regression data RSRI	1977 MRIO regression estimates or user defined	Census of transportation

TABLE 9 (continued)
Comparison of Five Regional Input-Output Models

Characteristics	Regional Model: RIMS II	ADOTMATR	RSRI	IMPLAN	SCHAFFER
IV. Regionalizing Procedure					
Product Mix	Keep at disaggregated level	User supplied employment weights	Keep at disaggregated level	Keep at disaggregated level	Keep 537 level of disagg. custom aggregation before iterative solution
Consumption	Row adjusted for commuting; Column adjusted for savings & state tax leakages	No (unless user adds data)	BLS regional CES	Adjust using RPC	No
Trade Patterns	Mixed LQ	LQ/S-D pool/Trade coefficient User's choice	RPCs	S-D pool (1.1) RPC (2.0)	Modified S-D pool
V. Special Features	Makes use of annually updated detailed BEA wage & salary data Can be linked with NRIES for fiscal analysis Direct earnings coefficient available (to aid in final demand identification)	Flexibility Ease of inclusion of user-supplied data Choice of output format	State tax effects Local tax effects Occupation impacts Value-added multipliers Pollution impacts Disaggregated retail impacts; tourism impacts	Type III income/emp. multipliers Labor force utilization Final demand vector identification aid	Final Demand Vector Identification

Ag. = Agriculture; BEA = Bureau of Economic Analysis; BLS = Bureau of Labor Statistics; CBP = County Business Patterns; CES = Consumer Expenditures Survey; Const. = Construction; Emp. = Employment; LQ = Location Quotient; Nat'l = National; NRIES = National-Regional Impact Evaluation System; PI = Personal income; RSRI = Regional Science Research Institute; S-D = Supply-Demand; Tech. = Technical.

Source: S.M. Brucker, S.E. Hastings, and W.R. Latham. 1990. "The Variation of Estimated Impacts from Five Regional Input-Output Models," International Regional Science Review, Vol. 13, Nos. 1-2, pp. 119-139.

level of accuracy desired (Brucker, Hastings, and Latham, 1990; Polenske, Crown, and Möhr, 1986; Round, 1983; Stevens et al., 1980; Stevens, Treyz, and Lahr, 1989).

Analysts have made considerable progress in meeting some of these criticisms. Burress, Eglinske, and Oslund (1988) conducted a survey of regional input-output models in the United States. They identified 18 dynamic input-output models, most of which belong to one of five modeling systems: (1) the REMI model; (2) Johnson, developed by Thomas Johnson; (3) Interactive Policy Analysis Simulation System (IPASS), produced in the U.S. Forest Service; (4) Kansas Long-Term Model (KLTM,) produced at the University of Kansas; and (5) Washington Projection and Simulation Model, developed by Conway and his colleagues (1990). Table 10 presents a comparison of these five models.

Regional Econometric Models

Econometric models are multiple-equation systems that attempt to describe structural relationships within regional economies (Pleeter, 1980; Sivitanidou and Polenske, 1988). In contrast to regional economic-base and input-output modelers, regional econometricians often take an eclectic approach, basing their models on more than one economic theory (Pleeter, 1980; Glickman, 1977). In fact, one component of regional econometric modeling is to verify empirically the theory upon which the model is based (Pleeter, 1980). Econometricians typically construct the model and estimate the relationship by performing regression analyses with time-series data (rather than the typical single-period reference of economic-base and static input-output models).

Analysts can use regional econometric models as an alternative way of calculating multipliers and conducting economic-impact analyses. Econometric multipliers have some interesting features, such as they usually decrease over time and vary over the business cycle (Glickman, 1977). For linear equations, the simplest econometric multiplier is a regression coefficient, sometimes called an "economic impact multiplier," which indicates the change in a dependent variable resulting from one unit change in an independent variable while holding all other variables constant. Because the total indirect and induced effects continue to build as time progresses, analysts may calculate an "interim multiplier" if the exogenous shock to the system is not sustained or a "total multiplier" if the shock is sustainable until the marginal economic impact from the shock approaches zero. For nonlinear models, analysts often refer to the multipliers as "dynamic multipliers," which are the differences between a "control solution" (with an external shock) and a "base solution" (without an external shock).

The quality and degree of sophistication of regional econometric models depends, to a large degree, on their functional forms. There are two classes of regional econometric models: simple and simultaneous equation (Glickman, 1977). The simple models consist of a series of regression equations in which national variables are related to regional ones. They are often extensions of the Keynesian macroeconomic model or economic-base models. Individual equations are not related to each other. Simultaneous-equation models can be solved either recursively or fully simultaneously. In recursive models, the regression equations are related unidirectionally and can be ordered in such a way that there is a unidirectional flow of causality among sectors or key variables. In fully simultaneous-equation models, all equations are related

Table 10
CHARACTERISTICS OF FIVE DYNAMIC INPUT-OUTPU T MODELS

Characteristic	Johnson	IPASS	KLTM	REMI (version FS-53)	WPSM
Matrix of import or regional purchase coefficients?	no	note a	yes	yes	yes
Endogenous household consumption?	no	yes	yes	yes	yes
Endogenous regional government consumption?	no	yes	yes	yes	yes
Endogenous exports?	no	yes (regional market share of of U.S. output)	yes (satellite model of U.S.)	yes	yes (linked to INFORUM)
Capacity variables?	yes	yes	yes	no	no
Capacity constraints on output?	yes	yes	yes	no	no
Depreciation matrix?	yes	yes	yes	no	no
Capital flows matrix?	yes	yes	yes	no	no
Capital/output ratios?	yes (fixed)	yes (fixed)	yes (fixed)	yes (fixed)	no
Expected output variables?	yes	yes	yes	yes	no
Capacity updating equation?	yes	yes	yes	no	no
Gestation lag?	yes	yes	yes	no	no
Inventory adjustment equation?	yes	yes	no	no	yes
Interindustry transaction data source:	survey, BEA	IMPLAN (note a)	Jack Faucett MRIO	BEA (national table brought down)	survey

Table 10 (continued)

Characteristic	Johnson	IPASS	KLTM	REMI (version FS-53)	WPSM
Interindustry investment data source:	survey	IMPLAN	BEA	(NA)	(note b)
Interindustry data base year:	1977	1982	1977	1977, 1984, and projected 2000	1982
Region(s) modeled:	Grant County, OR (and U.S.)	Alaska, Oregon, Minnesota	Kansas	many regions	Washington: Hawaii

SOURCE: David Burress, Michael Eglinski, and Pat Oslund. 1988. "A Survey of Static and Dynamic State-Level Input-Outpu Models." Discussion Paper No. 1988.1. Lawrence, KS: University of Kansas, Institute for Public Policy and Business Research.

NOTES:

a. IPASS is generally based on an IMPLAN database. Such a database takes import coefficients into account. It is not necessary for IPAS to rely on IMPLAN. Any source of the appropriate information is usable. IMPLAN databases may be constructed for any state, county, or county group.

b. Interindustry investment data is based on plant and equipment expenditure information from the U.S. census.

to each other and are solved simultaneously, taking into account the feedback effects. Analysts use simultaneous-equation models to portray the interdependence of the economic agents that compose the regional economy and the causal relationships among various equations and the endogenous variables. The simultaneous econometric models can incorporate aspects of a changed economic structure, such as productivity change, demographic composition, and industrial structure into the model. Until recently, regional analysts have not used them much because of their complexity and vast data requirements.

There are now a large number of regional econometric models, with various degrees of sophistication. Bolton (1980, 1982, 1985), Glickman (1977), Lakshmanan (1982), and Shapiro and Fulton (1985) provide excellent and extensive reviews of regional econometric models, including old and new models, data, and methodological issues. Table 10 describes the general structure of five well-known regional or multiregional econometric models. They are (1) the National-Regional Impact Evaluation System (NRIES), developed by Ballard, Gustely, and Wendling (1980) for the Bureau of Economic Analysis; (2) the Multiregional Econometric Model of Ohio (MREMO), developed by Baird (1983); (3) the Econometric Model of Chicago (Chicago), constructed by Duobinis (1981); (4) Multiregional Econometric Model of the U.S.A. (MAG), developed by Milne, Glickman, and Adams (1980); and (5) the Interregional Economic-Demographic Forecasting Model of the States (ECESIS), developed by researchers at the University of Iowa for U.S. Bureau of Census (Rietveld, 1982).[15]

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[15] In this literature review, we classify the REMI model as an integrated regional economic model, rather than a regional econometric model.

Although the use of time-series data is an important contribution of econometric models, it creates its own problems. First, reliable time-series data at a regional level are seldom available for a common set of industrial classifications. Data constraints severely limit flexibility in the choice of the functional form of the model. Model builders, therefore, often include fewer explanatory variables in the equations than theory would suggest and do not provide a complete specification of regional systems. Second, because of limited data, the sample size is often too small to satisfy some critical assumptions of statistical analyses. Third, Pleeter questions the integrity of the equation systems. Econometricians typically employ statistical tests to determine the structure of individual equations; however, such tests only identify the best-fitting individual equations, which do not necessarily constitute the "most accurate predictive model" (Pleeter, 1980, p. 22).

One type of regional econometric model, the Computable General Equilibrium (CGE) model, is gaining popularity in recent years (Anselin and Madden, 1990; Harrigan and McGregor, 1988; 1989; Robinson and Roland-Holst, 1988; Scarf, 1984; Spencer, 1988). CGE modelers emphasize the central role of relative prices in allocating resources. In its "strong" form, the CGE model can be viewed as a series of disequilibrium demand equations in which relative prices adjust to ensure that all markets clear (Harrigan and McGregor, 1989). It has a potential to help analysts model complex interdependencies in the economy (Anselin and Madden, 1990). Some analysts have started to construct regional CGE models (Hamilton and Whalley, 1985; Ko and Hewings, 1987). For economic-impact assessments of air-pollution controls, Jorgenson and Wilcoxen (1990) constructed a detailed CGE model for the U.S. economy to quantify the

Table 11

CHARACTERISTICS OF FIVE REGIONAL ECONOMETRIC MODELS

Characteristics	NRIES	MREMO	Chicago	MAG	ECESIS
MODEL SIZE					
Regions	51	6[a]	1	9[b]	51
Sectors	12	20[c]	19[d]	6	3
Exogenous Variables	INP	INP	INP	800	973
Endogenous Variables	14000	432	INP	1600	7179
Equations	14000[e]	INP	170[f]	1600	7179
MODEL STRUCTURE					
Production Technology	Linear[g]	C-D	Translog	CES	C-D[h]
National-Regional Links	Bottom-up	Regional	Regional	Note[i]	Note[j]
Supply/Demand	Demand	S-D	S-D	Note[k]	Demand with Supply Constraints
Functional Forms	Linear	Linear & Loglinear	Linear & Loglinear	Linear	Linear & Loglinear
Estimation Method	OLS[l]	OLS	2SLS and OLS	OLS	OLS & Cochrane-Orcutt

SOURCES:

Catherine Baird. 1983. "A Multiregional Econometric Model of Ohio," Journal of Regional Science, Vol. 23, pp. 501-516.

Stanley Duobinis. 1981. "An Econometric Model of the Chicago Standard Metropolitan Statistical Area," Journal of Regional Science, Vol. 21, pp. 123-156.

Piet Rietveld. 1982. "A Survey of Multiregional Econometric Models." In Multiregional Economic Modeling: Practice and Prospect, edited by Boris Issaev et al. Amsterdam: North-Holland Publishing Company, pp. 231-332.

Bottom-up = a bottom-up is applied to all main endogenous variables.
CD = Cobb-Douglas.
Demand = demand-driven.
INP = information not provided.
OLS = ordinary least squares.
Regional = primarily using regional data to estimate endogenous variables.
S-D = both demand and supply equations are specified.
2SLS = two-stage least squares.

Table 11 (continued)

[a] Five metropolitan areas: Cincinnati, Cleveland, Columbus, Dayton, Toledo and the rest of the State.

[b] Census regions.

[c] Two-digit manufacturing industries and six nonmanufacturing ones.

[d] Fourteen manufacturing and five nonmanufacturing sectors.

[e] Of which 3500 are behavioral equations.

[f] Of which 77 are stochastic.

[g] A linear labor demand relation is assumed. This relation takes into account technological change.

[h] A Cobb-Douglas production function is assumed for manufacturing with capital and labor as factors and constant but neutral technological change. The model is neoclassical but includes institutional factors, for instance, in wage determination.

[i] The model is driven by national variables, forecasted by the Wharton Annual Model.

[j] All endogenous national variables are calculated from the regional levels; no regional variables are formed by disaggregating national variables.

[k] In the manufacturing industries the regional shares depend on variables from the supply side: labor and energy costs. Regional output in the other industries depends on regional demand.

[l] In some cases with Cochrane-Orcutt adjustments.

costs of environmental regulation on the economy. They estimated the costs of pollution abatement to be more than 10 percent of the total cost of government purchases of goods and services. We believe that the CGE approach will play an increasingly important role in regional economic modeling.

Integrated Regional Economic Models

The economic-base, input-output, and econometric models we discuss above are conventional methods for conducting regional economic impact analyses (Pleeter, 1980; Sivitanidou and Polenske, 1988). Traditionally, analysts viewed the three types of models as competitors. In recent years, they have increasingly emphasized the complementarity and interrelationships among the three and have tended to integrate them into unified modeling systems.

There are several reasons why the development of integrated models may be desirable. First, integrated models enable analysts to relax some unrealistic assumptions of single models by allowing one model to compensate for weaknesses of another. Analysts, for example, may use an econometric method to predict future technical coefficients, thus relaxing the assumption of fixed factor proportions in an input-output model. Second, integration helps analysts to make an increasing number of exogenous elements endogenous, so that they can understand the behavior of the system better than before. Third, integrated modeling may provide analysts with a means to generate more detailed and/or relevant information for policy analyses. One advantage, for example, of combining the input-output model with other models is to provide sectoral detail of economic impacts. Fourth, an integrated model provides a framework within which different perspectives and different data sources can be combined in a meaningful way. This helps analysts to incorporate a wide range of factors and variables, accommodate different views and concerns, and identify trade-offs and alternatives.

Two approaches are commonly used to integrate individual regional economic-impact models: unification and modularization (Briassoulis, 1986; Anselin and Madden, 1990). In the unification approach, different models are incorporated into a comprehensive framework based on a single methodology, accounting for the feedbacks among individual models. Conway (1990), for example, used the National Income and Product Account system as a basic framework to combine the econometric and input-output models into a unified system--the Washington Projection and Simulation Model (WPSM). In the modular approach, individual models are linked, often unidirectionally, by their inputs and outputs. The District's REMI model, for example, has a main econometric module, an input-output module, and a demographic module. The advantage of the unification approach lies in its theoretical consistency and coherent system behavior. The disadvantages are that it often requires analysts to make many additional assumptions and does not allow them to have an unrestricted and flexible link of separately developed models. The strength of the modular approach, on the other hand, is its flexibility, while the weakness is its potential for inconsistencies. In practice, however, the two are often used in combination and a distinction between the two methods becomes less clear (Anselin and Madden, 1990).

Some well-known REI models were built using the integrated approach. They include the Multiregional Model of the Economy, Environment and Energy Model (MREEED), constructed by Lakshmanan (1979, 1983), which became a part of the U.S. Environmental Protection Agency's Strategic Environmental Assessment system (SEAS), the Multiregional, Multi-Industry Forecasting Model (MRMI), built by Harris (1980) at the University of Maryland using the Interindustry Forecasting Model (INFORUM) methodology, and many dynamic input-output models in which econometric methods are used to incorporate temporal changes in capital stock, to quantify capacity constraints, and to estimate the relationship between current investment and future output, and so on.

Integrated models, however, have their own limitations (Anselin et al., 1990; Beaumont, 1988). A few examples:

Incompatibility. Different submodels often have different assumptions, use different levels of temporal, sectoral, and spatial aggregation, and represent different views of reality, which may not be compatible with each other (Bolton, 1981; Beaumont, 1988). The timing of economic impacts in the input-output model, for example, may not correspond to the period chosen as the basis for the econometric estimations.

Restrictive Assumptions. Although integrated modeling helps analysts to relax some unrealistic assumptions of single models, they usually must make some additional assumptions about the relationships among individual submodels in order to bring those submodels together into an integrated system. Some of these additional assumptions, however, can be as unrealistic as, or even more problematic than, the assumptions in single models.

"Black Box." An integrated model runs a risk of additive and/or multiplicative errors. It may also obscure causal links. Because of the complexity of the integrated model, analysts may have difficulties in understanding the operation process of the economic-impact simulations and in identifying sources and directions of potential errors, information that is critical for an appropriate interpretation of the results.

Data Intensiveness. The accuracy of the modeling results, in part, depends on the quality of data and capability of the analysts. Integrated modeling often requires analysts to have large amounts of high-quality data and the capability to handle such data, both as inputs and as outputs. This increases the costs of the economic-impact analyses and reduces the practicality of the integrated modeling.

We should contrast integrated modeling with the "flexible method of analysis" that we are advocating. Fundamentally, integrated modeling tries to bring the capabilities of many different models into a single modeling structure. Under our flexible approach, we recommend that analysts "pick and choose" methods and models based on the particular type of analysis needed, rather than trying to do everything in a single model. Additional details about the differences between the flexible approach and integrated modeling are provided in Volume I.

Modeling Economic Impacts of Air-Pollution Controls

In modeling economic impacts of air-pollution controls, analysts must, explicitly or implicitly, answer the following two questions:

1. What is the regional economy likely to be in the future without the proposed air-pollution controls?
2. What is the likely future of the regional economy if the proposed air-pollution controls are implemented?

The answer to the first question is often called a baseline forecast (BF), and the answer to the second, a simulation forecast (SF). The economic impacts (E) of a specific air-pollution control regulation, then, can be defined conceptually as: $E = SF - BF$.

If analysts are to use an REI model to assess economic impacts of air-pollution controls, they must be able not only to generate a reasonably accurate baseline forecast of the regional economy, but also to simulate at least some, if not all, ways in which air-pollution controls might affect or interact with the regional economy. Ideally, the REI model should have sufficient detail so that an analyst can quantify size and distribution of the economic impacts, trace the causal relationships that lead to these economic impacts, and examine how these economic impacts may be improved by changing the rule design and/or implementation strategies.

Most existing REI models, however, are designed for general purpose economic-impact analyses, rather than specifically for assessing economic impacts of air-pollution controls. Using those models, analysts typically simulate economic impacts of an air-pollution control regulation through two channels (Rose, 1983). First, the regulations increase the cost of production, resulting in an increase in product prices and/or a decrease in profitability and industrial competitiveness, which, in turn, will reduce final demand and have repercussions on the regional economy. Second, the regulations force affected businesses to allocate resources to pollution-control equipment and services, which, like infrastructure projects, are assumed to have an expansionary and/or inflationary effects on the regional economy. Yet, air-pollution controls interact with the regional economy in a complex way and through many more channels than the other two that are commonly modelled (Rose, 1983).

Several important factors are typically neglected in modeling economic impacts of air-pollution controls. First, the models typically do not account for productivity changes and technological innovation, such as new products, better product quality, and improved production processes. This is problematic because some economists argue that there has been a fundamental shift from cost-based competition to productivity- or quality-based competition (Best, 1990; Reich, 1991; Thurow, 1985). According to these analysts, the economic competitiveness of a region depends less on the costs of factors of production than on the productivity of those factors and on the pace of technological innovation. Air-pollution controls can have both positive and negative impacts on productivity and innovation. Air-pollution control regulations, for example, may create a favorable condition for developing technologies that improve energy efficiency, use cleaner inputs, and minimize wastes. On the other hand, air-pollution controls put constraints on resource allocation in affected industries and increase the uncertainty of the regulatory environment, which tend to have a negative impact on both development and adoption of new technologies.

