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## **TAKING A BYTE OUT OF ABUSIVE AGENCY DISCRETION: A PROPOSAL FOR DISCLOSURE IN THE USE OF COMPUTER MODELS**

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During the past decade, federal administrative agencies and parties appearing before regulatory bodies have used computer-generated simulations, such as econometric models, with increasing frequency to formulate or attack policies. The use of well-documented models simplifies review procedures for the public, administrative agencies, and courts. The public can examine the assumptions and information that administrators used in making their decisions without having to probe the administrators' minds. Administrative agencies can review the logic behind the conclusions of parties appearing before them without costly and complex cross-examination or discovery proceedings. When the assumptions, methodology, and data used to construct models become part of the administrative record, courts can identify arbitrary and capricious agency actions with greater accuracy.

Problems arise, however, when agencies or parties appearing before agencies do not document their models adequately. Because some of the larger models such as the Data Resources model of the United States economy or the Wharton Econometric Forecasting Model use as many as sixteen hundred mathematical equations,<sup>1</sup> the assumptions and statistical techniques which provide such a tremendous opportunity for review can get lost in a mass of numbers. The public, agencies, and courts all gain from an explicit statement of the assumptions and data problems in these models. Stating the assumptions and making the models available for scrutiny not only helps those who object to an agency's decision review the underlying reasoning; it also forces those who create the models to examine the accuracy of their assumptions because they know critics will have the opportunity to review their decisions.

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1. Wall St. J., Feb. 17, 1983, at 1, 20, col. 6 (Wharton econometric model, 1600 equations; Data Resources model, 800 equations).

Currently, there are no comprehensive requirements detailing what information agencies must release when they make decisions based upon computer-generated simulations. Few agencies publish guidelines for parties seeking to introduce findings from computer models into administrative hearings.<sup>2</sup> The disclosure of this information would improve the policy process by providing decisionmakers and their critics with greater insight into the other party's conclusions. In the case of government-generated data, some explanation may be legally required.<sup>3</sup> This documentation should include the assumptions behind the model, the rationale or methodology used to construct the model, and the source and potential bias of the data.

This Note examines the need for comprehensive requirements for the release of information pertaining to the use of computer-generated simulations used by federal administrative agencies or parties appearing before regulatory bodies. Part I of this Note defines computer models, identifies some of their current uses in administrative proceedings, and describes the advantages of these models. Part II reviews the current requirements for documentation of computer models and the judicial review standards for agency findings. Part III examines the potential problems in the use of models and discusses the need for more adequate disclosure. Part IV describes several tests for verifying the accuracy of models. This Part concludes by suggesting documentation requirements to ensure the most beneficial use of computer models in administrative proceedings.

## I. CURRENT USES OF COMPUTER MODELS

### A. Definition

A computer model is usually a simplified image of reality based upon mathematical equations.<sup>4</sup> Computer models take many forms. The simplest models, such as the popular, commercial, electronic spreadsheet Lotus, allow users to make calculations faster and more accurately than they could by hand. Fi-

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2. Only the Federal Communications Commission (FCC), the Patent and Trademark Office, and the Postal Service have adopted formal guidelines for the review of computer models. See 47 C.F.R. § 1.363 (1985) (FCC); 37 C.F.R. § 301.51(i)(2) (1985) (Patent and Trademark Office); 39 C.F.R. § 3000.31(k)(2)(ii)-(3)(i) (1985) (Postal Rate Commission).

3. See *infra* notes 20, 58 and accompanying text.

4. For a more comprehensive definition of computer models, see D. MEADOWS & J. ROBINSON, *THE ELECTRONIC ORACLE* 5-7 (1985); D. MEADOWS, J. RICHARDSON, & G. BRUCKMANN, *GROPING IN THE DARK* 7 (1982).

nancial analysts use them for bookkeeping and budget allocation, as well as for simpler calculations such as determining finance charges on home purchases.

More complicated models produce results that, because of the tedious or complex interactive nature of the models, preclude hand calculations. Models can handle complex calculations in an efficient manner. For example, it would take a prohibitively long time for most policymakers to make hand calculations of the effect of an increase in sulfur dioxide emissions from a specific power plant over a 10, 20, or 100 year time frame. Even given infinite time, hand calculations of changes in models with two or more related variables will not produce accurate results because only a computer has the sophistication and power to capture the interactive relationship among the different variables. For instance, hand calculations could not capture the effect that a switch to low-sulfur coal and the installation of antipollution devices at a power plant would have on air pollution levels because the antipollution devices would work less effectively on low-sulfur coal. This lack of opportunity for independent verification necessitates an understanding of the assumptions and statistical inferences used to create models. The only realistic chance for review comes before, not after, the model produces its results. Only by scrutinizing the input can the agency, the public, or a reviewing court place faith in the model's output.

Administrative agencies and parties appearing before regulatory bodies typically use one of three classes of models for forecasting or policy analysis. The first, autoregressive models, a form of time-series forecasting, presumes no knowledge of the causal relationships that affect the variables. The modeler simply extrapolates from past trends to make predictions. Agencies can use these models in rate hearings to predict future train usage from past load figures, or in road building decisions to project increases in automobile traffic from past vehicle usage. Time-series modeling assumes that all of the factors measured must remain constant during the period studied for the model to produce consistent results. In the rate hearing example, past use will not predict future loads accurately if a competitor established a more economical transportation system in the interim. Failure to acknowledge this assumption and other limitations of the model yields incorrect conclusions.

Models of the second type, those employing single-equation simulations, represent a relationship with a single function of explanatory variables. In many cases, these models are too simple for agency needs. Nevertheless, an examination of their tech-

niques simplifies the understanding of more complex econometric models. Single-equation models can represent both linear and nonlinear functions, but linear models are more common. For example, the Environmental Protection Agency (EPA) may wish to measure the effect of auto emissions on the general air pollution level. Agency modelers would express this relationship with the general mathematical formula of

$$\psi_i = \alpha + \beta\chi_i$$

where " $\psi_i$ " represents the dependent variable of air pollution, " $\alpha$ " represents the intercept where the regression line crosses the "Y" axis, " $\beta$ " represents the slope of the line, and " $\chi_i$ " represents the independent variable of auto emissions.<sup>5</sup> The modeler could express this relationship in the following equation:

air pollution level due to auto emissions =  
 general air pollution level + increase in air pollution  
 caused by auto emissions

If the intercept were five, and each additional unit of auto emissions caused a ten percent increase in the air pollution level, the modeler could represent the regression line mathematically as:

$$\psi_i = 5 + 1/10\chi_i$$

The level of air pollution will therefore rise with the level of auto pollution. Even this oversimplified example illustrates potential errors. The model assumes that the general air pollution level will be five without auto pollution. The EPA could not have determined this figure by observation because the Agency could not eliminate all emissions from the environment in order to make this measurement. Only an analysis of the calculations

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5. The dependent variable is the variable the modeler wishes to alter. The modeler will manipulate an independent variable to gain a better understanding of the dependent variable's behavior. The intercept is the point in a linear relationship where the line representing the equation crosses either the "X" or "Y" axis and is the point where either the "X" or the "Y" variable does not affect the other variable. In the text example, the intercept is five, which means that if there are no auto emissions, there will still be five units of air pollution present. The slope of the line explains how much the independent variable affects the dependent variable. In the example in the text, a slope of "1/10" means that an increase of one unit in auto emissions will cause the general air pollution level to rise 1/10 unit.

used to determine the number will assure a fair critique of the model.

The methodology or rationale behind the model also deserves close scrutiny. The entire model assumes that an increase in auto emissions will increase the general air pollution level. Although this appears obvious intuitively, not all intuitive predictions have a basis in reality.<sup>6</sup> Some of the substances found in auto exhaust might work as a catalyst to reduce the general level of air pollution, rather than increase it. Finally, the data would deserve review. The EPA might not have used valid tests to measure the emissions level or its sampling may have biased the distribution of the data. For example, the Agency might obtain invalid overall readings because it measured exhaust levels in the most polluted areas, the least polluted, only from old cars, solely from new cars, etc. In order to assess the accuracy of the Agency's findings, the public must know the assumptions, methodology, and sources of data used to construct the model.

Most relationships, however, are not as easy to express as this simple air pollution model because imperfect data will often cause a degree of "scatter" around the line.<sup>7</sup> The line

$$\psi_i = \alpha + \beta\chi_i + \epsilon_i$$

where " $\epsilon_i$ " represents random influences on the dependent variable, known as "scatter," shows a more realistic relationship. In this example, the " $\epsilon_i$ " could affect the level of air pollution as well. In constant weather conditions, the level of air pollution should rise with an increase in automobile emissions. Wind or rain might disperse the pollution, however, and unless the modeler accounts for this factor, the model may predict that higher automobile emissions would reduce overall pollution.

These single-equation models eliminate the extraneous factors by determining how the independent variable affects the dependent variable. The modeler isolates the independent variable by performing a "least squares regression," which minimizes the sum of the squared deviations, or distance, between the actual and the predicted independent variable values.

6. See *infra* note 30.

7. "Scatter" is the distribution of the data around the expected or predicted line. A line drawn through two points will not have any scatter, but a line drawn through a field of ten points probably will. The scatter represents the distance from the line to those points not on the line. The farther the points are from the line, the less accurately the line will represent the relationship.

Most administrative agencies use the third type of model, often referred to as multivariate regression or econometric analysis.<sup>8</sup> These regression models estimate the effects of changes in economic, environmental, or other societal conditions based upon the alteration of one or more factors by government regulators. These models have two or more independent variables in addition to the constant term. The models assume that the dependent variable " $\psi_l$ " is a linear function of a series of independent variables  $\chi_1, \chi_2, \dots, \chi_k$  and an error term, " $\epsilon_l$ ." Modelers could represent multiple regression models with the following equation:

$$\psi_l = \beta_1 + \beta_2\chi_{2l} + \beta_3\chi_{3l} + \dots + \beta_k\chi_{kl} + \epsilon_l$$

The coefficients,  $\beta_1, \beta_2, \beta_3, \dots, \beta_k$ , each measure a change in Y from the associated X term. Depending on the form of the model, the X terms may also be related to each other. Because the complex interrelationships develop simultaneously, the terms can alter the dependent variable quickly and in a drastic manner. Although these models provide a more accurate representation of reality because of the quantification of these interrelationships, their complexity precludes verification through hand calculations. Model verification thus focuses on an examination of the construction and operation of the model, rather than on its results.

All three classes of models provide an imperfect but useful quantification of social and physical systems. For administrators, these models offer a glimpse of reality through numbers to predict the future behavior of these systems. The danger of these models lies in accepting their conclusions without examining their underlying assumptions.

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8. Regression can become very complicated for those unfamiliar with the jargon. One of the leading texts in this area is R. PINDYCK & D. RUBINFELD, *ECONOMETRIC MODELS AND ECONOMETRIC FORECASTS* (2d ed. 1981). A slightly older work explains these models to the uninitiated in a clearer manner. Intriligator, *Econometrics and Economic Forecasting*, in *ECONOMICS OF ENGINEERING AND SOCIAL SYSTEMS* 157 (J. English ed. 1972). For a clear, concise description of some of the limitations of econometric models, see D. MEADOWS & J. ROBINSON, *supra* note 4, at 51-54.

Several recent articles provide the clearest explanations for lawyers. See Fisher, *Multivariate Regression in Legal Proceedings*, 80 COLUM. L. REV. 702 (1980); Rubinfeld & Steiner, *Quantitative Methods in Antitrust Litigation*, LAW & CONTEMP. PROBS., Autumn 1983, at 69; see also Finkelstein, *Regression Models in Administrative Proceedings*, 86 HARV. L. REV. 1442 (1973).

For discussions of regression models in administrative proceedings, see M. FINKELSTEIN, *QUANTITATIVE METHODS IN LAW* 211-48 (1978); Case, *Problems in Judicial Review Arising from the Use of Computer Models and Other Quantitative Methodologies in Environmental Decisionmaking*, 10 B.C. ENVTL. L. REV. 251 (1982).

### B. Present Uses of Multivariate Regression Models

Administrative agencies have used multivariate regression models for years. Regression techniques gained prominence in the legal community in 1976 when the Solicitor General relied on them in several cases before the Supreme Court to show the deterrent effects of the death penalty upon murder.<sup>9</sup> Lawyers have also used regression analysis extensively in civil rights cases<sup>10</sup> and busing cases.<sup>11</sup> Examples of use of the method in administrative proceedings include modeling by parties involved in the AT & T divestiture case,<sup>12</sup> by the Department of Health and Human Services to set Medicare premium rates,<sup>13</sup> by the Federal Aviation Administration to predict injuries in airplane crashes,<sup>14</sup> by the Department of Energy in rate hearings,<sup>15</sup> by the Federal Communications Commission in television franchise licensing proceedings,<sup>16</sup> by the EPA in air pollution control,<sup>17</sup> and by the Department of Agriculture in deciding marketing agreements.<sup>18</sup> Private industry groups have also used models for purposes such as suggesting that the federal government devote more of its food stamp program to encouraging egg consumption.<sup>19</sup>

*Sierra Club v. Costle*<sup>20</sup> demonstrates the benefits of full dis-

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9. See, e.g., *Fowler v. North Carolina*, 428 U.S. 904 (1976); *Gregg v. Georgia*, 428 U.S. 153 (1976); *Jurek v. Texas*, 428 U.S. 262 (1976); *Proffitt v. Florida*, 428 U.S. 242 (1976).

10. See, e.g., *Wilkins v. University of Houston*, 654 F.2d 388 (5th Cir. 1981), *vacated*, 459 U.S. 809 (1982).

11. See, e.g., *Milliken v. Bradley*, 418 U.S. 717 (1974).

12. See, e.g., *Investigations of Access and Divestiture Related Tariffs; MTS and WATS Market Structure*, 49 Fed. Reg. 13,418 (1984).

13. See, e.g., *Medicare Program; Monthly Actuarial Rates and Monthly Premium Rates*, 49 Fed. Reg. 38,510 (1984).

14. See, e.g., *Draft Advisory Circular on Human Exposure to Impact and a Preview of the Agency's Crash Dynamics Program*, 49 Fed. Reg. 37,111, 37,114 (1984).

15. See, e.g., *Proposed Wholesale Power Rate Adjustment: Public Hearings and Opportunities for Public Review and Comment (Bonneville Power Administration, DOE)*, 49 Fed. Reg. 35,177 (1984).

16. See, e.g., *Revision of Programming and Commercialization Policies, Ascertainment Requirements and Program Log Requirements for Commercial Television Stations*, 49 Fed. Reg. 33,588 (1984).

17. See, e.g., *Battery Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards and New Source Performance Standards*, 49 Fed. Reg. 9108 (1984).

18. See, e.g., *Navel Oranges Grown in Arizona and Designated Part of California; Valencia Oranges Grown in Arizona and Designated Part of California; Decision on Proposed Further Amendment of Marketing Agreements and Orders 907 and 908, Both as Amended*, 49 Fed. Reg. 29,071 (1984).

19. See, e.g., *Food Stamp Program: Thrifty Food Plan*, 49 Fed. Reg. 39,879 (1984).

20. 657 F.2d 298 (D.C. Cir. 1981).



closure of a model's assumptions and methodology. In *Sierra Club*, the group challenged the EPA's standards governing emissions from coal-burning power plants. The plaintiffs argued that the proposed government standards would allow these plants to produce too much pollution. The EPA had promulgated these standards with the help of an econometric model. This model represented the affected parts of the country with a series of mathematical equations, used data from present conditions, and then estimated the effects of the new regulations. By testing alternative pollution control scenarios based upon possible future levels of pollution, the model predicted the effect of different emission amounts on pollution levels. The D.C. Circuit accepted the use of the model because the EPA explained the assumptions behind the model, the procedures used in constructing it, and the limitations of the Agency's conclusions.<sup>21</sup>

In this case, full disclosure helped all of the parties. Although the Sierra Club lost the case, it did have the opportunity to examine the EPA's equations and it convinced the EPA to make technical changes in the model.<sup>22</sup> The court had a more complete record on which to base its holding. Finally, although the EPA had to acknowledge errors in its modeling, it gained from having the Sierra Club and the court review its conclusions. It produced a solution based upon credible analysis. If the Agency had not disclosed the model's assumptions and limitations, some of its

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21. The court noted:

In this case, the utility model itself and its key assumptions were discussed in the proposed rule and background documents. EPA invited public comments on the model and its assumptions, with the agency recognizing the sensitivity of the model to a "few key initial assumptions." The joint interagency working group reviewed the results of model runs, revised assumptions, and required new runs of the model when it was deemed appropriate. The principal comments received by EPA on the model and the initial assumptions were discussed, together with the results of the three phases of the modeling and the major post-proposal changes to the model, in the preamble to the final [regulations]. In reviewing this record on the use of the econometric model we have carefully examined, within the limits of our competence, EPA's explanation for the model's premises, the results, and the conclusions drawn therefrom to test them for internal consistency and reasonableness. Although the EPA has the benefit of the presumption of good faith and regularity in agency action, we have attempted to ascertain whether the results have been improperly skewed by the modeling format. We conclude that EPA's reliance on its model did not exceed the bounds of its usefulness and that its conduct of the modeling exercise was proper in all respects. We are in fact reassured by EPA's own consciousness of the limits of its model, and its invitation and response to public comment on all aspects of the model.

*Id.* at 333-34 (citations omitted).

22. *Id.* at 335.

counterintuitive conclusions<sup>23</sup> might not have withstood a court review.