Second, analysts must consider capacity constraints and conditions in factor markets. If the regional economy is operating at full capacity with little slack in factor markets, for example, resources allocated to air-pollution controls must come from other sources and at the expense of other expenditures. When there is a capital shortage, air-pollution control expenditures may bid up interest rates, decelerate other investment and capital formation, which may have a negative effect on both productivity and long-term growth. In addition, air-pollution controls may significantly alter the choice of technologies (e.g., capital-labor ratio) and input mix (e.g., replacing coal with natural gas). Depending on market conditions of affected factors or inputs, this may result in factor-price changes, which, in turn, will affect the choice of technologies and input mix.[16]

Third, the current approach focuses on the effects of air-pollution controls on business relocation and plant closing. Some analysts, such as Garofalo and Chul (1988), however indicate that growing economies differ from declining economies not in the rate of plant closing and lay-off, but in the rate of new business formation. Birley (1986) and Lin, Buss, and Popovich (1991) have found that new business formation plays a central role in the job-generation process in the United States, and Shapero (1981) maintains that it

[16] This type of substitution, in fact, is captured better in REMI than in many less-complex REI models.

is a key to urban and regional economic development. Air-pollution controls can have both positive and negative effects on new business formation. They, for example, may create regulatory uncertainties and increase the risks of new business development. On the other hand, they may stimulate expenditures on air-pollution controls and generate new business opportunities.

Fourth, REI models, for the most part, are based on neoclassical economic theories, which often assume, among other things, perfect information, instantaneous adjustments, and constant returns to scale. Analysts who use the models, therefore, are not well equipped to estimate adjustment and cumulative effects. They typically fail to consider such factors as information and transaction costs of obtaining pollution-abatement technologies and know-how, time required to change from one technology or input mix to another, and the costs associated with using unfamiliar technologies. They also fail to consider cumulative impacts of air-pollution controls, which are not linear. A firm, for example, may reduce the costs of air-pollution reduction significantly by introducing systems that minimize waste residues and reduce several air pollutants simultaneously. On the other hand, it is also possible that implementing a particular new rule may limit many options available for the firm to comply with existing rules, thus significantly increasing the overall air-pollution control costs. In other words, the cumulative economic impact of individual rules does not necessarily equal the sum of the economic impacts of individual rules.

Fundamentally, air-pollution generation is not explicitly included in REI models, making it difficult to model compliance options and input-mix changes, to account for feedbacks between air pollution and economic growth, and to identify other ways to reduce air pollution, such as industrial restructuring. This limitation significantly reduces an analyst's ability to develop innovative strategies that can reduce air pollution and promote economic growth simultaneously. "Economic growth need not in and of itself cause pollution, nor must environmental protection measures necessarily limit growth. The zero-sum mentality--economic growth vs. the environment--must give way to a recognition that the two are not only mutually compatible, but complementary in many ways." (Hamrin, 1981, p. 1). Many analysts argue that structural changes and appropriate technologies can contribute both to less pollution and higher economic growth (Duchin, forthcoming; Ayres, 1991).

We identify three paths to overcome these limitations and to improve REI modeling of air-pollution controls: an integrated-modeling path, a scenario-based analysis, and a minimum-modeling approach.

Integrated-Modeling Path

One path is to extend the existing model, such as REMI, to include air-pollution components and to account for interactions between the regional economy and air-pollution controls, using either a modular approach or unification approach. The REMI model, for example, has been linked to the Energy 2020 model to study the impacts of the changing economic structure on future energy demand, which can be further extended to include an air-pollution component (Reed, 1991; Backus, 1991). Rose (1983) proposes a general framework for modeling efforts in this direction. His framework has three interlinked components (1) a standard input-output quantity component, (2) a pricing component, and (3) a substitution component. The results from one component become the inputs to the next and follow a series of interactions until equilibrium is reached in the entire modeling system.

In order to make integrated-modeling manageable and operational, analysts need to follow two basic principles in constructing large-scale models: "(i) the behavior of actors and subsystems at the most elementary level should be represented in an extremely simple fashion; (ii) the interactions between those components should also be simple, but very large in number." (Harris, 1982, p. 32). Furthermore, modelers should focus their attention on those factors that are closely related to air-pollution controls and try to simplify other components of the model as much as possible.

Scenario-based Analyses

An integrated model, however, is expensive and analysts may be hindered in applying it by data and resource constraints. Alternatively, analysts can build a sophisticated, but less than comprehensive, model and conduct what-if analyses and/or extensive sensitivity tests to estimate the economic impacts under different scenarios and assumptions (Rose, 1983). Using this approach, analysts may also be able to account for the economic impacts of various factors not directly included in the model and to identify critical factors that determine economic impacts.[17] The District's REMI model is well-suited for such an approach because it has a large number of policy variables and provide many options for analysts to incorporate air-pollution controls into the model. The model also allows users to change some important assumptions,

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[17] One way to do this is to perform a two-stage sensitivity analysis. In the first stage, analysts determine how the factor in question, which is not directly included in the model, relates to one or more variables that are included in the model. In the second stage, analysts can examine how sensitive the results of the impact analyses are to changes in those related variables.

incorporate local data, and use alternative projections from private firms, such as Wharton Economic Forecasting Associates and Data Resources, Inc.

Recent developments in consensus-modeling techniques may strengthen the scenario-based analysis. Andrews (1990), for example, develops a scenario-based multiple-attribute tradeoff analysis and applies it to two major electric-power planning projects in New England. He argues that when there is much uncertainty and controversy, analysts should not (1) do deterministic planning for a single most-likely future, (2) extrapolate future events econometrically only from what happened in the past, or (3) derive an optimal plan inside of a "black box" without sufficient public participation and scrutiny. Rather, analysts should start with sampling the future and identifying various alternatives--different options, assumptions, and possibilities. They can then perform what-if analyses for each alternative along multiple dimensions or attributes. This will help decision makers and participants to understand tradeoffs and uncertainties and to develop strategies with the potential for consensus based on this information.

Minimum-Modeling Approach

In developing a long-term global energy-carbon-dioxide model, Edmonds and Reilly (1986, p. 284) advocate a minimum modeling approach--"a modeling effort aimed at developing the simplest possible framework for analysis given the research question." They argue that there are many uncertainties in modeling a complex energy-economic-air-pollution system and in predicting futures. There are also many limitations imposed by the state of the modeling arts and our knowledge. "The model is not a crystal ball in which future events are unfolded with certainty." (p. 284).

Recognizing the limits of modeling the long term, Edmonds and Reilly identify three basic criteria for minimum modeling. First, a model should be task oriented and be as simple as possible, given the levels of detail and disaggregation dictated by the needs of the user community. Second, a model should be an "open box", rather than a "black box." It should be as understandable and transparent as possible. Third, modeling should focus on conditional what-if analyses, not on predicting the future. The central purpose of the model is "to explore alternatives in a logically, orderly, consistent, and reproducible manner." (p. 284).

Using the minimum-modeling approach, analysts may prefer simple models, such as regional input-output models, which have clear assumptions and well-understood strengths and limitations, to sophisticated large-scale models. They may decide, for example, to build a simple econometric model to quantify directly the relationships between air-pollution controls and important economic indicators, such as employment, output, and income. They then can complement this model with industry analyses, firm surveys, and case studies. If it becomes necessary to include air-pollution generation in the model, analysts may do so by using simple pollution-coefficients to approximate the relationships between gross output and air pollution in different sectors.

No matter what path analysts decide to follow, they must recognize the limits of the modeling approach and understand what models can and cannot do, as Dorfman (1973, pp. 255-256) pointed out:

> For all its numerical trappings, economics is fundamentally a qualitative science, and will long remain so. We are much better at detecting inefficiency than at measuring its extent. We can often say whether things will go up or down when we cannot say how far or how quickly. But these merely qualitative appreciations--predictions of the probable direction of change--are important. They are frequently all that are needed for informed policy decision.

CONCLUSION: TOWARD A FLEXIBLE METHOD OF ANALYSIS

There are many methods and models available for assessing economic impacts of air-pollution controls. At the risk of oversimplification, we group the economic impact methods used by air-pollution control agencies into three approaches: cost-effectiveness techniques, industry studies, and regional economic impact modeling. The three approaches are, to a large degree, complementary, rather than competing alternatives. Analysts typically perform cost-effectiveness analyses to identify air-pollution control standards that minimize the compliance cost of reaching a target level of pollution reduction, conduct industry studies to examine the impacts of air-pollution controls on regulated industries or businesses, and do regional economic-impact modeling to quantify direct, indirect, and induced effects of air-pollution controls on regional macroeconomy.

We recommend that the District's socioeconomic staff incorporate some elements of the cost-effectiveness analyses and industry studies into their current work to improve their economic-impact assessments.

1. **Conduct business surveys.** The socioeconomic staff can either have staff in-house or hire professional consultants to conduct business surveys to determine regulatory impacts on business climate and business decision-making about production and location. The survey results will help the staff understand how the regulations may affect business attraction, expansion, and creation, which are three major ways to generate jobs and incomes in the region. Information from the survey will also be useful in designing measures to mitigate negative economic impacts on small businesses and marginal firms and to dispel some misperceptions/misunderstandings about economic impacts of the rules. In conducting such surveys and interpreting their results,

analysts must be careful not to confuse what firms say they will do with their actual behavior. Schmenner (1982) has shown that firm managers often identify the "business climate" as being of foremost importance, although their Location decisions may not reflect this.

2. **Complement the REMI modeling with industry studies.** Based on the results of the REMI modeling, for example, the socioeconomic staff can select a few industries that are most adversely impacted to conduct in-depth analyses. Conversely, they could start with assessing the impacts on directly affected industries and then use the results of the analysis as an input into the REMI model to estimate indirect and induced effects.

3. **Strengthen the links between cost-effectiveness analyses and the REMI modeling.** A cost-effectiveness analysis is one way the socioeconomic staff currently use to prepare the inputs for the REMI modeling. In fact, when a rule, such as Rule 1135, mainly affects only a few firms with a relatively standardized production process, the cost-effectiveness analysis appears to play a central role in the rulemaking and standard-setting process. There are no feedbacks, however, from the REMI modeling to the cost-effectiveness analyses. We suggest two options for the socioeconomic staff to overcome this limitation: (1) prepare multiple inputs, based on different alternatives identified in the cost-effectiveness analyses, for scenario-based REMI modeling, and (2) perform sensitivity analyses to determine how uncertainty and inaccuracy in input numbers, such as control-cost estimates, may affect the results of economic impact assessments and to identify critical factors for an in-depth cost-effectiveness analysis.

4. **Use criticisms constructively.** Although criticisms and different impact assessments from outside analysts may hurt the credibility of the

District's economic-impact assessments, they present a unique opportunity for the District to check the accuracy of the analysis, to identify analytical priorities, and to consider different perspectives. The District could involve those people early and use the critiques constructively to improve impact analyses and their credibility. The District, for example, may invite those outside analysts to express their concerns and conduct sensitivity analyses or what-if analyses to determine to what degree their concerns are justified.

Throughout this report, we argue that there is no single "best" way to approach economic-impact analyses. Analysts can use many methods and models, each with strengths and limitations, and the information requirements and analytical needs vary significantly from one air-pollution control agency to another and often also differ from one rule to another in the same agency. The key to a good economic-impact analysis, therefore, is to match approaches to the task at hand and to mix different methods and models as needed. One path to this strategy is a flexible method of analysis--a basic analytical framework that has the capacity to incorporate other methods and models and to adopt to changing environment and analytical needs. Under such a system, analysts would "pick and choose" methods based on the particular type of analysis needed. We provide details on the flexible method of analysis, including the institutional requirement for its implementation, in Volume I.

The flexible method of analysis has three important methodological implications for assessing economic impacts of air-pollution controls.

First, each economic-impact analysis should have an analytical focus and the method used for such an analysis should be task-oriented. For a complex rule or large program, such as the Air-Quality Management Plan, it may be desirable to decompose the impact analysis into individual substudies or tasks, rather than conducting an omnibus study with multiple purposes, so that analysts can use a particular method or model where it is best suited. This is important because a multipurpose study often has conflicting methodological requirements and makes it difficult to select the most appropriate method or model.

Second, economic-impact analysis should go beyond a one-time study. Air-pollution controls affect the regional economy in an extremely complex way and through multiple channels. In assessing economic impacts, analysts are called upon to illuminate a large problem area in a comparatively short period of time. In doing so, they often identify many more questions than they can answer and face a difficult trade-off. To put extra effort into answering one question is to limit what will be learned about another. Furthermore, what variables deserve close attention may be changed, and new important variables may be discovered as the analysis proceeds. Analysts, therefore, must see economic-impact analyses as a continuing and learning process. Understanding about economic impacts of air-pollution controls comes out of the accumulation of findings in many studies, not out of one single study on one particular rule. Every previous rule provides valuable lessons and insights; every new rule presents an opportunity for analysts to extend their knowledge and to improve their methodologies.

Finally, economic-impact analysis should be policy relevant and contribute to the District's goals of improving air quality. The ultimate product of the economic-impact analysis is more than a summary of the costs or benefits by industry and other characteristics when a certain regulations or rules are implemented. It is important to know what factors determine the size of the costs and benefits and how the rules can be redesigned to improve their economic impacts and to lower the barriers to implementation.

APPENDIX II.1

STATE ENVIRONMENTAL AGENCY ECONOMIC IMPACT ASSESSMENT METHODS SURVEY

The questionnaire will take only a few minutes to complete, but the information you provide is critical to our project. Thank you for your assistance. Answer questions 2-4 only if you answer "yes" to question 1.

1. Do you conduct socio-economic impact analyses of your policies, rules, and/or regulations?
   a. Yes____
   b. No____

2. Do you use REMI or other economic models in assessing socio-economic impacts of air-quality rules or regulations?

   a. Yes____ Please describe:________________________________
   ____.

   b. No____

3. Do you conduct other types of socio-economic impact analyses (benefit-cost analyses, etc.)? Yes____ No____

   If Yes____. Please specify:
   ____
   ____.

4. Do you have your own economic data base for these analyses? Yes____ No____ If Yes____ Are the data maintained in a data-base management system? Yes____ No____

5. Please indicate a person in your agency whom we can phone or write to obtain further information on your socio-economic impact analyses:

   Name ________________________________
   Title ________________________________
   Agency Name__________________________
   Address ______________________________
   ____
   Phone ________________________________
   Fax ________________________________

Please return by no later than October 21 to:
Professor Karen R. Polenske
Room 9-535
Massachusetts Institute of Technology
Cambridge, MA 02139
Phone (617) 253-6881
Fax (617) 253-2654

If you have any questions, please feel free to write or phone Professor Polenske.

APPENDIX II.2

COUNTY ENVIRONMENTAL AGENCY ECONOMIC IMPACT ASSESSMENT METHODS SURVEY

The questionnaire will take only a few minutes to complete, but the information you provide is critical to our project. Thank you for your assistance. Answer questions 2-4 only if you answer "yes" to question 1.

1. Do you conduct socio-economic impact analyses of your policies, rules, and/or regulations?
   a. Yes____
   b. No____

2. Do you use REMI or other economic models in assessing socio-economic impacts of air-quality rules or regulations?

   a. Yes____ Please describe:______________________________
   ____.

   b. No____

3. Do you conduct other types of socio-economic impact analyses (benefit-cost analyses, etc.)? Yes____ No____

   If Yes____. Please specify:
   ____
   ____.

4. Do you have your own economic data base for these analyses?
   Yes____ No____ If Yes____ Are the data maintained in a data-base management system? Yes____ No____

5. Please indicate a person in your agency whom we can phone or write to obtain further information on your socio-economic impact analyses:

   Name ______________________________
   Title ______________________________
   Agency Name__________________________
   Address ____________________________
   ____
   Phone ______________________________
   Fax ________________________________

Please return by no later than October 21 to:
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If you have any questions, please feel free to write or phone Professor Polenske.

APPENDIX II.3

SOCIOECONOMIC MODELING QUESTIONNAIRE

Firm Name ______________________________
Phone No. ______________________________
Fax No. ______________________________

In order for our firm to conduct socioeconomic analyses for about 20 rules and regulations equivalent to that performed by the District staff, we estimate that it would cost us approximately (put a check by your best estimate):

__________ $249,000 or less

__________ $250,000-$399,000

__________ $400,000-$549,000

__________ $550,000-$699,000

__________ $700,000-$849,000

__________ $850,000-$999,000

__________ $1,000,000 or more

What advantages, if any, do you see from having a firm such as yours conduct the socioeconomic evaluations, rather than having them done by the District staff? Be as specific as possible. (Attach additional pages, if necessary).

What disadvantages, if any, do you see from having a firm such as yours conduct the socioeconomic evaluations, rather than having them done by the District staff? Be as specific as possible. (Attach additional pages, if necessary).

If you were to conduct the socioeconomic evaluations, what modeling technique, if any, would you use for them? Please cite the specific model or method. We would appreciate receiving a copy of a document describing details of the model or method.

Do you have any other comments concerning the socioeconomic evaluations being conducted by the District? (Attach additional pages, if necessary.)

APPENDIX II.4

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Little Rock, AR 72209

Assistant Executive Officer
Air Resources Board
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Sacramento, CA 95812

Program Administrator
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Chief
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Secretary
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Hanford, CA 93230

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Lake County AQMD
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Susanville, CA 96130

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Palo Alto, CA 94301

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Cambridge Systematics, Inc.
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Glen

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Appendix III

ECONOMIC VALUATION OF ENVIRONMENTAL ATTRIBUTES

May 1992

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The research reported here is financed with funds from Contract No. C91253 between the South Coast Air Quality Management District and the Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts. The authors take full responsibility for the conclusions, which are not necessarily those of the sponsoring agency.

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APPENDIX III

ECONOMIC VALUATION OF ENVIRONMENTAL ATTRIBUTES

The U.S. Clean Air Act was passed to promote goals of improving the health and safety of individuals and the integrity of the environment. Standards were to be set with "an ample margin of safety to protect public health".[1] Although legislators undertook moral deliberation and expressed concern about the condition of the overall environment while generating the legislation, economic costs and benefits are clearly a major consideration in the implementation of the law. The South Coast Air Quality Management District (District) in its 1991 Air Quality Management Plan (AQMP) identifies cost-effectiveness and efficiency as two important criteria for evaluating control measures (SCAQMD, 1991b, p. ES-10). Relying on the Regional Economic Modeling Systems, Inc. (REMI) model to illuminate the net economic contribution of a specific policy requires analysts to quantify not only environmental, but also complex moral and aesthetic values. To quantify the costs and benefits of pollution control, the District's socioeconomic staff need to be able to recognize the damages that result from various levels of pollution. This requires that they: (1) identify the affected physical and social components of the environment; (2) assess the social, physical, and economic relationships between emissions and damages; (3) estimate the effectiveness of mitigation responses, including the interaction among rules; and (4) quantify these relationships and values.

Public confidence in the fairness of the regulatory and rule-making process is vital to the success of the District's activities. Reliable economic estimates of environmental impacts, however, are difficult to obtain,

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[1] 42 U.S.C. Sec. 7409(b)(1), Supp. 1977; as quoted in Sagoff (1990).

and researchers analyzing the same data may come to dramatically different conclusions (Tietenberg, 1988). Furthermore, many people consider the quantification of environmental amenities to be inappropriate for the following reasons:

1. People's attitudes toward the environment are not only subjective; often they are also inconsistent over time and between situations. This apparent "irrationality" makes it impossible to apply economists' traditional economic methods (Ehrenfeld, 1981; Sagoff, 1990).

2. Ecosystem processes are synergistic--any one effect is dependent in a nonadditive way on how other elements of the system respond to pollution stress. Our understanding of environmental processes is incomplete and does not permit accurate measurement of all of the economic, social, and environmental impacts of pollution.

Nevertheless, particularly in the wake of President Reagan's 1982 Executive Order 12291 mandating the use of benefit-cost analysis in Federal regulatory decisions, analysts are trying to develop methods to quantify formerly unquantified environmental values (Vig, 1990; Freeman, 1990). Regardless of the methodologies or process applied, however, the economic valuation of air-pollution abatement remains highly subjective.