Significantly, the Sierra Club brought this action under the Clean Air Act,<sup>24</sup> a "hybrid" rulemaking statute that imposes additional procedural requirements beyond those found in the Administrative Procedure Act (APA).<sup>25</sup> The Clean Air Act requires the Agency, in promulgating rules, to include in its statement of basis and purpose "the factual data on which the proposed rule is based"<sup>26</sup> and "the methodology used in obtaining the data and in analyzing the data."<sup>27</sup> In a case where the government relied upon a computer model in a rulemaking procedure not governed by a "hybrid" statute, there would have been no requirement for disclosure of the methodology or data used in the decision.<sup>28</sup> The absence of disclosure would have hampered review by both the public and the court.

### C. *Advantages of Computer Models*

Models, such as the econometric model employed in *Sierra Club*, allow administrators to make predictions that would otherwise entail great cost—such as the effects of an airplane crash

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23. For an example of a counterintuitive administrative finding, see *infra* note 30 and accompanying text.

24. 42 U.S.C. §§ 7401-7642 (1982).

25. 5 U.S.C. §§ 551-559, 701-706 (1982). "Hybrid" rulemaking statutes impose more stringent requirements than those found in the Administrative Procedure Act (APA). Each statute specifies different procedural requirements relevant to the use of computer models. These statutes include: Clean Water Act, 33 U.S.C. § 1317(a) (1982) (public hearing, if requested, to include cross-examination on disputed issues of material fact, substantial evidence review); Consumer Product Safety Act, 15 U.S.C. §§ 2056, 2060 (1982) (substantial evidence review); Department of Energy Authorization Act, 42 U.S.C. § 7191(b)-(d) (1982) (notice of proposed rulemaking to include rule and description of supporting data, oral presentation of views, data and argument if the rule is likely to have a substantial impact on the economy, individuals, or businesses, and the final rule accompanied by a statement responding to "major comments, criticisms, and alternatives offered" during the comment period); Magnuson-Moss Warranty-Federal Trade Commission Improvement Act, 15 U.S.C. § 57a(e)(3)(A)-(B) (1982) (cross-examination and rebuttal on disputed issues of material fact, substantial evidence review); Medical Device Amendments (to the Federal Food, Drug and Cosmetic Act), 21 U.S.C. § 360g(c) (1982) (substantial evidence review); Occupational Safety and Health Act, 29 U.S.C. § 655 (1982) (substantial evidence review); Securities Acts Amendments, 15 U.S.C. § 78f(e)(4)(A) (1982) (opportunity for oral presentation of data, views or arguments, cross-examination and rebuttal on disputed issues of material fact, substantial evidence review); Toxic Substances Control Act, 15 U.S.C. §§ 2605, 2618 (1976) (cross-examination and rebuttal on disputed issues of material fact, substantial evidence review).

26. 42 U.S.C. § 7607(d)(3)(A) (1982).

27. *Id.* § 7607(d)(3)(B).

28. See *supra* note 3 and accompanying text.

on the human body or the health consequences of inefficient pollution controls. Models allow policymakers to predict events before they occur. These models also circumvent the bias of the modelers and therefore sometimes identify counterintuitive trends.<sup>29</sup> For example, in *Sierra Club* the EPA discovered that tighter controls on coal-burning plants did not always lead to lower pollution levels; in some cases, the lowest levels resulted from *relaxing* the controls.<sup>30</sup> The computer model allowed the administrators to reach conclusions that they might have overlooked had they relied solely on their professional judgment and past experience.

Computer models also can provide error-free deductions from the information entered.<sup>31</sup> Modelers specify their understanding of a real-world system in mathematical form. Consequently, judges can review an administrative decision based upon a computer model without probing an administrator's mind to find an explanation for the ruling or adjudication.<sup>32</sup> The judge can di-

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29. According to one theory, all humans see the world through deep, implicit operating assumptions. An understanding of the modeler's preconceptions, or paradigms, will help the lawyer to understand the modeler's biases and how they shape the outcome of the model. For a theoretical discussion of paradigms, see T. KUHN, *THE STRUCTURE OF SCIENTIFIC REVOLUTIONS* (2d ed. 1970). Kuhn notes that "[s]cientists work from models acquired through education and through subsequent exposure to the literature often without quite knowing or needing to know what characteristics have given these models the status of community paradigms . . . . Paradigms may be prior to, more binding, and more complete than any set of rules . . . ." *Id.* at 46.

30.

One finding that has been clearly demonstrated by the two years of analysis is that lower emission standards on new plants do not necessarily result in lower national [sulfur dioxide] emissions when total emissions from the entire utility system are considered. There are two reasons for this finding. First, the lowest emissions tend to result from strategies that encourage the construction of new coal capacity. This capacity, almost regardless of the alternative analyzed, will be less polluting than the existing coal- or oil-fired capacity that it replaces. Second, the higher cost of operating the new capacity (due to higher pollution costs) may cause the newer, cleaner plants to be utilized less than they would be under a less stringent alternative. These situations are demonstrated by the [computer models] presented here.

657 F.2d 298, 335 (quoting 44 Fed. Reg. 33,580, 33,607 (1979)).

31. In most cases, this property will be an advantage in the policy process. But this property can also harm the modeler. Analysts may assume that the computer will produce the correct results when in reality the results may be based upon improper inputs. Without the proper scrutiny of the assumptions, methodology, and data used to construct the model, the logical properties of the computer may hurt the policy process.

32. The court may not "probe the [actual] mental processes" that the administrator used to make the decision. *Morgan v. United States*, 304 U.S. 1, 18 (1938). Instead, the court must look at the information available to the administrator and then base the review on the standards presented in the APA, 5 U.S.C. § 706 (1982). See also *infra* Part II of this Note and notes 32-72.

rectly scrutinize the processes the administrator used to make the decision.

These advantages are lost, however, if agencies do not disclose the documentation behind the models. Without the chance to impeach these models by examining the assumptions, methodology, and data used in constructing them, the models' conclusions resemble hearsay evidence. The models' conclusions have no legal significance because the credibility of the agencies' findings rests upon the assertion of those not before a reviewing court. Forcing the public to dissect a mass of seemingly unrelated numbers and equations stifles the very purposes of the review provisions. Nor can the public rely on the courts to protect its rights when the courts have no realistic opportunity to scrutinize agency methods. The lack of training in quantitative analysis for judges, some of whom even describe themselves as "technically illiterate,"<sup>33</sup> only compounds the difficulties facing parties that seek review of computer models used by administrative agencies.

## II. THE STANDARD OF REVIEW FOR AGENCY MODELS

Before the shift to a greater emphasis on rulemaking in the late 1960's and early 1970's,<sup>34</sup> administrators introduced most regulations in trial-type proceedings. Challengers examined the evidence used and the decisionmaking process in much the same way that they would in a court.

Parties appearing before regulatory groups could challenge inaccurate models to ensure that the agency had not abused its discretion. If the agency did not reveal the factual basis of its decisions, parties could attack the agency's evidence by cross-examining the administrator, or by introducing counterevidence in the same way they would in a normal trial.

Today, if the majority of administrative proceedings resembled trials, agencies would not need to formulate additional rules for the disclosure of the assumptions, methodology, and data used in the construction of computer models. With the shift to

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33. *Ethyl Corp. v. EPA*, 541 F.2d 1, 67 (D.C. Cir.) (en banc) (Bazelon, C.J., concurring), cert. denied, 426 U.S. 941 (1976); see also Bazelon, *Coping with Technology Through the Legal Process*, 62 CORNELL L. REV. 817 (1977).

34. See, e.g., Pedersen, *Formal Records and Informal Rulemaking*, 85 YALE L.J. 38, 39 & n.10 (1975) (quoting the original four volume set of K. DAVIS, *ADMINISTRATIVE LAW TREATISE* (1958)); see also H. FRIENDLY, *THE FEDERAL ADMINISTRATIVE AGENCIES: THE NEED FOR BETTER DEFINITION OF STANDARDS* (1962); L. JAFFE, *JUDICIAL CONTROL OF ADMINISTRATIVE ACTION* (1965). See generally 1 K. DAVIS, *ADMINISTRATIVE LAW TREATISE* § 6:1, at 448-49 (2d ed. 1978).

informal rulemaking, however, the public has fewer opportunities to scrutinize and challenge agency findings. Under the APA, the agencies need only publish the "terms or substance of the proposed rule or a description of the subjects and issues involved"<sup>35</sup> in the *Federal Register*<sup>36</sup> and, after receiving comments from "interested persons,"<sup>37</sup> publish the final regulations and incorporate within them a "concise general statement of their basis and purpose."<sup>38</sup> The federal government has not promulgated any specific rules governing the use of computer models, although a few agencies have brief guidelines addressing what information the public should receive.<sup>39</sup>

Publication of the final rule does not end the rulemaking process. Interested parties often challenge these rules in court. Although a particular statute may govern the forum, venue, and timing of the review,<sup>40</sup> section 706 of the APA determines the scope or standard of review.<sup>41</sup> Courts will review the adequacy of agency disclosure in accordance with these procedural requirements. Individual cases can arise under almost any subsection of this Act, but most attempts to review agency decisions based upon findings derived from computer models will fall under one of three provisions. These standards include the "arbitrary and capricious," procedural deficiency, and substantial evidence provisions.