In this report, we discuss the complex issues involved in environmental valuation and the primary methods currently used to derive values for environmental amenities which may be used in policy-making. Each of these methods has strengths and weaknesses. After this discussion, we then describe the methods currently used by the District staff. The staff have integrated into their socioeconomic analyses a few values for health, congestion, crop damage, and changes in visibility. The majority of the costs and benefits, however, remain unvalued and are only rudimentally reflected in the social and economic analyses.

VALUATION OF ENVIRONMENTAL VARIABLES

The costs of air-pollution abatement are difficult to determine; the benefits of air-pollution control are even less well defined. From an environmental perspective, there are three types of air-pollution impact:

- Human: health, productivity, recreation, aesthetics, and visibility (including visibility's effect on human activities);
- Material structures: corrosion and deterioration of buildings and bridges, fabrics, art, construction materials (such as rubber, paint, and metals), electrical contacts, etc.
- Natural systems: agriculture, commercial forests, landscapes (landscaping), soil and water quality, and biodiversity.

In order to provide the reader with a sense of just how complex the valuation problem is, and how severely current methods underestimate total impacts on the environment, consider the case of the national forests within and adjacent to the District.

In the national forests surrounding the Los Angeles Basin, at least 1.3 million trees are believed to be adversely affected by high ozone levels. Abnormally high levels of ozone are known to cause chlorotic decline in ponderosa and Jeffrey pines resulting in decreased growth and increased mortality (Spurr and Barnes, 1980). The pollution weakens the trees but rarely kills them directly; instead leaving them vulnerable to other threats. Most commonly in California, pine bark beetles attack the vulnerable trees and are the actual cause of death.

The economic impacts of such destruction are not small. First, there are direct losses of timber and associated job losses in wood and paper product industries. Second, there are losses related to recreation and tourism declines. Third, there is evidence that chronic stress induced by air pollution is shifting forest composition in favor of poorly stocked stands of hardier, but less economically valuable species, slowly converting the national forests to brush (Miller, 1982; personal communication, 1992).

In California's mediterranean climate these changes in forest composition have special ramifications, especially in the presence of increased human settlement. California's forests have always been subject to seasonal forest fires. Many of the ozone-tolerant species that have invaded the forest's understory are highly flammable. These changes in the understory, along with the increased presence of standing dead trees make these forests highly susceptible to destructive wildfires. The 1991 Oakland fire and 1988 San Bernardino fires may presage more devastating fires yet to come, threatening people's lives, property, and jobs (Miller, 1992, personal communication).[2]

Air pollution of forests also poses a significant threat to California's critically important water supplies. Nitrogen-oxide emissions are deposited on soil and leaf surfaces on the eastern fall of the Sierra Nevada, where they are periodically flushed into surface water and deep storage aquifers used by the Basin. As a result, nitrate concentrations in the area's water supplies may significantly exceed the 10 parts per million health standard. Infants are particularly susceptible to nitrate poisoning.[3]

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[2] Although this discussion has focused on the national forests, agricultural and landscaping industries are similarly affected and inadequately recognized in current economic valuations. For more detail on this topic, the reader is referred to the published results of a special 1989 symposium held by the Air and Water Management Association (Miller, 1992; Olson and Lefon, 1989).

[3] Also known as "blue-baby disease." There is inadequate data on nitrate-loading in the Basin to quantify the effects on a regional basis at this time (Miller, personal communication, 1992).

VALUATION METHODOLOGIES

Clearly, making more fully-informed policies requires that we expand our ability to account for the benefits and costs of pollution control to include such diverse impacts as those described above. To make economic measurements of environmental impacts in the absence of actual markets for environmental resources, analysts most often rely on establishing some market proxy. We describe here the most common methods used: contingent valuation, hedonics, and travel cost. Each can provide approximations for particular values, although each method also has particular strengths and weaknesses.

Contingent Valuation Methods

In the contingent valuation method (CVM), analysts establish consumers' preferences using a questionnaire format. The basic approach is to ask people what they are willing to pay for a benefit, or what they would accept as payment for tolerating an environmentally related loss or cost. CVM is regarded to be technically applicable to virtually all contexts of environmental policy and is frequently the only technique used.

One special quality of CVM is that it can be used to estimate so-called "existence" values, the worth people place on the existence of an environmental experience with which they are not directly familiar. As an example, residents in Boston may willingly pay to protect healthy forests in California although they may never visit them. In a study by Brookshire, existence values were found to dominate total values, with existence-to-user values of 66:1 (Pearce and Markandya, 1989, p. 39).

This is not to say that CVM always provides useful results. In a Wyoming study directed toward quantifying the economic value of increased visibility resulting from pollution reduction, Rowe, D'Arge, and Brookshire (1980) found that slightly over one-half of the respondents required infinite compensation for pollution or refused to cooperate with the survey. In the same experiment, the majority of people in the sample rejected the concept of "consumer surplus" or the willingness-to-accept compensation approaches in quantifying trade-offs between health, safety, environmental quality, and economic growth. In a study in Hawaii, Samples, Dixon, and Gowen (1986) found that willingness-to-pay values are profoundly influenced by information received by the respondents during the course of the survey. Indeed, the interview process itself shapes and instructs preferences. Pearce and Markandya (1989) and Tietenburg (1988) summarize several categories of bias embedded in CVM:

- Strategic bias occurs when the respondents answer in a particular manner with the intent of influencing the outcome. For example, extraordinarily high protest bids may be made by participants who reject the valuing of a particular amenity on ethical grounds.

- Information biases occur when respondents value attributes about which they have little experience or for which full information is not available. The synergistic interaction among wildfires, timber productivity, pathogens, and ozone is an example of complex ecosystem interactions about which we have incomplete information. Fragmentary perceptions of the dynamics of the system may result in an undervaluation of the benefits gained by reducing emissions.

- Design biases include distortions caused by the starting point suggested by the interviewer or the vehicle by which payment would occur. Researchers have found, for instance, that people may value one lake virtually the same as they value all lakes; a carcinogen in the air at a work place may be valued very differently than the same carcinogen in the air at home. Using CVM to establish values for the preservation of the spotted owl in Washington State, Rubin, Helfand, and Loomis (1991) found that answers differed dramatically, depending on whether respondents believed they would actually have to pay directly for preservation of the owl or would pay indirectly through a shifting of federal funds.

- Hypothetical biases occur when choices in the hypothetical markets differ from real market choices. The same spotted-owl study found that willingness-to-pay changed significantly when respondents understood that the entire study was hypothetical, from when they thought they may actually be required to make real payments or policy decisions.

Hedonic Techniques

The "hedonic price" approach aims to attach values to environmental factors by estimating how they influence prices in related markets. Most commonly, analysts examine how property prices are affected by changes in environmental quality. Essentially, this equates to testing the hypothesis that cross-sectional differences in property values are significantly associated with spatial differences in pollution levels. Similar studies may be made using wage rates, based on the assumption that workers facing higher pollution-induced health risks will demand to be compensated for that added risk. In each case, decomposing wages or property values through regression techniques theoretically enables the analyst to identify the premium that people are willing to pay for improved environmental quality. The hedonic method has been used to estimate the benefits of increased visibility due to air-pollution reduction by modeling property values as a function of air quality (Trijonis et al., 1985).

In practice, there are difficulties associated with identifying relationships using this method. Variables are often inextricably intertwined. For example, total particulate matter is closely correlated to levels of nitrogen dioxide, and analysts cannot use known statistical methods to separate the effects of each pollutant. Often analysts may not need to distinguish the impact of particular air pollutants on property values. If individual pollutants are being modeled, however, hedonic results are not sensitive enough to contribute quantified estimates of specific pollutants' impacts.

Unlike contingent valuation, hedonic methods cannot measure how much people value having or losing the option to experience a particular amenity, such as clean air, when that option is exercised in the distant future. Nor can hedonics measure the value people place on protecting the existence of the amenity, although they may never personally enjoy it. Other difficulties associated with inferring willingness-to-pay through the hedonic method identified by Pearce and Markandya (1989) and Tietenburg (1988) include:

- It assumes a perfect market. In practice, the incomplete state of our knowledge about how pollution impacts consumption often makes it impossible for individuals to make clear choices. Lack of knowledge of the dangers of air pollution on the part of households may cause them to underestimate the benefits of reducing pollution. People may only respond to pollutants they know about or can see, ignoring other toxins of significant impact. Likewise, the potential existence of unknown ecological interactions are not acknowledged.

- Related, individuals do not exhibit the sort of extreme mobility assumed in perfect markets. Rather than entering the market as free and willing consumers, many people do not have the option to relocate so as to make an optimal tradeoff between reducing their exposure to pollution and other forms of consumption.

- Housing purchases, wage rates, and other proxies only capture a few of the ways in which individuals respond to pollution. For instance, extensive air-filtering systems may be installed in buildings. Hedonic methods not only fail to capture many of these "avoidance costs," but these factors are interrelated, making them poorly suited to analysis by regression techniques.

These inherent difficulties raise serious questions about just how reliable and accurate the estimates derived from hedonic methods really are. Although hedonic studies have shown that air pollution significantly affects property values, the impact estimates derived can vary by orders of magnitude

Moreover, the fundamental nature of these problems suggests that they are unlikely to be solved simply by developing better statistical techniques.

Hotelling-Clausen-Knetsch or Travel-Cost Methods

As with hedonic methods, analysts use the travel-cost method (TCM) to derive an estimate of demand for environmental attributes, such as clean water, fresh air, or a beautiful view, based on current spending behavior. The area surrounding a site is divided into concentric travel zones; visitors are identified by their home zone (how far they traveled); and travel costs are estimated for a representative round-trip between the zone of origin and the site. The resources that people spend getting to a particular site are then used as an estimate of willingness-to-pay for the amenities at that site.

The TCM is susceptible to many of the general problems of estimating willingness-to-pay that have already been raised. In addition, there are several problems unique to the approach. First, a very large sample size is required to obtain results that are both statistically significant and useful. Second, congestion in the area can artificially reduce the demand for use of a recreational site. Finally, and most important, analysts using the TCM must assume that travel occurs only to visit the site in question. Long-distance trips with multiple stops or trips with multiple purposes would change the time-cost relations. This is highly problematic, given that few people spend their vacations going directly to and from a particular site for the single purpose of visiting that locale. Moreover, it may add bias, because people are more likely make extra stops or side trips as their total travel distance increases.

Summary and Comparison

Taken on their own, the overall accuracy of each of the methods described above remains relatively low. These techniques may arrive at benefits and costs that vary by several orders of magnitude when performed repeatedly, by different research teams, or when small aspects of the study are varied. Choosing a particular value to use becomes a subjective decision. Jane Hall (1988, p. 5-7) ranked the contingent valuation method of assessing the costs of air pollution-related health risk more highly than hedonic wage-risk or other methods. The basis for her conclusion was that contingent valuation provided a better means for integrating elusive preferences and quality-of-life considerations than did the other methods, which use only direct factors such as wages lost or medical costs.

One possible means of overcoming the weaknesses of the individual methods is to combine them, performing multiple analyses. Hall (1988) argues that health-benefit estimates are stronger when similar values are derived from both hedonic and contingent valuation methods than from either one alone. Researchers have found that the TCM often results in estimates that overlap those obtained by CVM and hedonic methods. Still, agreement among studies does not necessarily mean that the values reached are "accurate," only that they fall within acceptable ranges of error (Pearce and Markandya, 1989, p. 37; Tietenburg, 1988).[4]

One problem common to all the techniques described is that quantifying poorly understood relationships may imbue estimated values with an unjustified appearance of certainty and impartiality. Current analyses often simplify the

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[4] This range may vary, but was plus or minus 60 percent in the studies cited.

downstream and side effects, substitutions, and inter-media transfers of pollution. Our knowledge is too incomplete to provide a scientific basis for reliable estimates of such intangibles as ecosystem integrity, biodiversity, or healthier human and natural systems. Likewise, many of the subjective factors that analysts are trying to quantify are subject to change. If we acknowledge that these estimates are only guesses and limited in their ability to incorporate broader social values, we must also question whether these estimates are appropriate for policy analyses (Lave, 1991). Rather than becoming clarified, the decision-making process may be made more opaque by these efforts unless their shortcomings are fully described.

THE DISTRICT'S CURRENT APPROACH TO QUANTIFICATION

Having described the major approaches to quantification that are available, let us now proceed to describe current District staff practices. In the Air Quality Management Plan (AQMP), the District staff acknowledge that there are substantial unquantified impacts of pollution and identify a two-step process for estimating benefits and costs. Overall, costs are partially quantified, and benefits are quantified very incompletely. We refer to the District's approach as a "partial cost analysis." Table 1 summarizes the various quantified and nonquantified costs associated with air-pollution abatement, and their integration into the REMI model. Known benefits of pollution control for which dollar values can be assigned are quantified. Remaining benefits that are known, but for which values cannot be assigned, are described qualitatively. Costs that are known or estimated are included. The remaining unquantified, but expected, costs are projected. They then use the REMI model to analyze only the quantified measures including forecasts of indirect and induced impacts. Many of the valuations made in the categories just described come from the work of Jane Hall and her associates. Not surprisingly, this work has been controversial. We include a review of Hall et al. (1989) and subsequent follow-up research in Appendix III.1.

Quantifiable benefits of air-pollution mitigation included within the AQMP are:

- increased yields for 18 commercial crops due to reduced ozone damage.
- increased visibility from reduction in suspended particulate matter (ignoring other components of smog, such as nitrogen oxides).
- health responses to criteria and noncriteria pollutant exposures for 4 out of 80 known health impacts. The quantified effects include morbidity reductions from reduced exposure to ozone and suspended particulates and reduced mortality due to suspended particulates (SCAQMD, 1991a, pp. 2-12 and 2-13).

Quantifiable costs associated with air-pollution reduction include primarily abatement costs and direct damage costs, such as control equipment, research and development costs, reformulation costs, annual operating and maintenance costs, and "potential savings related to new requirements" (SCAQMD, 1991a, p. 2-2). Investment in transportation projects is also included. Quantified health benefits are primarily derived by contingent valuation and hedonic methods, as detailed in the Hall et al. (1989) study. Additional benefits to be gained by reducing pollution, or conversely additional damages to plants, animals, building materials and the remaining 76 health impacts, are "known, but cannot easily be measured and quantified" (SCAQMD, 1991a, p. 2-13). As the District staff acknowledge in their draft Socioeconomic Report, assessments that incorporate only quantified benefits or costs significantly underestimate both (pp. 2-13 and 4-1).

TABLE I

Quantified and Unquantified Cost Categories
and Their Integration into the REMI Model

	COST CATEGORIES				
	Abatement Costs	Transaction Costs	Avoidance Costs	Direct Damage Costs	Indirect Damage Costs
Quantifiable Variables (monetized)	Capital investments; Operations; Maintenance; Labor.	Research; Planning; Compliance; Monitoring; Enforcement; General administration.	Special crops and materials; Avoidance technologies (filters, coatings, fungicides, pesticides); Migration.	Health: mortality/ morbidity; Infrastructure and material deterioration; Maintenance; Replacement; Loss in production (human, agricultural, forests, fisheries); Loss of visibility.	Property values; Fire; Slope stability (land use); Tourism; Recreation.
Unquantified Variables (non-monetized)	Loss of return on alternative investments.	Loss of return on alternative spending opportunities.	Reduced options; Opportunities lost; Fewer entrants.	Production and ecosystem degradation; Health: mental, physical, social.	Ecosystem resiliance (cumulative loss in system ability to compensate for damage); Soil and water quality; Reduced quality of life including increased accidents, social ills, etc.
Incorporated in the REMI Model	Some capital costs; Operations and maintenance; Labor.	Tangentially.	In part.	5% of the known health impacts; 15 crops; No ecosystem values; Limited maintenance and replacement costs.	Partial: property values.

Within the AQMP and socioeconomic assessments, five categories of costs can be identified from an environmental perspective. Most are unquantified.

1. <u>Abatement Costs</u>: costs of resources directed toward reducing pollution, including adverse effects on economic growth, employment, and production.

2. <u>Transaction Costs</u>: costs for resources used in research, planning, administering and monitoring pollution control.

3. <u>Direct Damage Costs</u>: costs of the direct economic impact of air pollution on resources. These include blighted crops and forests; illness, emotional stress, higher death rates, reduced productivity (both human and natural); and cleaning, maintenance and replacement costs to property and urban infrastructure due to corrosion and degradation.

4. <u>Avoidance costs</u>: economic and social costs of attempts to avoid pollution damages: lack of flexibility in building materials or choice of crop variety; increased dependence on pesticides or home and business air-filtering equipment; moving away from the polluted area; or discouragement of new entrants.

5. <u>Indirect costs</u>: reduced values, such as property values, tourism, and recreational revenue opportunities lost; soil and water quality; and species diversity and ecosystem resilience-redundancy. Other indirect costs, such as accidents and additional operational expenses for airplanes and ground transport due to reduced visibility.

The first two, abatement and transaction costs, are partially included within the District's accounting processes, in part through the Hall study, and therefore are tangentially included within the REMI calculations. Direct damage costs are included in part (crops, associated productivity, and mortality); visibility improvements are "translated into additional amenities" in the REMI model (SCAQMD, 1991a, p. 2-15). The remaining costs are not included, but may be even greater than the direct costs.

In modeling the economic impacts rule-by-rule, environmental impacts are implicitly assumed to be measurable on an incremental basis. Many of these impacts, however, are both physically and economically synergistic and are inappropriate to model in such a manner. This is particularly true with complex and interdependent ecosystem values, such as genetic diversity, regional landscape productivity, soil and water quality, and biotic regulation of biogeochemical cycles (Bormann, 1985). It may be possible for some ecosystem effects to be artificially segregated rule-by-rule, assigning percentage-of-the-total values. Overall, however, the rule-by-rule approach tends to obscure cumulative impacts, encouraging undervaluation of environmental impacts.

This poses a difficult tradeoff for analysts. If values of environmental variables that are known to be incomplete and questionable are not included in the REMI model, analysts will have easy-to-understand output that will allow them to make judgments about those aspects that are included in the analysis. In other words, adding environmental variables to the model adds uncertainty, and the findings may be suspect. On the other hand, not including the full range of benefits and costs means the analysis is incomplete and biased toward underestimating the true benefits of abatement. There appear to be several options available to the District staff:

(1) Estimate and incorporate into the REMI model values for the uncovered costs or benefits, which may increase controversy over the REMI model results.

(2) Develop a modeling process that uses the REMI model outputs to run a second-stage model, confining the highly uncertain estimations to the secondary model. In practice, this secondary assessment may actually be done by a series of specialized models, the combination of which would vary depending on the particular situation.

(3) Expand the qualitative valuation of the nonquantified costs to include technical descriptions of environmental impacts, a description of the types of uncertainty present, and where possible, ranges of likely values. Rather than including these as an appendix to the report, they should be placed in context in the main section of the report where possible.

The approaches to quantifying environmental benefits discussed above provide enough information to illustrate that environmental benefits are large, but analysts cannot use them to fine-tune policy. Clearly, better assessments of environmental impacts are desirable. Nevertheless, analysts needs to target those areas where improvements in our knowledge base can realistically be achieved and where those improvements can provide useful information. In the more immediate future, what is most clear is that the District staff must enhance their own abilities to incorporate impact assessments from outside the REMI model, including qualitative assessments.

APPENDIX III.1

Review of "Economic Assessment of the Health Benefits from Improvements in Air Quality in the South Coast Air Basin" (Hall et al., 1989); "Recent Evidence on the Distribution of Air Pollution Effects" (Brajer and Hall, 1991); and "Benefits of the 1989 Air Quality Management Plan for the South Coast Air Basin: A Reassessment" (Harrison and Nichols, 1990).

In the report "Economic Assessment of the Health Benefits from Improvements in Air Quality in the South Coast Air Basin", Hall and her co-investigators estimate the economic benefits of improved human health which may result from air pollution control in the Basin (Hall et al., 1989). These estimates are derived using the authors' regional human exposure model (REHEX) to forecast the distribution of air pollutants across the Basin and the exposure of population subgroups to pollution. The model integrates time-activity patterns, including mobility, activity levels, and some demographic characteristics and is presented as an improvement over previous methods used to describe pollution impacts because it is able to estimate exposure differences across geographical and social subgroups.

In creating REHEX, Hall et al. used their best judgement to select the most representative data available on the relationships between exposure concentrations and human physiological factors. They converted estimated exposure concentrations into doses received and then developed dose-response functions. REHEX estimates indicated that certain population subgroups are disproportionately exposed to air pollution concentrations. Infants and the elderly experience the lowest exposures, school-age children, college students, and adults working outdoors experience the highest exposure. Los Angeles, Riverside, and Orange counties experienced the first, second and third highest ozone exposure levels, respectively, within the Basin (60, 50 and 40 percent of the residents experience ozone above 28 pphm, respectively).

Estimates of the economic benefits of pollution control are derived from estimates of the doses experienced by Basin residents and the degree and manner in which they respond to the doses. As the study cautions,

> This study focused on those health effects that could be quantified with dose-response relationships and that have assignable economic value. Given the current limitations in our understanding of the health effects of air pollution, there were insufficient data to derive dose-response functions for many pollutants. . . . The dollar benefits estimated in this study are . . . based on a relatively limited subset of the possible health outcomes. **This study, consequently, represents a lower bound on the health values of improved air quality in the SoCAB**. (Hall et al., p. ii). (Emphasis added.)

The effects of toxic substances; acid deposition; increased asthma; days of hospitalization; increased cancer risks; and long-term, pollution-related biophysical impacts are explicitly not included in these estimates (p. 8-2), as well as many nonhealth related impacts, such as damage to agriculture, forestry, materials, and visibility (Hall et al., p. E-3).

Hall et al. have conducted an extensive literature review, compiling epidemiological and clinical studies, economic-valuation methods, and South Coast ambient-air data bases for six criteria pollutants. The review summarizes various economic-valuation methods and attempts, in a complex situation with wide ranges in valuation results, to find a middle ground. Among the publications surveyed are the Criteria Documents that are used in setting Federal and state air-quality standards for selected criteria pollutants.

The Hall et al. research is exceptionally well-documented. The authors describe their construction of the REHEX model, citing the particular studies used to select values, and providing detail on their methodology for constructing appropriate basin-specific values from willingness-to-pay (WTP) functions. The researchers also identify aspects of the model needing further refinement, with the goal of developing a second-generation exposure model that could be used for more detailed investigations of the socio-economic issues embedded in improving air quality in South Coast and elsewhere.

In a later report, "Recent Evidence on the Distribution of Air Pollution Effects," Brajer and Hall (1991) examine the distribution of benefits of air pollution control by population groups divided on a geographical and socioeconomic basis. Using the REHEX model, they estimate exposure distributions by population subgroups through detailed representations of their location, mobility, and activity levels (Brajer and Hall, p. 4). They disaggregate their research in three dimensions:

1. Micro-environment: disaggregated into indoor, outdoor and in-transit.
2. Geographic subdivision: distributed among 31 geographic subareas of the Basin.
3. Activity level: identified by five levels of activity from sleep to heavy exercise.

These detailed exposure estimates are then examined for statistical correlation with a variety of socioeconomic variables, including: median income, age, race, and educational attainment. Among their significant findings:

- Households in the low-income to middle-income classes were positively correlated with ozone exposure, while households in the highest income levels were negatively correlated. Families in the fortieth to sixtieth income percentiles had the strongest association with acute ozone exposure.
- College education is negatively related to ozone exposure.
- Youth is positively related to ozone exposure.

- Age is negatively correlated to ozone exposure, but infants are also negatively correlated.
- Racial correlations with ozone exposure are present but weak (whites and Asians appear to be negatively correlated; blacks and Hispanics positively correlated), except for the correlation of Hispanics and ozone, which is statistically significant.

These results raise important analytical questions. How should the unequal distribution of exposure to air pollution be reflected in the costs and benefits integrated in the SCAQMD analysis? How do differences in culture, work, housing, access to medical care influence the quantification of impacts? Are benefits relative? For instance, if the cost of lost work time due to pollution-based health reasons is examined on a basis sensitive to geographic and population subgroup differences and costs computed based on wage studies (a common measure), the value of reducing pollution in low-income neighborhoods may be considered lower than reducing it in other areas. How does the increased exposure of children, particularly low-income, black and Hispanic which REHEX modeled, influence the long-term health and productivity of those populations?

The work of Hall and her colleagues has been strongly criticized by Harrison and Nichols (1990) of National Economic Research Associates, Inc. (NERA). In a report prepared for the California Council for Environmental and Economic Balance (CCEEB), Harrison and Nichols claim that Hall and her co-investigators substantially overstate the likely benefits of the Air Quality Management Plan (AQMP), and they conclude the Hall study is inadequate for use in decision-making. Harrison and Nichols specifically criticize Hall et al. for not clarifying: the considerable statistical uncertainty that surrounds estimates of how meeting the ambient standards will affect population-exposure levels; which health effects are related to which pollutants; and, what the dose-response relationships are. In addition, they disagree with the Hall et al. sources used in estimating effects, dismissing them as outliers or not generally accepted authorities. In contrast, they relied heavily on U.S. Environmental Protection Agency (EPA) and U.S. Office of Technology Assessment (OTA) reports.

In fact, Harrison and Nichols' complaint may be more with the process of benefit estimation than with the work of Hall and her associates in particular. They conclude that benefits research as a whole may be less useful than expanding "research on alternative regulatory techniques to help translate ideas on regulatory flexibility into specific programs that can reduce costs" (Harrison and Nichols, 1990, p. 76), such as the tradeable pollution-permit program. "Such research could lead to initiatives that lowered the costs and increased the acceptability of control measures. The net result would ultimately be an outcome that all could applaud--a cleaner environment at lower cost (p. 76)."

Significantly, although tradeable permits have the reputation of being efficient and pragmatic, they cannot target control to particular hot-spots. These critical areas may not be identified in economically efficient solutions that are indifferent to distributional issues. As a result, the most efficient site for an industry to clean up pollution may not improve conditions for the most vulnerable populations. In fact, such targeting of policy requires exactly the type of distributional analysis used by Brajer and Hall.

Although Harrison and Nichols raise important issues, studies such as those by Hall and her associates must be pursued and integrated into the evaluation process to attain a balanced policy.[5]

Hall and Horwatt (1989) responded to some of the specific criticisms in the Harrison and Nichols study and not others. There are several important points of continuing disagreement that deserve clarification:

- Harrison and Nichols state that the AQMP falsely assigned and underestimated future clean-up costs. In their view, future reductions in emissions are likely to be more expensive than earlier ones.[6] Hall and Horwatt contest this as dogma, arguing that behavioral adjustments will occur that will reduce demand for polluting technologies and that there will be increased economic activity due to investments in control technologies and other related expenditures (Hall and Horwatt, 1989, p. 10-4).

- Hall and Horwatt criticize the calculations used by Harrison and Nichols to estimate control costs, charging that they use simple arithmetic averages of the highest possible costs of control measures--failing to integrate the existence of different control options for achieving various levels of reduction--and therefore biasing their cost estimates upwards.

- Harrison and Nichols criticize Hall and Horwatt for failing to reflect the tremendous uncertainty in dose-response studies. In fact, however, Hall and Horwatt select values for the REHEX model and then use REHEX outputs to calculate the range of dollar values using a variety of willingness-to-pay and cost-of-illness methodologies. In other words, they use the REHEX data as given and acknowledge uncertainty in the dollar-assigning end of the estimates. Harrison and Nichols recalculate values, providing what they believe to be a reasonable reflection of medical uncertainties. Their revised "mid-range" estimate of $2.9 billion compares with

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[5] Ideally, analysts eventually could link REHEX with the economic model, REMI. Because of the tremendous complexity of the health/pollution/cost interaction, the socioeconomic staff probably could conduct a qualitative analysis of these interactions, in a study that is integrated and reiterated for each rule they assess.

[6] This same point is also made by Krupnick and Portney (1991).

Hall et al.'s "best conservative estimate" of $9.4 billion[7] (Hall et al., iii, and 7-35). Harrison and Nichols charge that Hall et al. use valuation methods that assigned dollar values based on willingness-to-pay for <u>days</u> of symptoms avoided and apply those charges to data that reflect acute episodes on an <u>hourly</u> basis. This criticism is not answered by Hall and Horwatt in their response to the Harrison and Nichols report.

- Directly related to the argument over whether estimates are high or low is Harrison and Nichols' charge that Hall et al. rely on sources that are not representative. Yet, we can find no evidence that the Harrison and Nichols' sources are preferable. What we can say is that Hall et al. rely more on a large number of research findings, performing an extensive and comprehensive literature review. In contrast, Harrison and Nichols rely heavily on EPA and OTA reviews of the literature.

These criticisms and counter-criticisms illustrate more about the uncertainties and complexities of the issues the authors attempt to analyze, than about the strengths and failures of either group. Overall, the Hall et al. report is comprehensive and clearly documented, resting on a broad base of studies. Nonetheless, Harrison and Nichols raise valid questions about the study. The debate concerning the Hall et al. report might be eased if the authors responded to some of the questions raised by Harrison and Nichols, such as:

1. Why they feel their literature review was adequate and they chose not to rely more on OTA and EPA sources.

2. Whether willingness-to-pay was overestimated by multiplying acute episodes measured on an hourly basis by values based on days, and if so, how resulting estimates would be influenced.

3. How they arrived at values for input into REHEX and their confidence in the model output.

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[7] Harrison and Nichols' total valuation range is from $1.5 billion to 8.0 billion. Hall et al.'s total valuation range is $4.8 billion to $20.4 billion. All values are expressed in 1988 dollars.

Still, even recognizing the validity of these questions, we believe the Hall et al. study does not overestimate the values inherent in pollution control. If nothing else, so many cost categories are excluded from the analysis that the resulting undervaluation is likely to more than compensate for any overestimation in the cost categories that are quantified. Thus, the Hall et al. estimates would appear to be conservative, although they may not assign "accurate" costs to any one variable. Hall et al. openly and properly acknowledge that benefits estimates are incomplete and conservative. Given the very incomplete state of knowledge on the subject, we see no other alternative immediately available.

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Appendix IV

DATABASE MANAGEMENT SYSTEM

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The research reported here is financed with funds from Contract No. C91253 between the South Coast Air Quality Management District and the Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts. The authors take full responsibility for the conclusions, which are not necessarily those of the sponsoring agency.

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APPENDIX IV

DATABASE MANAGEMENT SYSTEM

The District's socioeconomic staff need to have a systematic method for storing and recording critical data. Any database management scheme adopted should satisfy several demands. First, there needs to be an audit trail of modeling assumptions, so that the results of any model run can be reproduced with a minimum amount of effort. Second, the staff needs a means for documenting data definitions, detailed assumptions inherent in different data sets, and any special aspects of the data. Third, they should maintain a database of economic-impact estimates that are comparable over time, to enhance the accounting for cumulative impacts. In this appendix, we describe a database management system that could be used to meet these demands. It is not intended as a working model, but rather as an example of the types of things that can be done and as a means of raising key points for consideration.

DATA TABLES

The database management system proposed here works as a series of linked data tables. Each table records a certain type of information. For instance, one table might record how each variable is changed in creating a simulation; another table might record the results of the simulation; yet another table might record where the data are stored, which REMI files hold the information, which cost indices are used, etc; finally, there might be yet another table holding a text field for miscellaneous information. Table 1 provides a brief description of several initial tables that would be valuable. Additional tables could be included as desired.

Table 1

TYPES OF TABLES FOR DATABASE MANAGEMENT SYSTEM

Table Name	Table Description
ACTION	The ACTION table is used to establish an audit trail of the variable changes that make up a simulation forecast. Within this table, each row represents an individual variable change. The date of the run is stored, along with a unique run identifier, the original value of the variable, its new value, and why the variable was changed.
RUNS	The RUNS table records the names of the REMI files for each model run and the location of those files, so that they can be located at a later date as needed. Each row of the table represents a separate simulation or control forecast run. Included in the table are run identifier, first and last years of the forecast, year prices are indexed to, type of run, directory where files are stored, file names of REMI output files.
IMPACT_O	The IMPACT_O table is used for the results of model runs, storing average annual impact on industry output. Each row in the table represents output changes for a specific industry in a given model run. For each such row, the user can optionally enter high and low estimates, or a single average impact. Other variables included to help identify each row uniquely include the SIC code of the industry, the run identifier, analyst, and date of run.
IMPACT_J	The IMPACT_J table is used for the results of model runs, storing average annual impact on jobs. Each row in the table represents job changes for a specific industry in a given model run. For each such row, the user can optionally enter high and low estimates, or a single average impact. Other variables included to help identify each row uniquely include the SIC code of the industry, the run identifier, analyst, and date of run.
IMPACT_R	The IMPACT_R table is used to separate job impacts by racial group. Each row in the table represents job impacts for a specific industry in a given model run. For each such row, the user can optionally disaggregate jobs by major racial group. Other variables included to help identify each row uniquely include the SIC code of the industry, the run identifier, analyst, and date of run.
CENSUS	The CENSUS table is a file of Census Bureau employment figures. Each row represents a 4-digit SIC industry code. Columns include the 1980 and 1990 employment for each industry group.
ELECTRIC	ELECTRIC records all cases where a rule is expected to affect local electricity rates. Each row represents an expected rate change in a simulation. Columns include the high, low, and average change expected for that simulation; and the rate category (residential, commercial, etc.)
NOTES	The NOTES table is used to record any notes that are needed to clarify points in the other tables. Notes are stored as a single text field, with each note representing a separate row in the table. Columns include the name of the table the note refers to, the run identifier and date of run.

Separating the data into multiple tables allows the user to store data by subject area. This is especially important because there is not necessarily a one-to-one correspondence between the subjects of each table. Accordingly, it would be wasteful of time and space to store the data from all the tables in one computer file. As an example, for any given simulation, there are many individual variable changes, even though these all apply to a single study period, use a single year for price indexing, and so forth. Storing these different types of data together would require either: (1) that the user create a table with columns representing every possible variable change, most of which would be unchanged for any given analysis; or (2) that the user let each row in the table represent a single variable change, but then s/he would need to repeat all the information about the time period of the study, etc., for each row. By breaking this material into more than one table, the user can allow each row in the ACTION table to represent a single variable change, whereas each row in the RUNS table represents an entire simulation.

SIMPLE QUERIES

If the analyst stores these data tables for use in any of several commonly available database management software packages, s/he gains very powerful access to the data by being able to perform simple queries on the database. The analyst might, for instance, use the ACTION table to obtain a listing of all the rules in which the REMI simulation entailed a change in the COSTPOL variables. Alternatively, s/he might use the RUNS table to check that all simulations on record are indexed to a common base year and that they all cover the same study period.

We will assume that the database manager chosen is one that supports the Structured Query Language (SQL). This is a standardized language for performing data queries that is similar across many different database managers.[1] This standardization allows the analyst to create and save commonly used queries that are not highly dependent on the particular database manager in use. SQL also has a syntax that is very similar to English. This makes it easy to understand and learn and distances the analyst from many of the complex operations that the database manager must perform. The simple queries described above might look like the following:

```
SELECT rule, variable_num, old_value, new_value
    FROM action
    WHERE variable_name = 'COSPOL';
```

This would give a list of all instances in the ACTION table for which the COSPOL variables were changed. It would also provide the specific variable number, the original value of the rule, and its new value.

```
SELECT rule, run_number, index_yr
    FROM runs
    ORDER BY rule;
```

This would provide a list of all simulations, along with the index year of each rule. Sorting the list by rule allows us to quickly check that any given rule uses a consistent price index for all simulations run on that rule.

In general, these types of queries could be used either to analyze the data directly or to improve modeling technique by identifying patterns in analytical methods. Consider the following examples:

---

[1] Caution should be exercised in purchasing a database manager, because the level of SQL support varies tremendously across software packages.

List all industries with job loss due to regulations of greater than (n) jobs per year; list relevant rules

List all variable changes from the control forecast for a given model run, along with reasons for each change (i.e., create an audit trail).

LINKING THE TABLES

In order to link the different tables, they must contain common variables (columns). For instance, different tables might be linked on variables such as the rule number, the date of analysis, the analyst making the model run, etc. In practice, it is usually advisable to include several such common fields. Queries on multiple tables are considerably more complex than the simple queries we have looked at so far, but the power gained by linking tables is immediately obvious. The following queries are designed to improve our ability to account for cumulative impacts of the District rules and regulation (we will not provide the actual SQL command to perform the query):

Link the RUNS and IMPACT_J tables. List all rules impacting a given industry, along with the total forecasted job impacts on the industry.

List the CENSUS and IMPACT_J tables. List total job impacts for industries identified by census as losing more than 100 jobs between 1980 and 1990.

Link the IMPACT_C, CENSUS, and IMPACT_R tables. List all simulations where minorities lost jobs in industries where overall employment increased between 1980 and 1990, or where the overall output impact of the rule was expected to be positive. (This could be used to identify unexpected adverse impacts on minority groups). List job impacts on Hispanics by rule, as a percent of regional employment and group employment in that sector.

As in the case of simpler queries, we can use the database management system to examine the process whereby we make socioeconomic assessments, looking for ways to improve our methods by discovering patterns in our methods.

Link the ELECTRICITY and ACTION tables. List all simulations where local electricity rates changed by more than 1 percent. Provide a summary of the variables that were changed. (This can help us identify which variables impact on local electric rates).

Link the IMPACT_R, IMPACT_J, and ACTION tables. List all cases where minority job impacts are below the average for all rules. Sort these by analyst and list the variables changed. (This could be used to detect difference in modeling style between analysts that cause them to systematically under forecast minority job impacts).

ESTABLISHING A DATABASE

The potential benefits of establishing a more formal database management system are considerable; however, collecting data in a systematic manner is not a trivial task. Such simple matters as whether text is stored in upper or lower case can prove crippling. A more complex example would be the question of how economic-impact data should be stored. Should job changes, for instance, be stored as some numeric change, as a percentage change, or some other way? Note that in the system described here, jobs are stored as an absolute starting figure and the number that original figure changes to, due to the simulation. This provides the greatest flexibility, since the number of jobs is available, but relative figures can be calculated as needed. If, for instance, we stored jobs as the number of jobs gained or lost, we would be unable to determine how important that change was relative to the base forecast. This is indicative of the types of problems analysts must consider in designing these systems.

Another problem is to design data structures that retain their usefulness over time. As an example, an analyst needs to consider how the database would change if the District ceased using REMI at some time in the future. We would hope that such a change would not make all the data collected in the past useless. This is one reason for separating the economic-impact data from the data describing the modeling process. As designed, a change in the model used would make one or two tables obsolete, but the overall record of economic impacts would remain usable.

There are many such potential problems, not all of which can be anticipated. For this reason, we recommend that the socioeconomic staff keep their database management system small in the beginning and use it for a while before irreversible decisions are made about entering large amounts of data. One common way of establishing a database management system is to start data collection around a relatively narrow study of current data. Thus, the socioeconomic staff would enter limited types of new data, but would make no initial effort to enter historical data. This also allows the staff to identify what types of queries are most useful to them.

Of particular importance are issues of data security. The improved access provided by a computer can make apparently mundane data very informative. To some extent, sensitive data can be protected by passwords; however, we recommend not collecting such data to begin with unless it has some clear value. One of the most common security problems comes from the fact that regional analysts are continually increasing their ability to obtain data at a more disaggregated level. As an example, cost data collected at the census tract or block level is fundamentally different from data collected at the county or zip code level, in that it is much easier to identify individual firms. There is a tendency for analysts to want unnecessarily fine detail. In the case just cited, for example, it is not clear that the socioeconomic staff need data collected below the zip code level. There are several hundred zip codes in the District's jurisdiction, making significant statistical analysis possible without going to finer detail. Besides, it is often expensive to obtain more detail.