### A. "Arbitrary and Capricious"

The "arbitrary and capricious" standard provides the easiest basis for instituting an action against an agency for inadequate disclosure. Under section 706(2)(A) of the APA, a reviewing court shall set aside agency findings that are "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law."<sup>42</sup> This standard requires that the agency must act with

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35. 5 U.S.C. § 553(b)(3) (1982). See generally ADMINISTRATIVE CONFERENCE OF THE UNITED STATES, A GUIDE TO FEDERAL AGENCY RULEMAKING (1983).

36. 5 U.S.C. § 553(b) (1982).

37. *Id.* § 553(c).

38. *Id.*

39. See, e.g., 16 U.S.C. § 410ii-6(b) (1982) (requiring that information about Chaco Culture National Historical Park be available in a computer database, but not specifying how one gains access to this information).

40. ADMINISTRATIVE CONFERENCE OF THE UNITED STATES, *supra* note 35, at 217.

41. *Id.*; see also 5 U.S.C. § 706 (1982).

42. 5 U.S.C. § 706(2)(A) (1982); see also *Citizens to Preserve Overton Park, Inc. v. Volpe*, 401 U.S. 402, 414 (1971); *Citizens Against the Refinery's Effects, Inc. v. EPA*, 643

consistency<sup>43</sup> and that the policy choice be rationally connected to the factual basis of the decision.<sup>44</sup> The language suggests that if the agency uses an econometric model, the agency must show a connection between its decision and the estimates of the model. In addition, by requiring an explanation of its decision, courts can ensure that the agency treats similarly-situated parties in an identical manner. As one administrator noted, "[A] decision that 'cannot be explained' is very likely to be an arbitrary decision."<sup>45</sup>

Although the arbitrary and capricious standard is the easiest basis for review, it nevertheless imposes a significant burden on the challenging party. A court will overturn a rule based upon improper fact-finding only where "there has been a clear error in judgment . . . . Although this inquiry into the facts is to be searching and careful, the ultimate standard of review is a narrow one. The court is not empowered to substitute its judgment for that of the agency."<sup>46</sup> The technical complexity of most computer-generated simulations only intensifies the difficulties in meeting this burden. Courts seldom wish to reevaluate an agency's scientific and technological determinations.<sup>47</sup> Judges do

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F.2d 178, 181 (4th Cir. 1981) (upholding model used by EPA); *Cincinnati Gas & Elec. Co. v. EPA*, 578 F.2d 660, 664 (6th Cir. 1978) (overturning the use of an EPA model because of the arbitrary and capricious assumptions made by the agency).

43. *Ethyl Corp. v. EPA*, 541 F.2d 1, 36 (D.C. Cir.), cert. denied, 426 U.S. 941 (1976); *Amoco Oil Co. v. EPA*, 501 F.2d 722, 740-41 (D.C. Cir. 1974); see also DeLong, *Informal Rulemaking and the Integration of Law and Policy*, 65 VA. L. REV. 257, 285-86, 289, 294-95, 334-35, 341, 347 (1979); cf. *SEC v. Chenery Corp.*, 318 U.S. 80, 94-95 (1943).

44. See *Citizens to Preserve Overton Park, Inc. v. Volpe*, 401 U.S. 402, 414 (1971).

45. U.S. DEP'T OF TRANSP., *THE SECRETARY'S DECISION ON CONCORDE SUPERSONIC TRANSPORT 7* (1976); see also Bazelon, *supra* note 33, at 824.

46. *Citizens to Preserve Overton Park, Inc. v. Volpe*, 401 U.S. 402, 416 (1971) (citations omitted).

47. See, e.g., *Federal Power Comm'n v. Florida Power & Light Co.*, 404 U.S. 453 (1972):

A court must be reluctant to reverse results supported by such a weight of considered and carefully articulated expert opinion. Particularly when we consider a purely factual question within the area of competence of an administrative agency created by Congress, and when resolution of that question depends on "engineering and scientific" considerations, we recognize the relevant agency's technical expertise and experience, and defer to its analysis unless it is without substantial basis in fact.

*Id.* at 463; *Natural Resources Defense Council, Inc. v. Herrington*, 768 F.2d 1355, 1389 (D.C. Cir. 1985) ("DOE's analysis of a technical engineering study [an econometric model of energy consumption] is entitled to great deference from judges, who are hardly equipped to match the expertise of DOE's scientists."); *Citizens Against the Refinery's Effects, Inc. v. EPA*, 643 F.2d 178, 181 (4th Cir. 1981) ("Analysis of modeling results required for [air pollution prevention] applications is a highly technical area particularly within the expertise of the EPA, and thus the agency interpretation should be given great weight by the court."); see also *United States v. Nova Scotia Food Prods. Corp.*,

not like to unravel complex statistical questions.<sup>48</sup> In addition, the agency retains a presumption favoring the validity of its own regulations.<sup>49</sup> Yet scientific and technological questions, perhaps more than other agency findings, deserve review precisely because of their complex character. Their complexity masks the tremendous agency discretion exercised in constructing these models.

Disclosure of a model's assumptions, methodology, and data reduces the difficulties in determining whether an agency acted in a rational manner. Disclosure allows a court to review the component elements of the decision instead of just the conclusions. If only the agency has access to the relevant information, the public and the courts cannot act as a check on the agency's discretion. Consequently, the court retains the responsibility, even in complex technical cases, to "penetrate to the underlying decisions of the agency, to satisfy itself that the agency has exercised a reasoned discretion, with reasons that do not deviate from or ignore the ascertainable legislative intent."<sup>50</sup>

In *Cincinnati Gas & Electric Co. v. EPA*,<sup>51</sup> the court used the "arbitrary and capricious" standard to review an EPA model that determined the level of pollution permitted for power plants in Ohio. The modelers made several assumptions in constructing the model. These assumptions all relied upon the pollution dissipating under "least" stable wind conditions. Yet the court found that these assumptions "have no support in data,

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568 F.2d 240, 251 (2d Cir. 1977) ("Though a reviewing court will not match submission against counter-submission to decide whether the agency was correct in its conclusion on scientific matters . . . , it will consider whether the agency has taken account of all 'relevant factors and whether there has been a clear error of judgment.'") (quoting *Citizens to Preserve Overton Park, Inc. v. Volpe*, 401 U.S. 402, 415-416 (1971)); *Smithkline Corp. v. FDA*, 587 F.2d 1107, 1118 (D.C. Cir. 1978).

48. See, e.g., *Wilkins v. University of Houston*, 654 F.2d 388, 410 (5th Cir. 1981), vacated, 459 U.S. 809 (1982):

We are no more statisticians than we are physicians, and counsel who expect of us informed and consistent treatment of such proofs are well advised to proceed as do those who advance knotty medical problems for resolution. Our innate capacity in such matters extends to the "inexorable zero" and perhaps, unevenly, somewhat beyond . . . .

49. *Udall v. Tallman*, 380 U.S. 1, 4 (1965); *Smithkline Corp. v. FDA*, 587 F.2d 1107, 1118 (D.C. Cir. 1978) (according great weight to the discretion of the agency in a disagreement of the experts); *Cleveland Elec. Illuminating Co. v. EPA*, 572 F.2d 1150, 1164 (6th Cir. 1978) (holding use of a computer model to determine air pollution levels not arbitrary or capricious).

50. *Greater Boston Television Corp. v. FCC*, 444 F.2d 841, 850 (D.C. Cir. 1970), cert. denied, 403 U.S. 923 (1971); see also Leventhal, *Environmental Decisionmaking and the Role of the Courts*, 122 U. PA. L. Rev. 509, 511 (1974).

51. 578 F.2d 660, 664 (6th Cir. 1978) (assumption used in an air pollution model "is not a rational decision and is arbitrary and capricious").

[have been] repudiated by most modelers and [were] demonstrated inaccurate by this record."<sup>52</sup> The court could make this determination only because it had access to the "methodology used in obtaining and analyzing the data" as required under the "hybrid" rulemaking provisions of the Clean Air Act.<sup>53</sup> Under most other regulatory regimes, the Agency would not have had to provide this information. Disclosure was therefore crucial to overturning the EPA's fact-finding.

### B. Procedural Deficiencies

Although judicial review in informal rulemaking now relies almost exclusively on the "arbitrary and capricious" standard,<sup>54</sup> challengers to administrative rules may also use other sections of the APA to obtain the review of computer models. Section 706(2)(D) requires a court to overturn a statute where an agency promulgates a rule without adhering to legally required procedures.<sup>55</sup> These procedures include the requirement that the agency provide a record of its reasoning.<sup>56</sup> A court, however, will remand the proceeding to the agency only where the failure to follow proper procedures resulted in harm to the individual or organization.<sup>57</sup> While no court has yet clarified this standard of harm in cases involving computer models, recent cases suggest that the public has the right to review the assumptions and the data incorporated into the model.<sup>58</sup> Merely reporting the model's

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52. *Id.* at 662.