Data entry is a major issue where data are not obtained from some secondary source (e.g., the Census Bureau). Most database management software allows users to create data-input screens, which provide users with far more than just a more pleasant computing environment. Input forms are extremely useful to control the format in which data are entered; for example, an input screen can require that telephone numbers be entered with an area code and that the area code be entered with parentheses. Most packages also allow the user to design various tools for error-trapping, for instance by forcing the user to reenter a value that is nonsensical. Finally, an analyst should create a standard set of utilities with any data management system. It is standard procedure, for instance, to have a program that can be run to check for duplicate records.

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
DATABASE MANAGEMENT SYSTEM

Data Dictionary

Table: **ACTION**
Description: **Variable Changes**

Column	Type	Width	Description
RULE	char	6	Rule #: normally 3-4 digit number 2 digit number denotes Regulation AQMP = Air Quality Management Plan A = amended rule
RUN_NO	char	3	Run #: normally 1-2 digit number representing the ordinal value of a run on that rule by that analyst on a given day. The first run of the day equals 1, the second run equals 2, etc.
VARIABLE_NAME	char	15	Variable name: The name of the REMI variable; full listing available below in Table nn.nn
VARIABLE_NUM	char	4	Variable number: Many REMI variables are disaggregated by sector, population group, etc. In these cases, the variables have a common name and are differentiated by a unique identifying number. A full listing of these is provided below in Table nn.nn.
OLD_VALUE	float	16	Original variable value before simulation: taken from the control forecast.
NEW_VALUE	float	16	New value of variable: taken from simulation forecast.
INDEX_YR	smallint	4	Year prices are indexed to.
REASON	char	225	Reason for variable change.

Table: **RUNS**
Description: **Storage Locations for Model Run Files**

Field	Type	Width	Description
RULE	char	6	Rule #: normally 3-4 digit number 2 digit number denotes Regulation AQMP = Air Quality Management Plan A = amended rule
RUN_NO	char	3	Run #: normally 1-2 digit number representing the ordinal value of a run on that rule by that analyst on a given day. The first run of the day equals 1, the second run equals 2, etc.
RUN_TYPE	char	10	Type of Run: CF=control forecast SI=simulation QF=quarterly forecast
DIRECTORY	char	29	Directory where files are stored: *d:\rule\date\run_no* *d* = drive designator *rule* = RULE identifier *date* = date of run (99_99_99 format) *run_no* = RUN_NO identifier
INDEX_YR	smallint	4	base year for prices & costs
BEGIN_YR	smallint	4	beginning year for impacts

Table: **NOTES**
Description: **File for storing extended notes on variable changes**

Column	Type	Width	Description
RULE	char	6	Rule #: normally 3-4 digit number 2 digit number denotes Regulation AQMP = Air Quality Management Plan A = amended rule
RUN_NO	char	3	Run #: normally 1-2 digit number representing the ordinal value of a run on that rule by that analyst on a given day. The first run of the day equals 1, the second run equals 2, etc.
VARIABLE_NAME	char	15	Variable name: The name of the REMI variable; full listing available below in Table nn.nn
VARIABLE_NUM	char	4	Variable number: Many REMI variables are disaggregated by sector, population group, etc. In these cases, the variables have a common name and are differentiated by a unique identifying number. A full listing of these is provided below in Table nn.nn.
NOTES	char	2000	Field for notes longer than fit in 225 character field of ACTION table.

Table: **IMPACT_C**
Description: **Cost Impacts**

Field	Type	Width	Description
RULE	char	6	Rule #: normally 3-4 digit number 2 digit number denotes Regulation AQMP= Air Quality Management Plan A = amended rule
EVAL_DATE	date	8	date of evaluation
SIC	char	6	SIC industry code: 0=total over all industries
INDUSTRY	char	20	industry name: industry 0 = TOTAL
ANALYST	char	15	last name of analyst responsible for evaluation
YRLY_COST_HI	float	6	total annual cost; upper estimate (in millions of dollars)
YRLY_COST_LO	float	6	total annual cost; lower estimate (in millions of dollars)
YRLY_COST_AVG	float	6	total annual cost; average estimate (in millions of dollars)
K_COST_HI	float	6	annual capital cost; upper estimate (in millions of dollars)
K_COST_LO	float	6	annual capital cost; lower estimate (in millions of dollars)
K_COST_AVG	float	6	annual capital cost; average estimate (in millions of dollars)
M_COST_HI	float	6	annual maintenance cost; High estimate (in millions of dollars)
M_COST_LO	float	6	annual maintenance cost; low estimate (in millions of dollars)
M_COST_AVG	float	6	annual maintenance cost; avg estimate (in millions of dollars)
END_YEAR	smallint	4	last year of impact counted
NOTES	char	120	miscellaneous notes on data

Table: **IMPACT_J**
Description: **Job Impacts**

Field	Type	Width	Description
RULE	char	6	Rule #: normally 3-4 digit number 2 digit number denotes Regulation AQMP= Air Quality Management Plan A = amended rule
EVAL_DATE	date	8	date of evaluation
SIC	char	6	SIC industry code: 0=total over all industries
JOBS_0	int	8	initial job forecast: from control forecast
JOBS_HI	int	8	annual job impact; upper estimate (must include sign)
JOBS_LO	int	8	annual job impact; lower estimate (must include sign)
JOBS_AVG	int	8	annual job impact; average estimate (must include sign)
END_YEAR	smallint	4	last year of impact counted

Table: **IMPACT_R**
Description: **Job Impacts by Racial Group**

Field	Type	Width	Description
RULE	char	6	Rule #: normally 3-4 digit number 2 digit number denotes Regulation AQMP= Air Quality Management Plan A = amended rule
EVAL_DATE	date	8	date of evaluation
SIC	char	6	SIC industry code:
JOBS_0W	int	8	initial job forecast for White Americans: from control forecast, disaggregation by estimate
JOBS_0H	int	8	initial job forecast for Hispanic Americans: from control forecast, disaggregation by estimate
JOBS_AA	int	8	initial job forecast for African Americans: from control forecast, disaggregation by estimate
JOBS_AS	int	8	initial job forecast for Asian Americans: from control forecast, disaggregation by estimate
JOBS_WN	int	8	initial job forecast for Women: from control forecast, disaggregation by estimate
JOBS_WHITE	int	8	Job impacts on Whites; Avg. est. (must include sign)
JOBS_HISP	int	8	Job impacts on Hispanics; Avg. est. (must include sign)
JOBS_AA	int	8	Job impacts on Afr. Amer.; Avg. est. (must include sign)
JOBS_AS	int	8	Job impacts on Asian Amer.; Avg. est. (must include sign)
JOBS_WN	int	8	Job impacts on women; Avg. est. (must include sign)
END_YEAR	smallint	4	last year of impact counted
NOTES	char	120	miscellaneous notes on data

Table: **ELECTRIC**
Description: **Electric Rate Impacts**

Field	Type	Width	Description
RULE	char	6	Rule #: normally 3-4 digit number 2 digit number denotes Regulation AQMP= Air Quality Management Plan A = amended rule
EVAL_DATE	date	8	date of evaluation
RATE_IMP_HI	float	6	impact on electric rates: high est. (cents per KWH -- must be signed)
RATE_IMP_LO	float	6	impact on electric rates: low est. (cents per KWH -- must be signed)
RATE_IMP_AVG	float	6	impact on electric rates: avg. est. (cents per KWH -- must be signed)
CLASS	smallint	3	Rate category: 0 = overall 1 = commercial 2 = industrial 3 = household -1 = unknown
END_YEAR	smallint	4	last year of reductions counted
INDEX_YR	smallint	4	base year for prices & costs
NOTES	char	120	miscellaneous notes on data

Table: **NOX**
Description: **NOx Impacts**

Field	Type	Width	Description
RULE	char	6	Rule #: normally 3-4 digit number 2 digit number denotes Regulation AQMP= Air Quality Management Plan A = amended rule
EVAL_DATE	date	8	date of evaluation
COST_TON_HI	float	8	cost per ton reduced (high est) (dollars)
COST_TON_LO	float	8	cost per ton reduced (low est) (dollars)
COST_TON_AVG	float	8	cost per ton reduced (avg est) (dollars)
INDEX_YR	smallint	4	base year for prices & costs
TONS_CUT_AVG	int	8	tons per year reduced (avg. est)
END_YEAR	smallint	4	last year of reductions counted
NOTES	char	120	miscellaneous notes on data

Appendix V

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT EVALUATION GUIDELINES

May 1992

Prepared for the

South Coast Air Quality Management District
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The research reported here is financed with funds from Contract No. C91253 between the South Coast Air Quality Management District and the Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts. The authors take full responsibility for the conclusions, which are not necessarily those of the sponsoring agency.

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APPENDIX V

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT EVALUATION GUIDELINES

May 21, 1992

I. GENERAL

These guidelines should be available for public inspection and should be subject to frequent review.

II. DATA STANDARDS

Consistency with California Environmental Quality Act

The alternatives described should parallel those offered in the environmental impact report.

Acquisition of Cost Data

Analysts need to obtain cost data, not only from potential vendors, but also from firms already using the technology or process in question. Vendor estimates most often represent a lower bound on costs.

The analysts need to differentiate clearly between capital-cost increases and changes in operating and maintenance costs.

Direct, Indirect, and Induced Economic Impacts

Analysts need to use consistent terminology for direct and indirect economic impacts.

Direct economic impacts. These are the initial economic impacts from spending. An example would be the dollar cost to a firm of buying a piece of pollution-control equipment and the revenue from that sale earned by the vendor of the equipment.

Indirect economic impacts. These are the second- and higher-round economic impacts due to these firms buying additional inputs from other firms to fulfill the original stimulus to demand. In the example from above, the vendor and his/her suppliers would each have to buy inputs from other firms to build the components of pollution-control equipment.

Induced economic impacts. These are the economic impacts of consumer spending generated by a stimulus to final demand. To continue the example, workers earning income from the production of pollution-control equipment, which they can use for private consumption purchases. These additional private consumption expenditures generate increases in demand for output over and above the initial direct and indirect economic impacts.

Appropriate Quantification

Insignificant impacts should not be made to appear more important than they are by excessive quantification.

Data Weaknesses

Each report should include a section explaining potential data weaknesses.

III. ECONOMIC IMPACTS TO BE CONSIDERED

Industry Analyses

The socioeconomic reports should always provide a detailed profile of industries likely to be affected. The following key factors should be considered in this analysis. (The list is by no means exhaustive.)

Labor intensity of the industry. Can the existing economic activity easily be transferred elsewhere?

Skill levels of workers in the industry. What types of skill levels are needed? Do these act as a barrier to the industry leaving the area? Do they act as a barrier to a potential new industry being created? What kinds of jobs are being gained and lost (including union versus nonunion)?

Capacity utilization. Does the industry have excess capacity? If not, can newer technologies be included in new plant and equipment at less cost? Alternatively, if excess capacity does exist, will retrofitting plants be more expensive?

General portrayal of local competitive advantages and disadvantages.

Recent Performance History

Has the industry shown signs of decline or growth? If already declining, what are the key indicators of that decline?

Market share.
Employment (or employment being shifted overseas).
Profitability.
Output.

What are the key strategic barriers facing the industry?

Failure to enter new markets.
Low real investment.
Inadequate access to capital.
Trade barriers or subsidized foreign competition.

What capital needs exist to ensure that the rule is implemented to the fullest extent?

Homogeneity of the Industry

Analysts of an industry need to ask if there is only a single model for competition in the industry, or whether there are different sectors within the industry. This is most obvious with respect to the split between large and small firms, but may apply for other factors as well.

When considering small and large firms, will analysts find that small and large firms are likely to respond to a proposed rule in fundamentally different ways? The definition of small firms is problematic. The U.S. Small Business Administration defines "small" as firms under 500 employees, while the state of California uses 250 employees (California Government Code, Article 2, Section 11342). Yet, as Piore (1989) notes, many experts would consider firms with more than 100 employees as medium-sized. The District staff typically have defined small as firms with 10 or fewer employees. To be consistent with state standards, we recommend using the special designation of "microenterprise" to refer to firms with 10 or fewer employees.

Small firms may have a variety of special needs, which become especially important when the District considers technology-forcing rules. These needs include:

They cannot easily afford large or "lumpy" fixed investments.

They rarely have large internal research and development functions, so that they are reliant on outside suppliers of control technologies and services

They may overcome these problems in several ways.

- They may contract out specialized services and subprocesses that they cannot afford to keep in-house.

- They may pool resources with other small firms through cooperatives or other similar organizational forms.

The potential of such arrangements should be studied.

What are the likely economic impacts of expected changes in product quality (especially on demand)?

Are there disproportionate economic impacts on disadvantaged businesses that are different from those identified for small firms?

Minority-owned/operated.
Female-owned/operated.

Possibilities for New Business Creation

Will additional jobs accrue directly to regulatory effort--do they constitute a legitimate cost of cleaning up the air, or are they wasted resources?

Will new processes be generated; will businesses stop producing some goods and services internal to the firm, choosing instead to obtain these from contractors?

What is the likelihood that new demand will be met by local businesses?

Leverage Points

Each report should identify areas to target in order to lessen impacts/increase benefits to local industry.

Aids to Compliance

Each report should include a section explaining how a business, organization, or individual can comply with the law, where to go for help, etc.

<u>Community Impacts</u>

In addition to an industry analysis, each report should contain an analysis of occupational groups and communities likely to be affected. First, are those employee groups most likely to be affected by a rule particularly vulnerable to job losses? For instance, do they exhibit:

Low real income.
A prior history of high and/or extended unemployment.
Low educational or skill levels (including language skills) making them less easily hired in other sectors.

High skill levels that are so specialized as not to be easily transferable to new products and services.
Membership in racial, ethnic, gender, or immigration-status groups that have traditionally been discriminated against in hiring.

Analysts need to determine as carefully as possible the quality of jobs created or lost. Even when the number of jobs does not change, the economic well-being of people is affected by the following kinds of shifts:

From full-time to part-time work.
From permanent to temporary work.
From high-skilled to low-skilled work.
From union to nonunion work.

How are costs likely to be borne by the community at large?

Retraining costs.
Higher social welfare costs.
Higher crime rates.

In each case, what are the alternatives?

How are consumers likely to be affected?

Price changes.
Declining availability of certain products.
Are substitutes available? Do these have their own costs?

In each case, are some consumers hurt more than others and what does that imply?

Cross-Media Impacts

Does the proposed rule create new kinds of pollution that may not be the direct responsibility of the District? As an example, does the installation of scrubbers create toxic compounds that will need to be treated and disposed?

Technology-Forcing Rules

In cases where a rule is technology-forcing, analysts need to conduct some form of risk analysis that describes what will happen if a new technology does not evolve. At the same time, the analyst should provide a description of what needs to happen for that technology to become viable and identify areas where policy can help or hinder that technology.

IV. PRESENTATION STANDARDS

Time References

Economic impacts should be presented in annualized terms to ease comparison across reports.

The period over which the economic impacts occur must be included. (If all economic impacts occur before 2010, the analyst may nevertheless present the average annual figures for the entire period, so as to make these comparable with other rules--this may vary by circumstance.)

Within any given report, the base year for price indexes should be consistent.

Use of Percentages

When using percentages, analysts should place them in perspective. It is misleading, for instance, to say that "most job impacts will be felt by whites," since whites are the majority of the population. The important question is whether job impacts will be disproportionate to the number of whites in the work force of the affected industries.

REFERENCE

Piore, Michael. 1989. "The Changing Role of Small Business in the U.S. Economy." Paper prepared for the Project on the New Industrial Organization. Geneva, Switzerland: International Labour Organization.

Appendix VI

IMPROVING THE QUALITY OF PUBLIC INPUT

May 1992

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Appendix VI

IMPROVING THE QUALITY OF PUBLIC INPUT

The South Coast Air Quality Management District (District) has, to some extent, incorporated public input into its regulatory process since its inception. Still, pressed by deteriorating economic conditions and more stringent air-quality regulations, the District's constituency has demanded continually greater access to the decision-making process in the 1990s. In Volume 1, we made the argument that expanded public input could be especially valuable to improving the quality of the District staff's socioeconomic reports. To summarize, expanded public input can help improve analyses by: (1) providing specialized information not otherwise available; (2) illuminating otherwise neglected costs and benefits; (3) encouraging alternative ways of modeling socioeconomic impacts; (4) helping to minimize conflict that might otherwise cause rules to be ignored or circumvented; and, (5) helping to focus debate on areas where there is disagreement.

In this appendix, we consider three alternatives whereby public input into the socioeconomic impact assessment process might be improved. These include: public modeling, improved public outreach, and negotiated rulemaking.

PUBLIC MODELING

As we explain in Volume 1, we believe there are strong reasons to keep the primary responsibility for modeling with the District's socioeconomic staff. These include the need to coordinate socioeconomic modeling with other District activities, the desirability of tapping into the resources of the District personnel, and the desire to build consistency and long-term institutional learning into the system. Nevertheless, this leaves the potential for a conflict of interest that may result from having the agency in charge of pollution regulation evaluating the impact of their own policies. In Volume I, we recommend the formation of an advisory committee to help ensure that the District staff are accountable to the public. In addition, the District staff may be able to improve public input by providing the public with more direct access to the REMI (Regional Economic Models, Inc.) model.

The District and the public will reap several potential benefits of public modeling. First, it will improve the public's understanding of and confidence in the District's socioeconomic analyses, and it will provide the District with some alternative ways of thinking about regulatory effects--a prerequisite to encouraging creative policy. In addition, by having the public use the same model to generate distinct policy alternatives, the District can shift the debate from technical details of the model to more substantive policy issues. Finally, through use of the model, the public will help to demystify the forecasting methodology. A more general discussion of the benefits and problems associated with public involvement in technical modeling is given in Nyhart and Samarasan (1989).

The most obvious difficulty in allowing public access to any socioeconomic model the District may use is that the operation of such models requires considerable expertise. Clearly, untrained individuals would require help in using REMI or any similar model. This could be provided by either the District staff or a third-party. We favor the use of a third-party, because the main purpose of the public-modeling exercise is to encourage alternative thinking. In addition, information from our interviews strongly suggests that members of the public would have more confidence in an outside contractor than in the District's staff. Presumably, this added confidence would make them more likely to take advantage of the service.

One way to implement our proposal would be to hire a contractor on retainer who would be available to help members of the public construct and interpret policy alternatives. Ideally, this contractor would be appointed by a body comprising both District administrators and members of the public, with the public holding a majority vote and with the public membership being divided between a number of different interest groups. This might be the Socioeconomic Review Committee (SRC) we recommend in Volume 1.

A number of issues, such as the funding and contracting procedure, submittal of requests, and scheduling of jobs, would have to be worked out prior to implementing our proposal. For the funding and contracting procedure, at least two possibilities exist. If the SRC selected the contractor, the District could pay the contractor's salary without being able to exercise undue control over hiring that would constitute a conflict of interest. Another possibility would be to have the contractor hired with funds from some other source, for instance, funds allocated directly by the California legislature. The contractor's pay should be on a fixed contract, rather than through a job-by-job contract, because the latter might encourage retaliation for an unpopular analysis. Similarly, the contract term should be long enough to give the contractor some independence. As an example, if the contractor were hired for two years at a time, s/he would be less likely to lose the job due to a single unpopular report.

Each request for using the model would have to be submitted according to a predesigned format, so that alternative requests could be easily and quickly compared. Demand for the contractor's time might become too great for available resources. If necessary, there are several ways to ration the service without posing an economic burden on those unable to afford it. First, the contractor could be given the power to refuse jobs if some prenegotiated workload would be exceeded by taking on additional assignments. These refusals could be subject to review by the hiring committee; if they believed a particular study was especially important, they could require the contractor to place a particular job higher in the queue. In times of slack demand for her/his services, the consultant could fill out the allotted time with analyses requested by the District, and the consultant would be encouraged to suggest such studies to the District staff.

To ensure reproducibility and validity of results, all data used and model runs made by either the contractor or the District would have to be available to all parties concerned. Likewise, the contractor should be given access to District facilities and staff. The point is not to encourage competing runs, but the sharing of alternative ideas. To the extent possible, the contractor should be involved in ongoing staff discussions about how to improve the socioeconomic analyses, including the use of REMI. Likewise, public involvement in the modeling process must not be mistakenly viewed as a replacement for the District's in-house modeling activities.

We recognize that public modeling could impose significant additional costs. First, a consultant must be hired. Second, the District may need to renegotiate its contract with the REMI vendor to allow additional copies of the software to be used. Another cost would be that the District staff would have to spend additional time incorporating these alternative analyses into their socioeconomic reports. There may also be costs associated with the committee that oversaw the contractor's activities. Even so, we recommend that the District find the means to support public modeling, because we believe that the benefits will far outweigh the costs.

IMPROVED PUBLIC OUTREACH

To ensure that community interests and concerns are taken into account, the District must continually seek to improve its public-outreach activities. In fact, the District has made significant progress in this area over the past several years, especially through the continuing efforts of the Public Advisor's Office (which includes the Small Business Assistance Office). A full evaluation of the District's community relations and public education activities is beyond the scope of this report. Nevertheless, we can borrow from the work of others to suggest a number of principles that are essential to conducting community outreach. The Environmental Protection Agency (EPA), through its Superfund Program, and the Western Rural Development Center have both developed procedures describing the basics of public participation, which can serve as models for community-relations programs (EPA, 1989; Kaufman, 1981). A summary of these principles of public participation is provided in Table 1.

The District's activities already meet many of these criteria. Still, there are five important areas where the District might improve its current outreach programs:

(1) Seek to bring the community into the rule-development process at an earlier date than at present.

(2) Make the process more iterative than at present, meaning that there is not just one workshop, but a continuing dialogue.

(3) Make a visible and significant effort to identify the population groups who are currently under-represented in the rule-development process, and determine ways to improve the access of these groups. In the course of our interviews, for instance, we have noted that

local neighborhood and community groups seemed to be much less involved in District activities than they probably should be--and certainly much less involved than either the business or professional environmental communities.

(4) Investigate the use of third parties to provide under-represented groups with technical support and to act as mediators where necessary.

(5) Investigate ways to reduce the burden imposed on the public as a result of their effort to become involved in District activities.

NEGOTIATED RULEMAKING

A less conservative approach to improving public input would be for the District to engage in direct negotiation with interest groups as a fundamental part of its rulemaking procedures. By taking this particular step, the District could engage all relevant interest groups directly in the process. Formally known as negotiated rulemaking (NRM), this process has been experimented with for the past decade, especially by the EPA, the Federal Aviation Administration (FAA), and the Occupational Safety and Health Administration (OSHA) (Harter, 1982; Susskind and McMahon, 1985; Pritzker and Dalton, 1990) These experiments led to the passage of PL 101-552 (the Administrative Dispute Resolution Act) and PL 101-648 (the Negotiated Rule-Making Act of 1990). Together these laws encourage, but do not require, the federal government to use informal procedures for resolving disputes, often with the help of third-party mediators.

Negotiated rulemaking is not a substitute for procedures mandated by court order, legislation, or good public-administration practice. Rather, it is a preliminary step in which various interest groups and the agency come together to determine and build upon interests that they share. The goal is

Table 1

SEVENTEEN PRINCIPLES FOR IMPROVING PUBLIC PARTICIPATION

No.	Principle
1	Proponents must conduct a thorough pre-assessment of socioeconomic, environmental, and political considerations.
2	Public participation should start early in the decision process and continue throughout.
3	People need to be aware of the level of power being offered.
4	Programs must have unequivocal official support.
5	The program must be vigorously conducted.
6	Efforts should be made by the agency to identify all interested parties and include them on relevant panels or committees or at the negotiation table.
7	Third-party neutrals should be used whenever possible.
8	The process of public participation should be agreed upon between the agency and participants.
9	The objectives of the public participation need to be clearly stated and described in a written plan.
10	Information should be freely and regularly available to all participants.
11	Two-way and multiple dialogues should be promoted.
12	Trust-building should be a top priority of officials.
13	Communication should be concise and nontechnical.
14	Time in joint meetings must not be wasted.
15	Citizens should be valued in the process.
16	Participants should know how their submissions will be processed.
17	Where appropriate, costs for participants should be reimbursed (e.g., for travel and large time commitments).

Source: Institute for Participatory Planning, 1981 as cited in Geoffrey Syme and Elizabeth Eaton. 1989. "Public Involvement as a Negotiation Process." Journal of Social Issues, Vol. 45, No. 1, pp. 87-107.

to identify regulatory solutions that produce mutual gains, rather than just assuming that regulators and the community are at odds (Fisher, Ury, and Patton, 1991; Susskind and Cruikshank, 1987). When the parties do disagree, NRM also provides a forum for reaching compromise. Prior to discussing EPA's negotiated rulemaking process, we outline the District's current process.

The District's Rule-Development Process

Figure 1 traces an idealized flow chart of the District's rule-development process. Although any individual rule may vary from this diagram in specific respects, we believe it is an accurate portrayal of the overall process. Rule development is undertaken mainly by the Planning and Rules Division of the District.[1] Within planning and rules, responsibility for rule formulation rests mainly with the rules staff. The socioeconomic analysts in the planning section act primarily in a support function.

The general levels of pollution reduction required by specific rules are determined by the District in the Air-Quality Management Plan (AQMP). The District staff, in turn, determine AQMP-specified reductions by comparing estimates of future pollution levels with levels specified under both state and federal air-pollution regulations. Once a reduction target for a specific rule is determined, the District staff discuss and formulate the exact details of the draft rule, trying to take into account what is technically feasible, most enforceable, and likely to be least burdensome on local firms and individuals.

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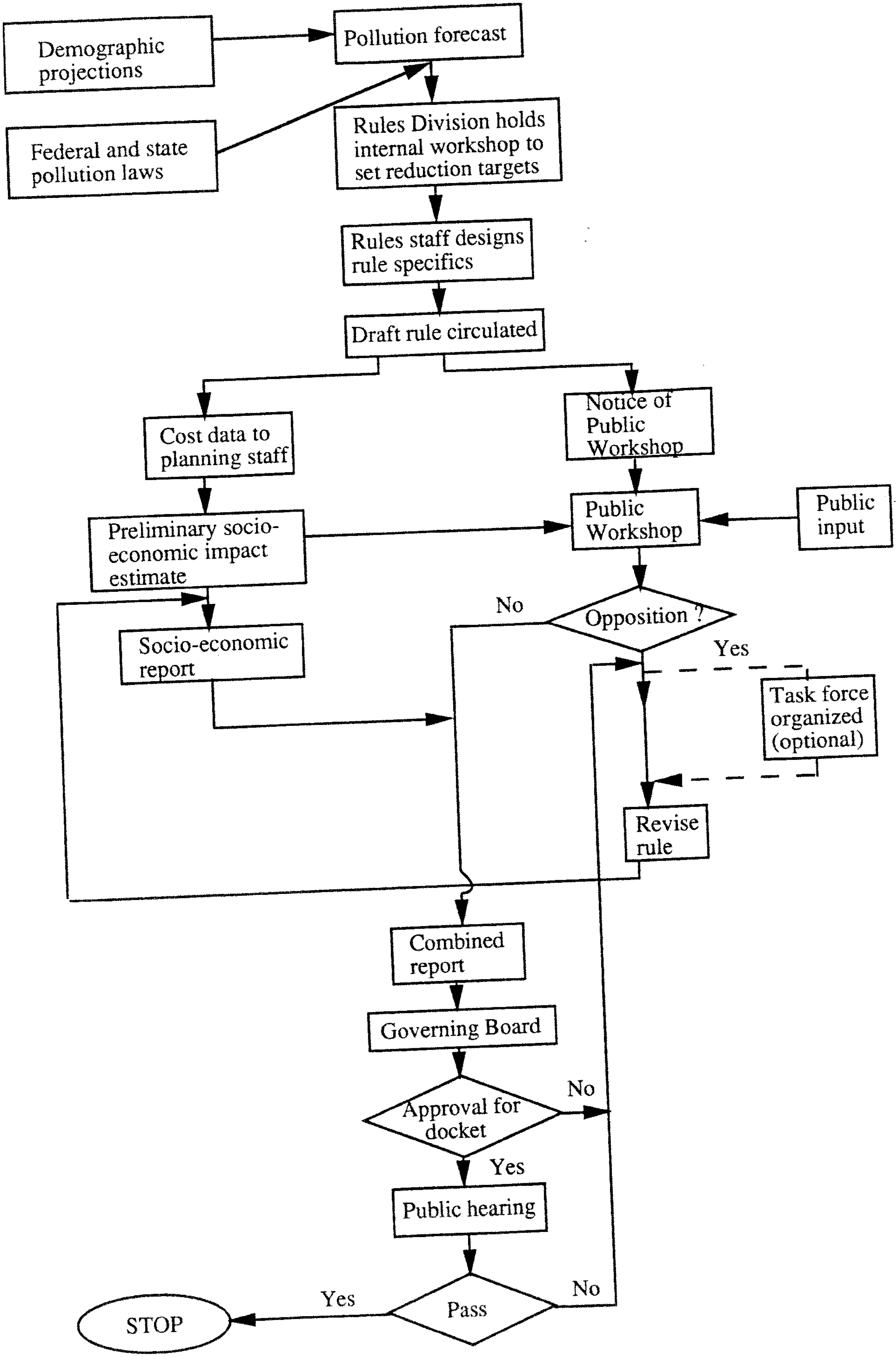
[1] The District is in the process of restructuring and renaming the divisions. We refer here to the names the District used while we were conducting the major part of our evaluation in 1991 and early 1992.

Figure 1

THE DISTRICT'S RULE DEVELOPMENT PROCESS



Once in draft form, the proposed rule is circulated and the public is invited to comment on the rule in a public workshop. As a result of the comments obtained in the public workshop, further public input may be solicited, either by forming a special task force or by additional rounds of workshops. Parallel to this public-input process, the socioeconomic staff prepare the socioeconomic report for the proposed rule. The socioeconomic staff may be required to update their analysis in the event a rule is changed in response to public comments. Eventually, the result is a proposed rule in final form, with a completed socioeconomic report. The socioeconomic report is submitted to the Governing Board, along with other documentation supporting the rule, in a single integrated report. Public comment is accepted at the Board meetings, but is usually oriented toward broad policy concerns rather than detailed design issues, which have presumably been solved by the time the rule is reviewed by the Board. The Board may then pass the rule, or they may return it for further revision. If the rule is later amended, the amendments must go through a similar process.

There are several points of the process worth noting. First, unlike EPA's negotiated rulemaking (discussed below), the public has very little input into the design of the proposed rule, nor does the public contribute significantly to the production of the socioeconomic report, unless the District staff actively seek such input. There is no institutional requirement for such input, other than what might emerge at the workshop. The socioeconomic report is normally not completed at the time of the public workshop; thus, it is not available for comment until later. This also means that the public is denied the benefit of having the socioeconomic report at its initial and most important opportunity for input. This, in turn, may prevent important issues from being raised that might have otherwise led to further public workshops or the creation of a special task force.

<u>Suitability of the District's Rulemaking to NRM</u>

EPA's negotiated rulemaking process (shown in Figure 2) can be contrasted to the existing District process (Figure 1). Not all rules or regulations are appropriately decided by negotiation. According to EPA's official assessment of its experience with NRM:

> [EPA]'s analysis indicates that [NRM] can sometimes be better than the conventional rulemaking process. In the "right" situations, [NRM] can produce proposed rules that meet statutory requirements but are more pragmatic than proposals EPA would be likely to develop on its own and may produce better environmental results; in addition, negotiated rules are more likely (than conventional rules) to be accepted by the affected industries and other interested parties involved in developing them. Negotiation also may reduce the time it takes to proceed from proposed to final rulemaking. Picking the "right" situations is critical; frequently undertaking negotiations in cases where it is inappropriate or unlikely to produce consensus could eventually discredit the process. (EPA, 1987)

EPA has set forth the following 10 factors that can help to identify the "right" situations for using NRM (Pritzker and Dalton, 1990):

- A limited number of interests will be significantly affected, and they are such that individuals can be selected to represent them.
- The issues are known and ready for a decision to be made.
- No party will have to compromise a fundamental value.
- The rule involves diverse issues.
- The outcome is genuinely in doubt.
- The parties view it to be in their interest to use the process.

Figure 2

NEGOTIATED RULEMAKING AT EPA

EVALUATION PHASE

Identify issues and dealdines.
Identify interested parties.
Compare to selection criteria.
Confirm management interest.
Select convenor.

↓

CONVENING - PHASE I

Identify additional parties.
Discuss regulation negotiations with parties.
Discuss issues with parties.
Determine willingness of parties to negotiate.
Report to agency.
Obtain agency management commitment.
Preliminary survey of 12-15 participants.

↓

CONVENING - PHASE II

Obtain parties' commitment to negotiate.
Publish "notice of intent to negotiate."
Select facilitator/mediator.
Respond to public comments on "notice."
Adjust committee membership if necessary.
Arrange organizational meeting.
Arrange committee orientation/training.

↓

NEGOTIATIONS

Establish ground rules/protocols.
Define "consensus."
Set meeting schedule.
Publish notices of meetings.
Review available information and issues.
Review draft rule or proposal if available.
Establish work groups or subcommittees as necessary.
Negotiate text or outline of proposed rule.

↓

RULEMAKING

Negotiations concluded:

If consensus is reached on language of rule:

- agency circulates draft for external/internal review
- agency publishes consensus as draft review

If consensus is reached only on issues or outline:

- agency drafts proposed rule
- agency circulates draft for internal/external review
- agency publishes proposed rule

If consensus is not reached:

- agency proceeds with rulemaking using discussions as a guide
- agency drafts and publishes proposed rule

Draft rule subjected to public comment.
Committee notified of public comments.
Agency revises rule if necessary.
Agency publishes final rule.

Source: Figure adapted from Pritzker, David M., and Deborah S. Dalton. 1990. Negotiated Rulemaking Sourcebook. Washington, DC: Administrative Conference of the United States.

- The agency is willing to use the process and participate in it.
- The agency is willing to conduct proactive recruitment of parties and to support new or weaker parties with training and resources.
- No one interest should be able to dominate the proceeding.
- There should be a deadline for achieving consensus.

Many of the District's rules fit these criteria well, especially those rules that mainly affect a few large firms or institutions. This was the case when the District recently brought together a large number of interested parties around Rule 1135 (Emissions of Oxides of Nitrogen from Electrical Generating Systems). This "roundtable" approach shared many similarities to NRM, in that it sought to bring together many diverse interests; however, it stopped short of an actual commitment to negotiation or reliance on consensus decision-making.

For rules that affect large groups of smaller firms or citizens, the District will require a far more extensive effort to organize and support the various parties involved in order for NRM to work. We should note that the California Senate recently approved the creation of a new Center for the Resolution of Environmental Disputes. The Center, which will be run by California State University, will provide neutral, third-party help to businesses, local governments, and citizen groups to mediate clashes over natural resource use and rulemaking. The Center will also offer course work and conduct research in environmental dispute resolution.

NRM is not without its costs. It demands considerable resources from the agency involved to assemble the affected parties, especially those parties that may need financial assistance to become involved.

The process also tends to compress the agency's internal review schedule. In addition, many agencies are reluctant to give up their sovereignty to the public. The level of trust necessary to make the process work can only be built through experience. This suggests that NRM should not be treated as a short-run solution to a particular rulemaking problem, but rather as a long-term improvement in the way an agency conducts its business (Pritzker and Dalton, 1990). Finally, the success of NRM depends to a very large degree on who is invited to participate. In the worst case, this could result in policies being formulated by a group of insiders representing only a narrow set of public interests.

CONCLUSION

We have tried to present examples that give the range of alternatives available to the District. These examples are neither exhaustive, nor exclusive of one another. Researchers working in a large number of different contexts have confirmed the general point that increasing public access is good environmental policy. A few of these other representative cases include: land-use planning (Forester, 1985; Susskind 1980); nonconformance penalties under Sec. 206(g) of the Clean Air Act (Pritzker and Dalton, 1990; Susskind and McMahan, 1985); wood stove performance standards (Ozawa, 1991; Pritzker and Dalton, 1990); emergency pesticide exemptions (Pritzker and Dalton, 1990; Susskind and McMahan, 1985); forest management (Wondolleck, 1988); Superfund cleanups (Konkel, 1991); facility siting (Laws and Susskind, 1991); Resource Conservation and Recovery Act permit modifications (Ozawa, 1991; Pritzker and Dalton, 1990); electric power planning (Andrews,

1990) and offshore oil and gas exploration (Stedman, 1983). Any particular mix of policies that the District may pursue in trying to improve public input would require more careful consideration than allowed for in our current analysis.

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Appendix VII

REMI MODELING AND INTERPRETATION: AN EXAMPLE OF JOB IMPACTS OF RULE 1135A

May 1992

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The research reported here is financed with funds from Contract No. C91253 between the South Coast Air Quality Management District and the Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts. The authors take full responsibility for the conclusions, which are not necessarily those of the sponsoring agency.

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REMI MODELING AND INTERPRETATION: AN EXAMPLE OF JOB IMPACTS OF RULE 1135A

In this appendix, we carefully examine an actual set of simulations conducted by the District using the REMI model. Our goals are to ensure that their results are reproducible, to determine if their interpretations of the model results are reasonable, and to suggest alternative approaches that might have been used to model the proposed rule. We will not attempt to go back after-the-fact and determine if the simulation results have been proven true or false.

We base our sample analysis on Rule 1135A--alternative proposal to control nitrogen oxide (NO_x) emissions from the electric utilities (SCAQMD, 1991)[1]. Rule 1135A amends existing rules on NO_x emissions from the electric utilities in the Southern California, accelerating the schedule for meeting annual and daily limits on NO_x emission rates. It also makes adjustments in the ways those reductions can be met.

For ease of comparison with the District's analysis, we adopt the same assumptions, input data, and procedures the District socioeconomic staff used in modeling the economic impacts of Rule 1135A. We also restrict our discussion to job impacts in the four-county region as a whole to avoid repetition. Analysts can use the same modeling procedure to analyze economic impacts other than jobs or to look at each individual county for more disaggregated economic impacts.

THE DISTRICT'S SOCIOECONOMIC ANALYSES

The modeling procedure adopted by the socioeconomic staff can be summarized into one basic question: how do increasing expenditures on NO_x reduction and higher electricity costs affect the regional economy? The staff

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[1] Input data were provided to us by the socioeconomic staff.

quantify compliance expenditures for each year during the compliance period using the PROSYM model--an electricity production simulation model (SCAQMD, 1991). They assume that operation and maintenance expenditures peak in the compliance years and that they stay at their peak level for the rest of the study period. Compliance with Rule 1135A is assumed to affect the economy through two main channels (SCAQMD, 1991, Appendix J).[2]

First, Rule 1135A requires installation, operation, and maintenance of pollution-control equipment. These expenditures increase total demand, having an expansionary effect on the regional macroeconomy. Most capital expenditures are assumed to be spent in the following sectors: Fabricated Metal Products (SIC 34), Instruments (SIC 38), and Industrial Machinery (SIC 35). The operation and maintenance expenditures--increasing electricity, fuel, and ammonia costs--are allocated to the following sectors: Public Utilities (SIC 49), Fabricated Metals (SIC 34), and Chemicals (SIC 28). The increased expenditures are introduced into REMI using demand policy variables (DEMPOLs), which indicate changes in spending on the products of various sectors.