53. 42 U.S.C. § 7607(d) (1982).

54. *Citizens to Preserve Overton Park, Inc. v. Volpe*, 401 U.S. 402 (1971).

55. 5 U.S.C. § 706(2)(D) (1982).

56. This requirement of a record includes informal rulemaking as well as formal rulemaking. See *Citizens to Preserve Overton Park, Inc. v. Volpe*, 401 U.S. 402, 420-21 (1971); see also ADMINISTRATIVE CONFERENCE OF THE UNITED STATES, *supra* note 35, at 141:

Agencies today must anticipate that courts will conduct a "thorough, probing, in-depth review" of informal rulemaking, and that they will require the agency to produce an administrative record to support its final rule. The power to require submission of a "rulemaking record" for judicial review purposes is inherent in the review function. If a reviewing court is not given the reasoning and factual support needed to demonstrate the rationality of the rule, the court has no choice—absent a statutory provision for *de novo* review—but to remand the matter to the agency for further proceedings.

(footnote omitted).

57. See, e.g., *Mision Indus., Inc. v. EPA*, 547 F.2d 123, 128 (1st Cir. 1976) (suggesting lack of a computer printout of the agency's model before the hearing did not materially affect petitioner's presentation of views at the hearing).

58. *Sierra Club v. Costle*, 657 F.2d 298, 334 (D.C. Cir. 1981):

The safety valves in the use of such sophisticated methodology are the require-



output is not sufficient.<sup>59</sup>

Admittedly, the *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council*<sup>60</sup> decision sharply limited the ability of courts to require procedures in addition to those imposed by the APA. Nevertheless, some of the procedural requirements developed by courts in the 1970's apparently survived the Court's decision in *Vermont Yankee*.<sup>61</sup> Rules must still be supported by facts in the rulemaking record.<sup>62</sup> Although the exact standard remains unclear,<sup>63</sup> courts generally agree with Judge Leventhal's statement in *Portland Cement Association v. Ruckleshaus* that "[i]t is not consonant with the purpose of a rule-making proceeding to promulgate rules on the basis of inadequate data, or on data that, critical degree [sic], is known only to the agency."<sup>64</sup> In *Portland Cement*, the court remanded to the EPA a decision on the pollution effects from cement plants because of inadequate disclosure of the test results and procedures used on existing plants. This information had formed the partial basis for the emission control level adopted. If an agency does not disclose the data upon which it relied in its construc-

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ment of public exposure of the assumptions and data incorporated into the analysis and the acceptance and consideration of public comment, the admission of uncertainties where they exist, and the insistence that ultimate responsibility for the policy decision remains with the agency rather than the computer.

(footnotes omitted); see also *American Pub. Gas Ass'n v. Federal Power Comm'n*, 567 F.2d 1016, 1039 (D.C. Cir. 1977) ("[T]he Commission is obligated to provide a complete analytical defense of its model . . .").

59. *Washington Trollers Ass'n v. Kreps*, 645 F.2d 684, 685-86 (9th Cir. 1981).

60. 435 U.S. 519 (1976).

61. The Supreme Court's broad dicta in *Vermont Yankee*, 435 U.S. at 546-49, if taken literally, would eliminate most of the additional procedural requirements for rulemaking imposed by courts in the 1970's. Commentators, however, reject the premise that the Supreme Court sought to do this in its narrow holding. See 1 K. DAVIS, *supra* note 34, § 6:36, at 609-10: "The Court's broad dictum probably should not be read literally but was probably intended to be no broader than the problem before the Court . . . ."

62. See 1 K. DAVIS, *supra* note 34, § 6:13, at 508:

The question of when rules must be supported with facts can be easily answered in vague terms, but at the most profound level the question is beyond present understanding and therefore beyond present law. The vague answer, which may suffice for most practical purposes, is that a rule must be supported with facts when a statute so requires, when an issue of fact has arisen in the rulemaking proceeding that needs to be resolved in order to determine the content of the rule, and when the rule would be arbitrary and capricious unless it is supported with facts.

63. *Id.* at 509.

64. 486 F.2d 375, 393 (D.C. Cir. 1973), *cert. denied*, 417 U.S. 921 (1974); see also 1 K. DAVIS, *supra* note 34, § 6:13, at 508.

tion of the computer model, a court may overturn the decision because of the agency's failure to support its actions by facts.<sup>65</sup>

### C. Substantial Evidence

Section 706(2)(E) of the APA provides the final mechanism for review of computer models used by administrative agencies. This section requires a court to set aside an agency action "unsupported by substantial evidence in a case subject to sections 556 and 557 of this title or otherwise reviewed on the record of an agency hearing provided by statute."<sup>66</sup> In practice, this standard does not differ substantially from the "arbitrary and capricious" standard, and thus is not restricted to adjudications and formal rulemaking.<sup>67</sup>

A case decided before *Vermont Yankee* stressed the importance of the substantial evidence test. The court in *Mobil Oil Corp. v. Federal Power Commission* noted that "the rule that the 'whole record' be considered—both evidence for and against—means that the procedures must provide some mechanism for interested parties to introduce adverse evidence and

65. Cf. *United States v. Nova Scotia Food Prods. Corp.*, 568 F.2d 240, 251 (2d Cir. 1977). In that case, the court overturned a Food and Drug Administration ruling where [i]nterested parties were not informed of the scientific data, or at least of a selection of such data deemed important by the agency, so that comments could be addressed to the data. . . .

. . . [A]ll the scientific research was collected by the agency, and none of it was disclosed to interested parties as the material upon which the proposed rule would be fashioned.

*Id.* (footnote omitted); see also *International Harvester Co. v. Ruckelshaus*, 478 F.2d 615, 643 (D.C. Cir. 1973) (rejecting EPA assumption in making prediction of pollution level where vehicle manufacturers established that the technology was not available to meet the requirements of the Clean Air Act and the EPA sought to dispute this flawed technological methodology).

66. 5 U.S.C. § 706(2)(E) (1982). In *American Pub. Gas Ass'n v. Federal Power Comm'n*, 567 F.2d 1016, 1037 (D.C. Cir. 1977), the association challenged the estimates of an economic model on the basis that the estimates did not rise to the level of substantial evidence. The court acknowledged that it could review this model under the substantial evidence test, but it did not overturn the agency's findings.

67. The holding in *Citizens to Preserve Overton Park, Inc. v. Volpe*, 401 U.S. 402 (1971) essentially settled the question of which test should be applied in judicial review of informal rulemaking even though the case did not involve informal rulemaking. See Pedersen, *supra* note 34, at 47. Subsequent cases have sometimes merged the two standards. See *Associated Indus. v. United States Dep't of Labor*, 487 F.2d 342, 349-50 (2d Cir. 1973) (Friendly, J.): "[I]n the review of rules of general applicability made after notice and comment rulemaking, the two criteria [the arbitrary and capricious test and the substantial evidence test] do tend to converge." See also *National Nutritional Foods Ass'n v. Weinberger*, 512 F.2d 688, 705 (2d Cir. 1975) (Lumbard, J., concurring); Note, *Judicial Review of the Facts in Informal Rulemaking: A Proposed Standard*, 84 YALE L.J. 1750 (1975).

criticize evidence introduced by others.”<sup>68</sup> The court also stated that “the requirement of facts based on substantial evidence mandates greater procedural protection than those accorded under section 553 of the APA.”<sup>69</sup> This opinion indicates that a failure to allow the public to meet and contradict the findings that agencies made with computer models violates the procedural safeguards found in the APA. The Supreme Court, however, squarely rejected the premise that courts can apply requirements in addition to those stated in the APA in the 1978 *Vermont Yankee* decision:

Agencies are free to grant additional procedural rights in the exercise of their discretion, but reviewing courts are generally not free to impose them if the agencies have not chosen to grant them. This is not to say necessarily that there are no circumstances which would ever justify a court in overturning agency action because of a failure to employ procedures beyond those required by the statute. But such circumstances, if they exist, are extremely rare.<sup>70</sup>

While the precedential weight of this dicta is open to debate,<sup>71</sup> the opinion comes close to stating that the power to institute procedural safeguards comes only from the agency itself or from specific statutory authority, and that courts cannot impose these requirements unilaterally. Because the nature of computer models almost precludes review of their findings in any way other than by examining the model’s construction, and agencies have no incentives to require additional procedural safeguards for their modelers, the public must rely on an extension of present statutory authority to review these models.

### III. POTENTIAL ERRORS IN COMPUTER MODELS

One of the goals of administrative law is to allow the public and the courts to review the rationale behind agency decisions. Review of computer models presents special difficulties. Their estimates may appear straightforward initially because of their

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68. 483 F.2d 1238, 1258 (D.C. Cir. 1973) (emphasis omitted).

69. *Id.* at 1258 n.70.