The socioeconomic staff then assume that the increased costs of producing electricity will be passed on entirely as rate increases to consumers and businesses. Three REMI policy variables are changed to model the economic impacts of increased electricity costs: (1) relative electric fuel costs for commercial users (Variable 941); (2) relative electric fuel costs for industrial users (Variable 942); and (3) the local consumer price index (CPI) (Variable 902). REMI then calculates the contractionary effects

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[2] The socioeconomic staff modeled the fuel oil phaseout by reducing sales in the Petroleum Products sector (SIC 29) (SCAQMD, 1991, p. J-4).

resulting from increased costs of doing business in electricity-using sectors and higher electric bills for consumers.

VIABILITY OF THE DISTRICT'S ANALYSES

There is no single "right" way to model the economic impacts of 1135A. The socioeconomic staff used one reasonable possibility. It is plausible to expect that, as regulated utilities, the local electricity producers would go to the Public Utilities Commission (PUC) and request a rate increase to cover the entire cost of complying with the rule. However, several issues should have been discussed in the socioeconomic report that were not.

First, the compliance pattern suggested by the PROSYM modeling is just one alternative and reflects certain ways to comply with Rule 1135A. We applaud the District for their creative approach of combining the analyses from the energy model and REMI; however, PROSYM seems like too much of a "black box." The real actions taken by the utilities to comply with the rule may be very different from the PROSYM simulation. We should have been told more about what likely alternatives were available to the utilities, how stable the PROSYM results were, what conditions might cause a shift in the optimal production configuration, and how these might affect costs to the utilities.

Second, even if analysts agree on the compliance pattern suggested by PROSYM modeling, they can introduce the compliance effects into the REMI model in different ways. Analysts, for example, can use cost policy variables (COSPOL) to incorporate the increased costs of electricity production into the REMI model directly, rather than assuming total cost pass-through, and then let the REMI model determine changes in relative electricity costs and the local CPI variables. An advantage of using the COSPOL variable is that it allows the REMI modeler to determine how much of the cost increase can be passed on to consumers and how users may respond to the rate increase. The major disadvantage is that REMI only provides a COSPOL variable for public utilities as a whole (SIC 49), rather than for public and private electric utilities. By using COSPOL, therefore, analysts may not be able to capture the unique characteristics of electricity production and consumption in the region.

Third, the increased costs to the utilities of air-pollution control expenditures need not be paid for strictly by a rate increase. It is possible, for instance, that the utility's request for a rate increase would be turned down by the PUC, or that the PUC would grant a rate increase smaller than they requested. In this event, the utilities might have to pay for the changes in some other manner, for instance through borrowing, or by spending part of their retained earnings (undistributed profits). Again, there should be some discussion of these alternatives in the socioeconomic report; at a minimum, we should have an explanation of why these alternatives were rejected.

Finally, the District's modeling procedure is a partial-cost analysis and does not include such factors as information and transaction costs of obtaining pollution-abatement technologies and know-how, economic impacts on productivity caused by using unfamiliar technologies and substitution of other inputs for electricity, and one of the most important, benefits of air-pollution reductions. Rule 1135A, if it is successfully implemented, should improve the quality of air in the District. This may, for example, improve public health, reduce mortalities, and lower health-care costs. To the extent that employers at least partially pay for the health-care costs, the costs of production may be reduced and competitiveness of local industries may increase. Better air quality can also enhance amenities, influence migration, and help growth in tourist industries. We recognize that these economic impacts may be difficult to quantify. Even if the socioeconomic staff did not include these potential economic impacts in the REMI modeling exercise, they should have provided a thorough explanation of them, their general direction, and magnitude.

REPRODUCIBILITY OF RESULTS

The first question we asked about the results of our REMI runs was whether or not we could reproduce the District's results. We were able to do so, but it was more difficult than we would have liked. First, the staff did not provide good documentation on (1) how the control expenditures were estimated; (2) how those expenditures were translated into electricity fuel-cost increases for different users; and (3) how those costs and expenditures were allocated among industries, the four counties, and over time. In some cases, we had to go through formulae in the LOTUS file provided by the District's socioeconomic staff to make sense of input data.

Second, the socioeconomic staff provide very few explanations for why particular policy variables were used and how their input values were calculated for different counties and different years. In some cases, there is more than one policy variable that can be used to incorporate the same input, but we do not know why the socioeconomic staff preferred one variable to another. We even needed to refer to the REMI manual to get the names and definitions of the policy variables used in the modeling process. Again, we had to go through formulae in the LOTUS file to understand input values of some policy variables.

The documentation for the modeling procedure is even less complete than the description of variables and input values. The socioeconomic staff do not explain how an analyst can use the REMI and the data file they provided to reproduce the District's results. This is particularly problematic for the REMI model, because the model has many options available and requires some personal judgements in the modeling process.

INTERPRETING THE SIMULATION RESULTS

In presenting the results, the socioeconomic staff separated job impacts for Rule 1135A into direct and indirect job impacts (SCAQMD, 1991).[3] Direct job impacts are those accruing to the five utilities directly regulated. Indirect job impacts are those job losses or gains occurring in other sectors.[4]

Coverage of the Analysis

The staff also separated job impacts by industry and racial group. The industrial breakdown comes as normal REMI output. They made the racial disaggregation by assuming that jobs in the affected sectors are distributed among racial groups in the same proportions as are people in the general population. They calculated the number of jobs created or lost relative to

---

[3] Actually, the written report and our computerized data refer to slightly different figures, because the socioeconomic staff had revised their figures in the computer, but had not yet issued a revision of the written report.

[4] These definitions do not concur with standard economic practice. In the District definition, for instance, direct job impacts include job changes accruing to rounds of spending besides the first round. Conversely, standard economic practice would allow direct job losses in industries outside of the utility sector.

the control forecast in each of five sample years and in terms of an annual average. In the conclusion, they indicate that total job impacts are extremely small relative to projected job growth during the same period, but this point is nearly lost in the analysis.

Other variables they assessed include electricity rates and total energy costs, with the economic impacts on electricity rates being given in the greatest detail. They show rate increases as percentage changes relative to the average U.S. energy cost. They also point out that the rate increases are very small relative to the control forecast. Still, they do not discuss how reliable the results are, other than to say that the assumption of total cost pass-through is likely to provide an upper bound on rate increases.

They also provide some cost-effectiveness data as the average costs of removing a ton of emissions. It is important to note that the socioeconomic staff did not try to minimize average costs. This approach would be misguided, because the alternative giving the lowest average cost need not give the lowest total cost. However, they then compare the average cost per ton of pollutant reduced across several rules, without pointing out this important fact.

To place the economic impacts of the proposed amendment in context, the socioeconomic staff compared two alternatives proposals--one of which is more stringent and one of which is less stringent than the actual proposal. They compared these in terms of total emissions reduced and total job impacts. They also provide a brief statement that costs may be mitigated somewhat by provisions in the law that allow utilities to bank their emissions together under a system-wide NO_x limit.

Critique of the Analysis

Impact assessments from the REMI model should be interpreted as an indication of relative magnitude of economic impacts or one likely economic consequence of Rule 1135A, not as an exact description of economic impacts or the only possible economic consequence. In Rule 1135A, the socioeconomic staff primarily use the REMI model to determine aggregate economic impacts, especially job impacts and electricity rate changes. Their analysis is not as informative as it might be. They do not place these figures in perspective well, nor do they indicate how stable or certain the results are. When interpreting REMI simulation results, the socioeconomic staff need to focus on how the rule affects the regional economy rather than just on a summary of aggregate job gains/losses.

From Table 1, we can see that Rule 1135A has a negative impact on aggregate job generation, reducing total employment between 1991 and 2010 by an average of 586 jobs a year, 540 of which are in private nonfarm employment.[5] These are among the largest job impacts found in any of the analyses the socioeconomic staff have conducted using REMI. The job impacts of Rule 1135A vary significantly over time. Between 1991 and 1994, the expansionary effect of air-pollution control expenditures outweighs the contractionary effect of increasing electricity costs and total employment increases. After 1994, most capital investment to comply with Rule 1135A has been completed and operation and maintenance expenditures stabilize. On the other hand, the impact of the increasing electricity costs works through

[5] We use the term job gains/losses to indicate changes in employment resulting from implementation of Rule 1135A. They do not necessarily mean an increase or reduction in employment. The job impacts in the private nonfarm economy are shown in Table 2.

Table I

SUMMARY OF JOB AND INCOME IMPACTS

Year	Total Employment (persons)	Wage & Salary (million, nominal $)	Disposable Income (million, 1977$)
1991	66	2.38	0
1993	353	19.50	-6
1995	-181	-1.30	-14
1997	-785	-30.91	-23
1999	-921	-45.93	-27
2001	-913	-49.59	-29
2003	-359	-15.35	-25
2005	-752	-41.38	-33
2007	-1,056	-71.78	-37
2010	-1,088	-87.52	-40
Annual Average	-586	-31.99	-24

Source: Tables 1 and 4 of the REMI Output.

gradually into all sectors of the regional economy. Total annual job impacts peak in the year 2010, with 1088 jobs being lost in that year, 974 of which are in the private nonfarm economy. As a percentage of total forecast employment, this figure levels off and remains almost constant in the later years over the period 1991-2010.

We will focus on job impacts, but similar patterns are found in output and income impacts. Relative to the control forecast, the impact on wages and salaries disbursement ranges from a $2 million gain in 1993, to a loss of more than $87 million in 2010 (in nominal dollars). In constant 1977 dollars, this translates to an annual average loss of $24 million in disposable income between 1991 and 2010. Again the pattern of increasing economic impacts is evident, with a peak loss of $40 million in real disposable income for the year 2010.

Although these appear to be very significant economic impacts, in fact they are very small relative to the totals. The peak job impact is less than 0.02 percent of the projected annual employment for the year (2010) in which it was made, with the average being even less in percentage terms.[6] Similar percentages hold true for income and output as well. If the figures were reliable, they would be important. After all, the loss of a thousand jobs matters a great deal if you are one of the people losing his/her job. However, what is important to realize is that these economic impacts are likely to be smaller than the normal statistical errors we would expect in making any such forecast, especially when making forecasts far into the

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[6] The total private nonfarm employment forecast in the region for 2010 is 7,589,361.

future. In other words, we cannot hold much faith that these forecasts are statistically meaningful.

We need to explore this fact further. The fact that overall economic impacts of the forecast are small may not prevent us from obtaining statistically reliable results. Job and income losses, for example, may be distributed overwhelmingly to a few sectors, where they represent a much larger percentage of the total forecast values. Table 2 shows how Rule 1135A affects job generation in each of 49 private nonfarm industries for which we can obtain REMI results. We look at the industrial distribution of job impacts in 1993--the year with the highest total employment gain. Most job gains resulting from the compliance expenditure are in Fabricated Metal Products, Chemical and Allied Products, Wholesale Trade, Miscellaneous Business Services, and Public Utilities, which provide a vast majority of the control equipment, materials, and services. The Electric Utility sector, which is directly affected by Rule 1135A, is expected to increase its employment by nine people in 1993 in order to achieve the required level of NO_x reduction.[7] As with our earlier results, job losses are statistically too small to be reliable, even when we take a more disaggregated look at the numbers.

Looking at 2000, the year of maximum job losses, we find that most of the forecast job loss is in nonmanufacturing industries, especially Other Retail Trade, Miscellaneous Business Services, and Medical and Other Health Services. These industries also tend to be characterized by lower than average wages (see Table 3). Although we cannot place much faith in the

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[7] The job impact number for the Electric Utilities is from Table 17 of the REMI output (Detailed/3rd-Level Employment--136 Sectors). This figure is just 0.04 percent of the forecasted employment in the sector.

Table 2

JOB IMPACTS BY INDUSTRY*
(number of jobs)

Industry	1993	1995	2000	2005	2010
Lumber (24)	0	-1	-3	-3	-3
Furniture (25)	0	-4	-7	-6	-7
Stone, clay, etc. (32)	2	0	-4	-2	-3
Primary metals (33)	7	3	-3	1	-3
Fabricated metal (34)	243	160	-10	124	-10
Non-electric machine (35)	12	7	-8	1	-6
Electrical equipment (36)	-1	-8	-16	-13	-12
Motor vehicles (371)	0	-1	-2	-2	-2
Rest. trans. equipment (R37)	-2	-4	-6	-6	-4
Instruments (38)	-1	-4	-8	-9	-8
Miscellaneous manufacture (39)	0	-1	-2	-2	-2
Food (20)	-2	-5	-9	-9	-9
Tobacco manufacture (21)	0	0	0	0	0
Textiles (22)	0	-1	-2	-2	-2
Apparel (23)	-2	-5	-8	-7	-7
Paper (26)	0	-2	-5	-5	-5
Printing (27)	3	-4	-13	-12	-14
Chemicals (28)	24	7	3	2	0
Petroleum products (29)	1	0	0	1	1
Rubber (30)	0	-5	-10	-10	-9
Leather (31)	0	0	-1	-1	-1
Mining	2	0	-2	-1	-2
Construction	15	-13	-54	-49	-64
Railroad (40)	0	0	-1	0	0
Trucking (42)	3	-2	-8	-7	-10
Local/interurban (41)	0	-1	-3	-3	-3
Air transport (45)	1	-3	-7	-6	-8
Other transport	1	-2	-5	-4	-5
Communication (48)	2	-3	-8	-7	-8
Public utililties (49)	18	5	1	2	0
Banking (60)	1	-9	-22	-20	-24
Insurance (63 + 64)	0	-10	-21	-21	-25
Credit + finance (61 + 62)	-1	-10	-22	-22	-25
Real estate (65, 69)	-3	-12	-24	-23	-27
Eating & drinking (58)	0	-25	-61	-53	-64
Rest of retail (R52)	-16	-78	-156	-137	-143
Wholesale	28	-11	-59	-43	-64
Hotels (70)	4	-10	-17	-19	-19
Per. serv. & repr.	-1	-10	-22	-21	-24
Private household	-1	-3	-6	-6	-7
Auro rep/service (75)	0	-5	-14	-13	-16
Miscellaneous business services (73)	26	-18	-89	-78	-110
Amusement & recreation (79)	-2	-6	-10	-8	-7
Motion pictures (78)	0	-2	-3	-3	-2
Medical (80)	-12	-44	-93	-94	-109
Miscellaneous professional services (81)	9	-11	-40	-37	-50
Education (82)	1	-6	-15	-13	-15
Non-profit organizations (83)	-3	-14	-28	-25	-27
Agriculture/forestry/fishery services	0	-3	-7	-7	-8
Total private non-farm jobs	343	-177	-907	-680	-974

* For private non-farm employment only

Source: Table 18 of the REMI Output.

Table 3

INDUSTRIAL STRUCTURE OF THE SOUTH COAST REGION, 1987

Industry	Employment (thousand people)	Percentage of total employment	Average annual wage (thousand dollar)
Lumber (24)	25.5	0.41	20.0
Furniture (25)	52.6	0.84	17.1
Stone, clay, etc. (32)	30.9	0.49	23.0
Primary metals (33)	27.7	0.44	27.8
Fabricated metal (34)	99.1	1.58	23.5
Non-electric machine (35)	99.2	1.58	30.3
Electrical equipment (36)	219.7	3.49	31.5
Motor vehicles (371)	22.9	0.36	23.4
Rest. trans. equipment (R37)	203.8	3.24	35.1
Instruments (38)	47.2	0.75	30.1
Miscellaneous manufacture (39)	34.7	0.55	16.0
Food (20)	61.2	0.97	24.9
Tobacco manufacture (21)	0.1	0.00	1.0
Textiles (22)	14.6	0.23	18.3
Apparel (23)	110.3	1.75	12.7
Paper (26)	24.9	0.40	28.5
Printing (27)	90.9	1.45	23.8
Chemicals (28)	37.5	0.60	31.4
Petroleum products (29)	12.6	0.20	41.8
Rubber (30)	55.3	0.88	20.9
Leather (31)	6.0	0.10	13.5
Mining	18.1	0.29	30.5
Construction	339.1	5.39	21.3
Railroad (40)	9.2	0.15	38.4
Trucking (42)	87.1	1.38	18.7
Local/interurban (41)	15.8	0.25	15.3
Air transport (45)	42.0	0.67	33.8
Other transport	39.4	0.63	23.9
Communication (48)	72.1	1.15	33.2
Public utililties (49)	33.9	0.54	36.6
Banking (60)	100.2	1.59	28.2
Insurance (63 + 64)	135.4	2.15	29.3
Credit + finance (61 + 62)	107.3	1.71	40.8
Real estate (65, 69)	311.7	4.96	7.8
Eating & drinking (58)	374.6	5.96	9.3
Rest of retail (R52)	729.1	11.59	14.7
Wholesale	409.0	6.50	27.2
Hotels (70)	72.5	1.15	14.4
Per. serv. & repr.	187.1	2.97	8.0
Private household	95.8	1.52	7.1
Auro rep/service (75)	82.8	1.32	14.2
Miscellaneous business services (73)	584.3	9.29	15.4
Amusement & recreation (79)	95.1	1.51	16.3
Motion pictures (78)	102.1	1.62	34.8
Medical (80)	389.1	6.19	25.1
Miscellaneous professional services (81)	280.5	4.46	23.0
Education (82)	91.7	1.46	14.2
Non-profit organizations (83)	138.7	2.20	15.3
Agriculture/forestry/fishery services	69.8	1.11	9.3

Source: Tables 18 and 38 of the REMI Output.

numbers, we might wish to target these sectors for further analysis, because even extremely small economic impacts are important if they fall on low income people least able to afford job loss.

Another possibility we should explore is that, although job impacts are small, their impact on other important variables may be larger. We might ask, for instance, whether these job impacts have a significant impact on local wage rates. Theoretically, Rule 1135A has both positive and negative economic impacts on wages. On the one hand, higher electricity costs stimulate substitution of labor for electricity and may bid up wage rates. On the other hand, the electricity-rate increase has a dampening effect on the regional economy, which exerts a downward pressure on wages. The overall economic impact depends on which effect dominates and cannot be determined easily a priori. The REMI simulation results indicate that, on balance, the economic impact of Rule 1135A on wage rates is negligible. For all industries, changes in average annual wages due to Rule 1135A is no more than three dollars in the five years we examine (1993, 1995, 2000, 2005, and 2010).[8]

Yet another possibility is that the higher electricity rates under 1135A will raise overall fuel costs. Table 4 shows that the overall fuel costs are increased by about 0.3 percent for most years between 1991 and 2010. These fuels cost increases remain so small as to be unreliable, ranging from 0.07 percent (Public Utilities) to 0.55 percent (Apparel) in 2005, the year of highest fuel-cost increases. Nevertheless, we trace their economic impact a bit further. It is conceivable that the economic impact might develop into a more important issue at some later point. Industries can reduce the

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[8] We obtained information on wage changes by industries from Table 38, Average Annual Wage Rate, of the REMI output.