70. *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council*, 435 U.S. 519, 524 (1976).

71. See 1 K. DAVIS, *supra* note 34, § 6:36, at 608-09.

quantitative precision, but the complexity of the models often masks the tremendous amount of discretionary judgment used in their construction.<sup>72</sup> To ensure that administrators do not abuse this discretion, the public and the courts must have the opportunity to examine these models carefully. Because most of the advanced computer models produce results that defy independent verification because of their complex interactive nature, scrutiny of the models must focus on their construction, rather than on their output. Any party, whether a representative of the public, an agency, or a court, should consider three main elements of a model to assess the validity of its predictions. Each of these areas—the model's assumptions, theory, and data—may affect the model's results.

### A. Model Assumptions

The assumptions behind the model determine the accuracy of its predictions. If the assumptions lack validity, the model cannot represent reality.<sup>73</sup> The failure to include relevant assumptions or variables in the model might cause the agency to make an incorrect policy choice. Without examining the assumptions behind a model, the public and the courts cannot assess a decision derived from a computer model.

The court in *Sierra Club v. Costle* recognized the importance of examining the assumptions in computer models. It noted that

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72. Otto Eckstein, Chairman of Data Resources, a major econometric consulting firm, noted in 1983 that his company's forecasts were "60% model and 40% judgment." Wall St. J., Feb. 17, 1983, at 1, 20, col 6.

73. See Fisher, *supra* note 8, at 708:

Various properties of multiple regression depend on the accuracy of the assumptions [and] different properties involving different assumptions. Moreover, the dependence is cumulative: if the early assumptions are invalid, the properties associated with the later assumptions are not likely to be present. In situations where the assumptions may fail, the use of multiple regression analysis is likely to be inappropriate.

(footnote omitted); cf. *American Pub. Gas Ass'n v. Federal Power Comm'n*, 567 F.2d 1016, 1037 (D.C. Cir. 1977):

These economic models are robbed in the elegance of high speed computers, but they are at base extrapolations from past experience, projections that must undergo continual examination and revision. They do not always have the reassuring concreteness of empirical observations, but they are the best we have to work with in casting our programs. Provided that the assumptions on which a model is based are adequately explained and justified, we see no reason why this type of evidence may not be used . . . .

See also Houston, *Why Models Go Wrong*, BYTE, Oct. 1985, at 151: "Most of the logical pitfalls of modeling are much older than computers, but computers enable us to misuse models at superhuman speed and to produce enormous volumes of invalid output."

"[t]he results [of the computer model] ultimately are shaped by the assumptions adopted at the outset, and can change drastically for a given range of input data if key assumptions are adjusted even slightly."<sup>74</sup> Indeed, even small errors in the underlying assumptions can cause gross errors in the predictions that flow from the model.<sup>75</sup>

One potential error involving assumptions is the failure to include relevant variables. For example, in *Southern Louisiana Area Rate Cases v. Federal Power Commission*,<sup>76</sup> the Fifth Circuit rejected a computer model used to estimate the number of natural gas wells drilled. The model only measured the relationship between the number of new wells drilled and the cost of the gas; it neglected the cost of drilling the wells. The model predicted that a two cent ceiling on the price of gas would cause energy companies to drill more exploratory wells in one year than the total number of wells that had been drilled since 1940.<sup>77</sup> This absurd result illustrates the potential for error when the modeler neglects a key variable. In this example, drilling costs had a direct bearing on the predictions of future drilling, but the model neglected this relationship. Because this case was not governed by a "hybrid" rulemaking statute,<sup>78</sup> the Federal Power Commission did not have to disclose the documentation behind its study. An initial review of this model could have prevented this case from reaching the court of appeals before anyone recognized the egregious errors in the model's assumptions.

The assumptions behind the representation of variables can also disrupt models. Many concepts defy quantification, so modelers will define them by a substitute or proxy. The modeler may equate literacy with modernization, or the number of television sets purchased with how much each individual household watches television. While the modeling process requires these estimations, the desire for quantification of essentially unquantifiable ideas may force the modeler to overlook key factors. This tendency to deny a model's complexity for the sake of mathematical efficiency is especially problematic in law where the issues frequently defy quantification.<sup>79</sup>

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74. 657 F.2d at 332.

75. *Id.*

76. 428 F.2d 407 (5th Cir.), *cert. denied*, 400 U.S. 950 (1970).

77. 428 F.2d at 436 n.91.

78. *See supra* note 25.

79. *See generally* M. FINKELSTEIN, *supra* note 8, at 11:

A mathematical model cannot reflect all elements of reality and need not do so to produce usable estimates. However, modeling involves drastic simplifications, and care is needed to avoid conclusions that are wide of the mark. In particular,

Modelers may also make assumptions about causality. Because of the interdependent nature of variables in simultaneous equation models, assumptions about causality can bias the model's prediction. Causality appears straightforward, but it can baffle even the most learned modelers.<sup>80</sup> If the model assumes that X causes Y, parties challenging the validity of the model should consider that Y may really cause X or that a third factor may cause both X and Y.<sup>81</sup> Only a review of these assumptions will ensure that the agency did not abuse its discretion and that it made its decisions in a fair and reasonable manner.

### B. Model Theory

The proper use of an econometric model presupposes an underlying theory. The agency should use the model to prove or disprove its theory, rather than to create the theory. Indeed, a model's theory is its most important independent variable. A frequent error of modelers who use prepackaged statistical programs but do not understand the theory behind modeling comes from the failure to specify the most important independent variable in advance of running the model.<sup>82</sup>

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there is a tendency—which must be scrutinized in each case—to sweep away complexity to permit mathematical accessibility. This drive for quantification sometimes tempts the mathematician to ignore or reject complicating factors that are nonetheless essential to the legal picture.

(footnote omitted).

80. Consider the problem in forecasting the inflation rate. The modeler must decide whether a drop in the level of employment will decrease the inflation rate, whether a drop in the inflation rate will lower the level of employment, or whether the two will move independently based upon some third factor such as interest rates. The room for error grows when the modeler not only risks making mistakes translating the phenomena she wishes to capture into equations, but also cannot find a clear consensus about what behavior she should model.

81. See *infra* note 86 and accompanying text.

82. Fisher, *supra* note 8, at 714:

To proceed by first looking at the data and then including those factors that appear correlated with the dependent variable is a recipe for spurious results. It leads to a situation where no true test of the estimated relationship can be made. In addition, it is likely to leave out variables that truly belong in and thus lead to invalid as well as untested results . . . .

I mention this emphatically because a number of packaged computer programs that are sometimes used involve what is known as "step-wise regression." Such programs build up multiple regression in ways similar to the following. First, the program finds the independent variable and does a regression involving it. It then looks at the sample deviations from the regression (the differences between the actual and predicted values) and asks whether those deviations are correlated with another independent variable. If so, it puts in the variable most correlated with those errors and so forth. This is not recommended. In the first

For example, if the Federal Aviation Administration sought to identify the causes of airplane crashes, it might study variables such as weather, pilot fatigue, equipment malfunction, and interference from other planes. Each of these explanatory variables will have some effect on crashes, and each factor will also influence the other factors.<sup>83</sup>

If the modelers would simply include all of those variables, they may "discover" a mathematical relationship between two of the variables, even though the two variables are not related.<sup>84</sup> The selection of an independent variable from a large group of interdependent variables often yields what appears to be a causal relationship even though no relationship exists between the explanatory and dependent variables.<sup>85</sup> To obtain accurate results, the agency must first develop a theory based upon one variable, such as pilot error, and then complete a regression analysis to verify this hypothesis. Without an initial theory, an

place, even if none of the independent variables have anything to do with the dependent variable, proceeding in this fashion is very likely to produce the appearance of a high correlation in a particular sample. Second, variables that in fact belong in the relationship but that are correlated with the independent variables used early in the procedure tend never to get in. In general, such computer programs suffer from the same problems as attempts to look by eye at bilateral relationships that in fact involve the influence of many variables: they are likely to attribute the effects of the omitted variables to the included ones and result in biased estimates.

83. For example, bad weather will increase pilot fatigue, make equipment more prone to malfunction, and make it more difficult to see other planes.

84. See Fisher, *supra* note 8, at 714.

85. *Id.* at 715, 735:

[I]t is important to realize that such building down cannot be done without an antecedent theory. . . . Without some theory about which variables are likely to matter, throwing a great number of variables into the hopper is likely to lead to spurious results. If one tries enough combinations of variables, then, in a particular sample, one will tend to get some relationship that appears to fit well. Therefore, a properly done study begins with a decent theoretical idea of what variables are likely to be important. It then can proceed to test well-defined hypotheses about additional variables. But a study that casts about for a good-looking relationship by trying all sorts of possibilities is very likely to come up with relationships where none exist.

. . . .

. . . While multiple regression and related econometric techniques are powerful tools for analyzing data, their proper use presupposes an underlying theory of the structure generating those data. While some hypotheses concerning that structure can be tested with these tools, the theory itself cannot be discovered by computer runs and data experimentation.