Table 4

CHANGES IN FUEL COSTS RELATIVE TO THE U.S. (%)

Industry	1993	1995	2000	2005	2010
Lumber (24)	0.183	0.209	0.258	0.280	0.245
Furniture (25)	0.258	0.332	0.400	0.452	0.396
Stone, clay, etc. (32)	0.111	0.137	0.166	0.185	0.162
Primary metals (33)	0.162	0.193	0.236	0.260	0.228
Fabricated metal (34)	0.232	0.293	0.354	0.397	0.348
Non-electric machine (35)	0.258	0.320	0.387	0.433	0.379
Electrical equipment (36)	0.289	0.352	0.428	0.475	0.416
Motor vehicles (371)	0.247	0.320	0.385	0.436	0.382
Rest. trans. equipment (R37)	0.246	0.313	0.378	0.425	0.373
Instruments (38)	0.252	0.297	0.364	0.400	0.350
Miscellaneous manufacture (39)	0.260	0.322	0.391	0.436	0.382
Food (20)	0.161	0.205	0.247	0.278	0.244
Tobacco manufacture (21)	0.201	0.273	0.325	0.373	0.327
Textiles (22)	0.229	0.289	0.349	0.392	0.343
Apparel (23)	0.303	0.402	0.481	0.549	0.481
Paper (26)	0.115	0.145	0.175	0.196	0.172
Printing (27)	0.314	0.397	0.480	0.539	0.472
Chemicals (28)	0.168	0.209	0.253	0.283	0.248
Petroleum products (29)	0.102	0.133	0.160	0.182	0.160
Rubber (30)	0.261	0.320	0.389	0.433	0.379
Leather (31)	0.221	0.296	0.354	0.405	0.355
Mining	0.217	0.282	0.326	0.352	0.301
Construction	0.219	0.272	0.317	0.337	0.287
Railroad (40)	0.045	0.060	0.069	0.075	0.064
Trucking (42)	0.045	0.061	0.070	0.077	0.066
Local/interurban (41)	0.045	0.060	0.069	0.075	0.064
Air transport (45)	0.044	0.064	0.073	0.082	0.070
Other transport	0.045	0.063	0.072	0.079	0.068
Communication (48)	0.045	0.060	0.069	0.076	0.065
Public utililties (49)	0.045	0.059	0.068	0.074	0.063
Banking (60)	0.216	0.291	0.335	0.366	0.313
Insurance (63 + 64)	0.216	0.291	0.335	0.365	0.312
Credit + finance (61 + 62)	0.217	0.285	0.330	0.357	0.305
Real estate (65, 69)	0.218	0.281	0.326	0.351	0.300
Eating & drinking (58)	0.218	0.279	0.323	0.347	0.296
Rest of retail (R52)	0.217	0.284	0.328	0.355	0.303
Wholesale	0.215	0.297	0.341	0.375	0.321
Hotels (70)	0.219	0.274	0.319	0.339	0.290
Per. serv. & repr.	0.216	0.288	0.332	0.361	0.308
Private household	0.216	0.288	0.332	0.361	0.308
Auro rep/service (75)	0.216	0.290	0.334	0.365	0.312
Miscellaneous business services (73)	0.216	0.291	0.335	0.366	0.313
Amusement & recreation (79)	0.219	0.271	0.316	0.335	0.285
Motion pictures (78)	0.213	0.312	0.354	0.397	0.340
Medical (80)	0.217	0.285	0.329	0.357	0.305
Miscellaneous professional services (81)	0.216	0.293	0.337	0.369	0.316
Education (82)	0.215	0.297	0.340	0.374	0.320
Non-profit organizations (83)	0.216	0.288	0.332	0.361	0.309
Agriculture/forestry/fishery services	0.221	0.263	0.308	0.323	0.275
All private non-farm sectors	0.194	0.252	0.295	0.324	0.279

Source: Tables 2 and 29 of the REMI Output.

negative effects of higher fuel costs by substituting labor, capital, and/or other nonfuel inputs for fuels. This, combined with the expenditures on air-pollution controls, creates an upward pressure on specific factor and input costs. This factor/input inflationary effect, however, is insignificant.[9] Rule 1135A results in less than a 0.01 percent increase in the relative costs of labor, capital, or overall intermediate inputs for all industries and for the regional economy as a whole.

Given the overall small economic impacts of Rule 1135A as modeled, we should not expect that it has any significant impact on overall competitiveness of local firms. Indeed, this is the case. As an example, Table 5 shows that selling prices increase the most in Public Utilities and Petroleum Products, but that these changes are still too small to be reliable (0.01-0.03 percent). Likewise, Table 6 shows that the change in the overall profitability was not greater than 0.02 percent in any of the 49 REMI private industry groups.

STABILITY OF THE RESULTS

We need to have some sense of how stable our simulation results are. If, for example, our input data are questionable, we need to know how results will be changed and how changes in the estimates will affect the overall simulation. Even though we have estimates of cost increases that are very different from one another, these errors may be unimportant in determining our aggregate results. Also, relatively minor changes in timing of a rule may have significant economic impacts on costs and benefits accruing to the control strategy.

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[9] Shown in Table 2 and Tables 27-31 of the REMI output.

Table 5

CHANGES IN SELLING PRICE RELATIVE TO THE U.S. (%)

Industry	1993	1995	2000	2005	2010
Lumber (24)	0.000	0.000	0.000	0.000	0.000
Furniture (25)	0.000	0.000	0.000	0.000	0.000
Stone, clay, etc. (32)	0.010	0.011	0.011	0.014	0.012
Primary metals (33)	0.000	0.000	0.000	0.000	0.000
Fabricated metal (34)	0.000	0.000	0.000	0.000	0.000
Non-electric machine (35)	0.000	0.000	0.000	0.000	0.000
Electrical equipment (36)	0.000	0.000	0.000	0.000	0.000
Motor vehicles (371)	0.000	0.000	0.000	0.000	0.000
Rest. trans. equipment (R37)	0.000	0.000	0.000	0.000	0.000
Instruments (38)	0.000	0.000	0.000	0.000	0.000
Miscellaneous manufacture (39)	0.000	0.000	0.000	0.000	0.000
Food (20)	0.000	0.000	0.000	0.000	0.000
Tobacco manufacture (21)	0.000	0.000	0.000	0.000	0.000
Textiles (22)	0.000	0.000	0.000	0.000	0.000
Apparel (23)	0.000	0.000	0.000	0.000	0.000
Paper (26)	0.000	0.000	0.000	0.000	0.000
Printing (27)	0.006	0.007	0.008	0.009	0.007
Chemicals (28)	0.000	0.000	0.000	0.000	0.000
Petroleum products (29)	0.016	0.020	0.021	0.026	0.022
Rubber (30)	0.000	0.000	0.000	0.000	0.000
Leather (31)	0.000	0.000	0.000	0.000	0.000
Mining	0.010	0.012	0.011	0.014	0.011
Construction	0.007	0.007	0.004	0.007	0.005
Railroad (40)	0.006	0.008	0.006	0.009	0.007
Trucking (42)	0.005	0.006	0.004	0.007	0.006
Local/interurban (41)	0.009	0.011	0.010	0.013	0.011
Air transport (45)	0.008	0.010	0.008	0.012	0.010
Other transport	0.006	0.007	0.005	0.008	0.007
Communication (48)	0.004	0.004	0.002	0.004	0.003
Public utililties (49)	0.013	0.016	0.016	0.019	0.016
Banking (60)	0.008	0.010	0.008	0.011	0.009
Insurance (63 + 64)	0.005	0.005	0.002	0.005	0.003
Credit + finance (61 + 62)	0.011	0.012	0.008	0.013	0.012
Real estate (65, 69)	0.001	0.000	-0.007	-0.008	-0.012
Eating & drinking (58)	0.007	0.009	0.008	0.011	0.009
Rest of retail (R52)	0.011	0.012	0.011	0.014	0.011
Wholesale	0.008	0.010	0.008	0.011	0.009
Hotels (70)	0.000	0.000	0.000	0.000	0.000
Per. serv. & repr.	0.011	0.013	0.012	0.015	0.013
Private household	0.003	0.003	-0.001	0.003	0.003
Auro rep/service (75)	0.009	0.011	0.010	0.013	0.010
Miscellaneous business services (73)	0.006	0.007	0.005	0.008	0.006
Amusement & recreation (79)	0.011	0.013	0.012	0.015	0.012
Motion pictures (78)	0.010	0.001	0.009	0.013	0.011
Medical (80)	0.009	0.010	0.006	0.010	0.007
Miscellaneous professional services (81)	0.006	0.006	0.002	0.005	0.003
Education (82)	0.010	0.011	0.008	0.012	0.009
Non-profit organizations (83)	0.011	0.012	0.011	0.014	0.011
Agriculture/forestry/fishery services	0.010	0.011	0.011	0.013	0.011
All private non-farm sectors	0.006	0.007	0.005	0.008	0.011

Source: Tables 2 and 26 of the REMI Output.

Table 6

CHANGES IN PROFITABILITY OF INDUSTRIES RELATIVE TO THE U.S. (%)

Industry	1993	1995	2000	2005	2010
Lumber (24)	-0.005	-0.005	-0.005	-0.007	-0.006
Furniture (25)	-0.005	-0.006	-0.005	-0.007	-0.006
Stone, clay, etc. (32)	0.000	0.000	0.000	0.000	0.000
Primary metals (33)	-0.008	-0.009	-0.009	-0.011	-0.010
Fabricated metal (34)	-0.005	-0.006	-0.005	-0.007	-0.006
Non-electric machine (35)	-0.004	-0.004	-0.004	-0.005	-0.005
Electrical equipment (36)	-0.005	-0.005	-0.004	-0.006	-0.005
Motor vehicles (371)	-0.003	-0.004	-0.003	-0.004	-0.003
Rest. trans. equipment (R37)	-0.004	-0.004	-0.003	-0.005	-0.004
Instruments (38)	-0.007	-0.007	-0.006	-0.008	-0.007
Miscellaneous manufacture (39)	-0.005	-0.005	-0.005	-0.007	-0.006
Food (20)	-0.003	-0.004	-0.004	-0.005	-0.004
Tobacco manufacture (21)	-0.002	-0.003	-0.002	-0.003	-0.003
Textiles (22)	-0.006	-0.007	-0.007	-0.009	-0.008
Apparel (23)	-0.003	-0.004	-0.004	-0.005	-0.005
Paper (26)	-0.008	-0.009	-0.010	-0.012	-0.010
Printing (27)	0.000	0.000	0.000	0.000	0.000
Chemicals (28)	-0.012	-0.014	-0.015	-0.018	-0.016
Petroleum products (29)	0.000	0.000	0.000	0.000	0.000
Rubber (30)	-0.009	-0.011	-0.011	-0.014	-0.012
Leather (31)	-0.004	-0.005	-0.005	-0.007	-0.006
Mining	0.000	0.000	0.000	0.000	0.000
Construction	0.000	0.000	0.000	0.000	0.000
Railroad (40)	0.000	0.000	0.000	0.000	0.000
Trucking (42)	0.000	0.000	0.000	0.000	0.000
Local/interurban (41)	0.000	0.000	0.000	0.000	0.000
Air transport (45)	0.000	0.000	0.000	0.000	0.000
Other transport	0.000	0.000	0.000	0.000	0.000
Communication (48)	0.000	0.000	0.000	0.000	0.000
Public utililties (49)	0.000	0.000	0.000	0.000	0.000
Banking (60)	0.000	0.000	0.000	0.000	0.000
Insurance (63 + 64)	0.000	0.000	0.000	0.000	0.000
Credit + finance (61 + 62)	0.000	0.000	0.000	0.000	0.000
Real estate (65, 69)	0.000	0.000	0.000	0.000	0.000
Eating & drinking (58)	0.000	0.000	0.000	0.000	0.000
Rest of retail (R52)	0.000	0.000	0.000	0.000	0.000
Wholesale	0.000	0.000	0.000	0.000	0.000
Hotels (70)	-0.013	-0.015	-0.015	-0.018	-0.015
Per. serv. & repr.	0.000	0.000	0.000	0.000	0.000
Private household	0.000	0.000	0.000	0.000	0.000
Auro rep/service (75)	0.000	0.000	0.000	0.000	0.000
Miscellaneous business services (73)	0.000	0.000	0.000	0.000	0.000
Amusement & recreation (79)	0.000	0.000	0.000	0.000	0.000
Motion pictures (78)	0.000	0.000	0.000	0.000	0.000
Medical (80)	0.000	0.000	0.000	0.000	0.000
Miscellaneous professional services (81)	0.000	0.000	0.000	0.000	0.000
Education (82)	0.000	0.000	0.000	0.000	0.000
Non-profit organizations (83)	0.000	0.000	0.000	0.000	0.000
Agriculture/forestry/fishery services	0.000	0.000	0.000	0.000	0.000

Source: Table 33 of the REMI Output.

The most important question for the analysis of Rule 1135A is whether minor changes in the variables we have used to model the rule would be likely to change our conclusion that overall economic impacts are so small as to be unreliable. We performed two sets of sensitivity analyses. First, we examined how sensitive the results of the impact assessment were to changes in the input values of Variable 680 (changes in the demand for public utilities); second, we examined how sensitive the results of the impact assessment were to changes in the input values of Variable 941 (relative electric fuel costs for commercial users).

Tables 7 and 8 show the sensitivity of the impact assessment to changes in the input value of Variable 680 and Variable 941, respectively. A priori, we would expect smaller pollution-control expenditures and larger electricity rate increases to worsen the economic impact of Rule 1135A. The results of our sensitivity analyses indicate our assumptions are correct. In neither case, however, is the sensitivity great enough to make much difference. A relatively large decrease in demand for public utilities (20%) is associated with just seven additional jobs being lost in 2010. A similar 20% increase in electric fuel costs for commercial users is somewhat more influential, but still statistically insignificant, with a peak of 60 additional jobs lost in 2010.

CONCLUSION

Overall, our conclusion is that the job impacts from the socioeconomic staff's evaluation of Rule 1135A are too small to give us much confidence in them. This does not mean that the REMI model was not useful. After all, without the model, we could not have been certain that this was the case,

Table 7

SENSITIVITY TEST OF THE REGULAR POLICY VARIABLE 680:
CHANGES IN THE DEMAND FOR PUBLIC UTILITIES
(with the 1987 F&G REMI Model)

Economic indicator	Year	Percentage Changes in the Values of Variable 680 +20%	+10%	+5%	-5%	-10%	-20%	
Employment (no. of people)	1995	5	3	2	0	-4	-5	*
		-2.8%	-1.7%	-1.1%	0.0%	2.2%	2.8%	**
		-0.14	-0.17	-0.22	0.00	-0.22	-0.14	***
	2000	6	4	3	0	-3	-6	
		-0.6%	-0.4%	-0.3%	0.0%	0.3%	0.6%	
		-0.03	-0.04	-0.06	0.00	-0.03	-0.03	
	2005	6	4	2	-1	-2	-6	
		-0.8%	-0.5%	-0.3%	0.1%	0.3%	0.8%	
		-0.04	-0.05	-0.05	-0.03	-0.03	-0.04	
	2010	7	4	3	-2	-3	-7	
		-0.6%	-0.4%	-0.3%	0.2%	0.3%	0.6%	
		-0.03	-0.04	-0.06	-0.04	-0.03	-0.03	
GRP (millions of 1977 dollars)	1995	0	0	0	0	0	0	
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		0.00	0.00	0.00	0.00	0.00	0.00	
	2000	0	0	0	0	0	0	
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		0.00	0.00	0.59	0.59	0.00	0.00	
	2005	0	0	0	0	-1	-1	
		0.0%	0.0%	0.0%	0.0%	3.2%	3.2%	
		0.00	0.00	0.00	0.00	-0.32	-0.16	
	2010	0	0	0	0	0	-1	
		0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	
		0.00	0.00	0.00	0.00	0.00	-0.10	
Disposable income (millions of 1977 dollars)	1995	0	0	0	0	0	0	
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		0.00	0.00	0.00	0.00	0.00	0.00	
	2000	0	0	0	0	-1	-1	
		0.0%	0.0%	0.0%	0.0%	3.6%	3.6%	
		0.00	0.00	0.00	0.00	-0.36	-0.18	
	2005	0	0	0	0	0	0	
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		0.00	0.00	0.00	0.00	0.00	0.00	
	2010	0	0	0	0	0	0	
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
		0.00	0.00	0.00	0.00	0.00	0.00	

Source: Calculations made by the MIT Multiregional Planning Staff.

Notes: * Change in the estimated job impacts resulting from the percentage change in the input value of Variable 680.

** Percentage change in the estimated job impacts.

*** Elasticity, which is the ratio of the percentage change in the estimated job (GRP or disposable income) impacts to the percentage change in the input values.

Table 8

SENSITIVITY TEST OF THE REGULAR POLICY VARIABLE 941:
RELATIVE ELECTRIC FUEL COSTS FOR THE COMMERCIAL SECTOR
(with the 1987 F&G REMI Model)

Economic indicator	Year	Percentage Changes in the Values of Variable 941					
		+20%	+10%	+5%	-5%	-10%	-20%
Employment (no. of people)	1995	-50	-25	-12	13	25	51 *
		27.6%	13.8%	6.6%	-7.2%	-13.8%	-28.2% **
		1.38	1.38	1.33	1.44	1.38	1.41 ***
	2000	-70	-35	-16	17	36	71
		7.2%	3.6%	1.7%	-1.8%	-3.7%	-7.3%
		0.36	0.36	0.33	0.35	0.37	0.37
	2005	-71	-35	-19	17	36	74
		9.4%	4.7%	2.5%	-2.3%	-4.8%	-9.8%
		0.47	0.47	0.51	0.45	0.48	0.49
	2010	-60	-31	-16	16	30	64
		5.5%	2.8%	1.5%	-1.5%	-2.8%	-5.9%
		0.28	0.28	0.29	0.29	0.28	0.29
GRP (millions of 1977 dollars)	1995	-2	-1	-1	0	1	1
		50.0%	25.0%	25.0%	0.0%	-25.0%	-25.0%
		2.50	2.50	5.00	0.00	2.50	1.25
	2000	-3	-1	-1	1	2	3
		8.8%	2.9%	2.9%	-2.9%	-5.9%	-8.8%
		0.44	0.29	0.59	0.59	0.59	0.44
	2005	-4	-2	-1	1	2	4
		12.9%	6.5%	3.2%	-3.2%	-6.5%	-12.9%
		0.65	0.65	0.65	0.65	0.65	0.65
	2010	-5	-2	-1	1	2	4
		10.2%	4.1%	2.0%	-2.0%	-4.1%	-8.2%
		0.51	0.41	0.41	0.41	0.41	0.41
Disposable income (millions of 1977 dollars)	1995	-1	-1	0	0	1	2
		7.1%	7.1%	0.0%	0.0%	-7.1%	-14.3%
		0.36	0.71	0.00	0.00	0.71	0.71
	2000	-3	-2	-1	0	1	2
		10.7%	7.1%	3.6%	0.0%	-3.6%	-7.1%
		0.54	0.71	0.71	0.00	0.36	0.36
	2005	-3	-1	-1	1	1	3
		9.1%	3.0%	3.0%	-3.0%	-3.0%	-9.1%
		0.45	0.30	0.61	0.61	0.30	0.45
	2010	-3	-2	-1	0	1	2
		7.5%	5.0%	2.5%	0.0%	-2.5%	-5.0%
		0.37	0.50	0.50	0.00	0.25	0.25

Source: Calculations made by the MIT Multiregional Planning Staff.

Notes: * Change in the estimated job impacts resulting from the percentage change in the input value of Variable 941.

** Percentage change in the estimated job impacts.

*** Elasticity, which is the ratio of the percentage change in the estimated job (GRP or disposable income) impacts to the percentage change in the input values.

nor could we have been certain that minor changes in our input values of the policy variables would not have changed this basic result. As it is, we can be fairly confident of our conclusion.

Our "null result" also does not mean that the rule has no economic impact. What it does tell us is the cost increases associated with spending on pollution-control equipment does not have significant macroeconomic effects in the four-county region. We could have spent much more time exploring what the effects on specific utilities were. The rule may have forced power producers to alter their long-term capacity planning, requiring them to take on additional debt and financing costs or to lose prior investment in capacity that will not come on line now. Alternatively, the reconfiguration of capacity by the major power producers may have created a system that was less reliable--raising the possibility of costly power outages in the future. Another issue we might have considered is whether the new rules caused power production to be shifted to areas outside the Los Angeles basin. If so, this could cause significant economic and environmental impacts elsewhere. We would have hoped that the results of REMI analysis would have encouraged the socioeconomic staff to pursue these other questions in greater detail than they did.

The fact that the results were too small to be reliable in this case is not unusual among the analyses the District conducts. This has two important implications. First, the socioeconomic staff should complement the REMI modeling with other types of studies, such as business surveys and case studies, to verify the modeling results and to identify those economic impacts that are not captured by the REMI model. Second, the socioeconomic staff should examine cumulative economic impacts of air-pollution control rules in addition to rule-by-rule impact analyses.

REFERENCE

South Coast Air Quality Management District SCAQMD). 1991. Final Staff Report for Proposed Amendments to Rule 1135 (PAR 1135)--Emissions of Oxides of Nitrogen from Electrical Generating Systems. Diamond Bar, CA: SCAQMD.