See also Henning & Mann, *An Appraisal of Model Building in Industrial Organization*, 3 RESEARCH IN L. & ECON. 1, 9 (1981): "To proceed empirically with regression analysis when one cannot have matter a priori confidence in one of the theories will generate numerical values, no matter how sophisticated the econometric technique, which are meaningless."

agency could justify almost any policy choice.<sup>86</sup> As one professor of economics warned, “[T]he measurement provided by least squares regression is a way of making theoretical assumptions precise or of testing them; it is not a substitute for thought.”<sup>87</sup>

A regression analysis used in a ratemaking proceeding illustrates the inherent dangers of using a computer to generate relationships randomly between variables.<sup>88</sup> The expert, who had a total of fifty possible explanatory variables to choose from, developed a theory and then, instead of using the variables to substantiate or disprove the theory, he merely developed a theory around the seven variables that produced the best correlation.<sup>89</sup> His results showed explanatory variables that yielded statistically significant figures. Yet closer inspection showed that he had allowed a type of statistical interference, the correlation effect, to affect the relationship between the explanatory and dependent variables. This study had the aura of authority but did not depict accurately the costs the agency had attempted to model. It merely manipulated a mass of numbers into a statistical relationship; it failed to capture the behavior the modeler wished to represent. In this case, the model was precise, meaning that it produced statistically significant figures, but not accurate, because it did not represent reality.

Indeed, the very precision of the results from the models may make the public and the courts *less* likely to review their accuracy because of lawyers' respect for and fear of numbers. An agency finding of fact produced on computer paper may not be challenged as rigorously as one produced in any other medium. Congress grants agencies the authority to make policy choices. This grant of authority includes the right to study policy options with tools such as computer models. But when agencies use models to justify *predetermined* policy choices, the agency may abuse this discretion. The public and the courts can keep the agencies in check only by reviewing their actions. Review of actions involving the use of computer models requires disclosure.

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86. See Henning & Mann, *supra* note 85 (demonstrating the possibility of taking three relationships, X causes Y, Y causes X, and X and Y cause each other, and “proving” each relationship by a regression analysis). The “proof” of each relationship depends upon the selection of the underlying theory necessary to explain the relationship.

87. Fisher, *supra* note 8, at 714.

88. See Finkelstein, *supra* note 8, at 1449 n.27 (discussing testimony regarding a regression study introduced in Long Island Lighting Co., 90 P.U.R.3d 93 (N.Y.P.S.C. 1971)).

89. Finkelstein, *supra* note 8, at 1449 n.27.



### C. Data Problems

Obtaining empirical data for multivariate regression models frustrates most modelers. Policymakers often cannot gather data in controlled experiments because they cannot isolate every factor in a problem to permit measurement of one variable.<sup>90</sup> The advantage of computer models lies in their ability to digest large volumes of data and make predictions. Yet this ability can also become a disadvantage; any errors in the initial data will be magnified in the results of the model. Courts will review data errors in computer models.<sup>91</sup> These data errors fall into six categories.

Too little data will disrupt models. Statisticians label this the "degrees of freedom" problem.<sup>92</sup> The number of degrees of freedom of a statistic is the number of available observations minus the number of constraints placed on the data by the calculation procedure. When the number of observations is small relative to the number of explanatory variables, modelers can make a statistically significant correlation, even though the variables are not actually related.<sup>93</sup> This apparent correlation will often diminish or disappear if the modeler includes a larger body of data.

Second, variables may be highly but not perfectly correlated with each other. This is often termed the "multicollinearity problem."<sup>94</sup> When the functions of two independent variables have a close relationship, the modeler may believe a relationship exists between the regression coefficients when there is none. This

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90. Consider the difficulty in measuring and isolating the sources of air pollution. If the EPA decided to impose stricter emission controls on new cars, it would have a difficult time determining the environmental effect of this decision because of the many different sources of pollution. Only a computer model can artificially hold all other sources of pollution constant so that it can measure one source. *Cf. DeLong, supra* note 43, at 329: "[F]ew [policy] choices are easily bounded. Most have side effects, and in many cases these impacts, good or bad, outweigh the importance of the objective." DeLong continues:

Most government choices involve "polycentric problems" in which it is impossible to affect just one variable in a complicated web of interconnecting relationships. Because the government cannot restrict its effects to one area, analysis of these side effects is extremely difficult, and often impossible, especially when second, third, or nth order consequences are involved.

*Id.* at n.342 (citations omitted); *see also* Fisher, *supra* note 8, at 705.

91. *See, e.g.,* Sierra Club v. Costle, 657 F.2d 298, 334 (D.C. Cir. 1981).

92. *See* Intriligator, *supra* note 8, at 157.

93. *See generally* M. EZEKIEL & K. FOX, METHODS OF CORRELATION AND REGRESSION ANALYSIS 300-05 (3d ed. 1967).

94. *See* Intriligator, *supra* note 8, at 157.

problem will make it more difficult to estimate the regression coefficients and to determine the extent of the relationship. In addition, some of the other variables may correlate highly with one or more of the included variables. Because multicollinearity depends upon sample size, the modeler must obtain more data.<sup>95</sup>

“Serial correlation”<sup>96</sup> represents the third major problem facing those working with econometric models. This problem occurs when the error terms from one observation carry over into other observations. For example, in predicting vehicle usage for a road expansion, an overestimate in one year may lead to overestimates in succeeding years.

Fourth, a discontinuous change in the real world may cause the data to refer to different populations or events. This “structural change problem”<sup>97</sup> arises most frequently where the modelers do not recognize a major shift in the relationship between variables. For example, the gasoline-buying habits of Americans shifted dramatically after the 1973 oil shock. A gasoline consumption model based upon pre-1972 data would not recognize the effect of conservation measures on consumption. This problem occurs frequently when modelers do not use data from a sufficiently long time span to provide meaningful results. For example, it may take five or more years for an air pollution regulation to improve the environment. If the EPA attempted to measure a change in pollution with twelve samples over a one-year period, it is possible that the measurements would show little change even though the policy was working. Time-series data should therefore span a sufficient time period to ensure accurate predictions.

Fifth, statistical problems arise from the measurement of economic variables. This “errors of measurement problem”<sup>98</sup> can take many forms, such as poor calibration of the instruments used to collect the data or improper placing of the measuring devices.<sup>99</sup> One of the most prevalent measurement problems lies in trying to use imprecise measurements to produce precise results. Computer models that produce exact numbers may give the aura of authority when, in truth, such models lack precision.<sup>100</sup> For example, the EPA may decide to measure the level

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95. See, e.g., R. PINDYCK & D. RUBINFELD, *supra* note 8, at 68.

96. See Intriligator, *supra* note 8, at 157.

97. *Id.*

98. *Id.*

99. *Id.*

100. An important distinction exists between a model's accuracy and its precision. Any modeler can make a computer model precise, which means that it reports its find-

of air pollution in a certain valley. If some of the agency's instruments could only measure readings to two decimal places even though the computer model could accept measurements with ten or twenty significant figures, the agency could report its findings accurately to only two decimal places. The measurement of the data controls the model's accuracy.

The final data problem with econometric models lies in their inability to handle extreme data points, called "outlier data." Econometric models rely on "least squares" regression. This analysis measures the distance of individual data points from the mean, the plotted position of the average value. Because this distance is squared, an extreme data point has a magnified effect on the model. If an agency had to disclose the model's data, then the opposing party could determine if the agency data suffered from this problem by dropping one or more of the data points, reestimating the least-squares regression line, and comparing it with the original line.<sup>101</sup> If this new run yielded little change, then the party challenging the model can assume that the outliers did not disrupt the results.

Economists have developed a number of techniques to counter these problems. Unfortunately, these techniques may disrupt rather than explain the data.<sup>102</sup> None of these methods for salvaging a model can create information; they can only analyze the information the agency collected. Only models with viable theories and unbiased data can yield proper results for agencies. Only agencies that release the assumptions, methodology, and sources of data used to construct their models can give the public and the courts the opportunity to make an adequate review of agency decisions.

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ings exactly, often to a number of decimal places. Yet agencies should only make decisions from accurate models, meaning that the models capture the true behavior of the system the agency wishes to study. Most computer models can more easily measure trends than they can provide exact answers to inexact policy questions. The more precise the agency makes the model, the more the lawyer should suspect that the agency modelers do not understand the limits of the model. *Cf. Sierra Club v. Costle*, 657 F.2d 298, 332 (D.C. Cir. 1981) ("Such [computer] models . . . are at best imperfect and subject to manipulation as EPA forthrightly recognizes.") (footnote omitted); Flynn, *The Misuse of Economic Analysis in Antitrust Litigation*, 12 Sw. L.J. 335, 358-60 (1981).

101. See R. PINDYCK & D. RUBINFELD, *supra* note 8, at 68.

102. See Intriligator, *supra* note 8, at 157:

For example, replacing annual data by quarterly data increases the number of data points but tends to aggravate both the multicollinearity and the serial correlation problems; eliminating data points referring to unusual periods, such as during war years, overcomes the structural change problems, but aggravates both the degree of freedom and the multicollinearity problems; and replacing variables by their first differences overcomes the serial correlation problem but aggravates the errors of measurement problem.

#### IV. METHODS OF VERIFYING THE RESULTS OF COMPUTER MODELS USED BY ADMINISTRATIVE AGENCIES

Models can be verified in one of two ways. Agencies and the public can run tests to ensure that the modelers followed proper procedures in constructing these models. A successful completion of these tests will not prove that the agency produced the correct results, but many models that fail these tests will not make correct predictions. The second way to verify these models is to examine the assumptions, model theory, and data used by the agency.

##### A. Tests

One can often determine whether or not the modeler started with a theory by examining the number of computer runs the modeler used to produce a statistically significant relationship. The higher the number of runs, particularly those involving mindless mechanical work, the greater the chance that the modeler used the computer to conform the model to the agency's predetermined findings, rather than using the results from the model to make the findings.

Parties reviewing models can also check them against other models and historical trends. Verifying these relationships may require the services of an expert. The best agency models and rules will have already made these comparisons with the results reported in the administrative record.<sup>103</sup> If the agency has not done this, parties scrutinizing the model should determine whether the model can describe known fact situations with ease and precision. If a Department of Energy model predicts that a nuclear power plant will lead to higher electric rates for customers ten years from now, the same model should be able to analyze past data to predict present electric rates. The modeler should be able to examine data from ten years ago, use the assumptions valid at that time, and then use the model to "prove" that an operating nuclear plant that actually did cause higher rates should have done so.

Experts should also "insult" the model. To do this, a modeler makes one variable abnormally high or low, such as setting in-

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103. See *Sierra Club v. Costle*, 657 F.2d 298, 334 (D.C. Cir. 1981); *Citizens Against the Refinery's Effects v. EPA*, 643 F.2d 178, 182 (4th Cir. 1981); *E.I. du Pont de Nemours & Co. v. Train*, 541 F.2d 1018, 1026 (4th Cir. 1981).

terest rates at 150%. If the model cannot make a prediction with this amount, the modeler may have unjustifiably restricted the possible outcomes of the model by building biases into it.<sup>104</sup>

In extremely technical rulemakings, parties objecting to the results of models may have the opportunity to cross-examine the modeler.<sup>105</sup> To determine some of the possible errors in the model a lawyer might ask, "What would a skilled modeler have to do to disprove the model?" The modeler should know the weaknesses of the model better than anyone else; this question should allow those objecting to policy choices based upon computer models to isolate the model's weak points quickly and efficiently.

The use of these tests will help those objecting to agency fact-finders determine whether the agency abused its discretion. Because of the complexity and interactive character of most computer models, though, tests run after the completion of the mod-

104. For an example of an artificially constricted model, see *Southern La. Rate Cases v. Federal Power Comm'n*, 428 F.2d 407, 436 (5th Cir.), *cert. denied*, 400 U.S. 950 (1970). See also *supra* notes 27, 77-78 and accompanying text.

105. See, e.g., *International Harvester Co. v. Ruckleshaus*, 478 F.2d 615, 630 (D.C. Cir. 1973) (allowing cross-examination where "the general policy questions became inter-fused with relatively specific technical issues"); *Walter Holm & Co. v. Hardin*, 449 F.2d 1009, 1016 (D.C. Cir. 1971) ("fairness may require an opportunity for cross-examination on the crucial issues"). A party, however, must generally show that its interests would be prejudiced without cross-examination. See *National Asphalt Pavement Ass'n v. Train*, 539 F.2d 775, 782 (D.C. Cir. 1976); *American Pub. Gas Ass'n v. Federal Power Comm'n*, 498 F.2d 718, 723 (D.C. Cir. 1974); *O'Donnell v. Shaffer*, 491 F.2d 59, 62 (D.C. Cir. 1974); *Virgin Islands Hotel Ass'n v. Virgin Islands Water & Power Auth.*, 476 F.2d 1263, 1267-69 (3d Cir.), *cert. denied*, 414 U.S. 1067 (1973). Cf. *Cleveland Elec. Illuminating Co. v. EPA*, 572 F.2d 1150, 1160 (6th Cir. 1978). In this case, the court did not require cross-examination of the administrator in the use of an air quality simulation model, but it did note:

While we believe that cross-examination of an administrative agency's experts is not a required or normal part of informal rulemaking under section 553, we do not exclude the possibility that a case may be presented to this court wherein remand for cross-examination about disputed facts will prove both logical and necessary.

*Id.*

Note that all of these cases were decided before the 1978 case of *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council*, 435 U.S. 519, which struck down a large portion of the court-developed law of rulemaking procedure developed during the 1970's. According to Professor Davis, the decision did not reach the question of whether " 'elementary fairness' sometimes requires opportunity for a rule making party to cross-examine with respect to identified issues of specific fact, at least in some circumstances, even though [the APA] § 553 imposes no such requirement . . ." 1 K. DAVIS, *supra* note 34, § 6:36, at 610. The Supreme Court has not specifically ruled on this or whether or not cross-examination is allowed in administrative proceedings absent specific statutory authorization. No court has established a claim of right to cross-examination in administrative proceedings. See, e.g., *Ethyl Corp. v. EPA*, 541 F.2d 1, 54 (D.C. Cir.), *cert. denied*, 426 U.S. 941 (1976).

els can uncover only some of the problems. The *real* opportunity to examine the usefulness of agency predictions comes not from examining the outcome of the model but from examining the process and methods used to construct the model.

*B. Proposed Regulation: Requirements for the Disclosure of Information Used To Create Computer Models*

STATEMENT OF PURPOSE AND POLICY

**Federal Administrative Agencies and parties appearing before regulatory bodies frequently rely upon computer-generated simulations to formulate or attack policy. The results from many of these computer models can be replicated only by making another computer-based study. To ensure that the agencies make the proper decisions and that the public and the courts have the opportunity to review these decisions, all parties to a decision shall have an opportunity to review the assumptions, methodology, and data used in the completion of these models.**

SECTION I: DEFINITIONS

**For the purposes of this Act, the following words and phrases shall, unless the context clearly indicates otherwise, have the following meanings:**

- (a) **“Administrative Agencies” means**
  - (1) **all Federal agencies;**
  - (2) **all Federal regulatory bodies; and**
  - (3) **any groups or organizations exercising Federal administrative authority granted by Congress.**
- (b) **“Analysis” means all reports submitted to Administrative Agencies that include any statistical, mathematical, or computer analysis.**
- (c) **“Assumptions” means the facts and judgments that go into the construction or completion of the study or analysis.**
- (d) **“Computer model” means any computer-**

**generated simulation.**

- (e) **“Data collection” means all statistical information used to complete an analysis.**
- (f) **“Methodology” means the theory or rationale used to construct the model.**
- (g) **“Operating manuals” means the documentation used to run any software or hardware needed to complete the study or analysis.**
- (h) **“Parties” includes Administrative Agencies, and members of the public, organizations, or government units that appear before Administrative Agencies.**
- (i) **“Policy choices” means all decisions made by Administrative Agencies affecting any member of the public, organizations, or government units.**
- (j) **“Programs” means any software needed to complete the study or analysis.**
- (k) **“Study plan” means the theory upon which the model is based and includes a summary of all material used to develop the theory.**

## **SECTION II: GENERAL REQUIREMENTS**

**All studies and analyses used to formulate policy choices or offered as evidence or support in hearing proceedings or relied upon in support of other evidence shall include:**

- (a) **a clear statement of the assumptions and methodology employed;**
- (b) **a description of the data collection techniques, estimation, and testing used in the completion of the study or analysis; and**
- (c) **a clear statement of the alternative sources of action considered.**

## **SECTION III: ECONOMETRIC MODELS AND OTHER COMPUTER MODELS**

**All econometric and other computer models shall include a complete description of the model, including the**

**assumptions, methodology, and statistical specifications used in the construction of the model, and a clear statement of the effects on the final results of alterations of the assumptions.**

#### SECTION IV: ACCESS TO MODELS

**All econometric and other models completed by computer shall include provisions guaranteeing access to the data bases, operating manuals, and programs used in the formulation of the model. The parties shall provide this information either by releasing it in machine-readable form, or by providing access to a time-sharing system. The parties providing this information may charge a reasonable amount for its use. This provision shall not be construed to require the release of information protected under provisions of the Freedom of Information Act.**

#### SECTION V: ALTERNATIVE MODELS

**Upon request, a party that relies upon a model shall also submit to the requesting party any alternative studies, including those employing alternative models or variables, that were completed. The party shall also supply a description of any alternative studies contemplated but never completed, as well as the reasons for noncompletion.**

#### SECTION VI: DATA

**The parties shall provide the formulas used for any statistical estimates, the standard errors for each component estimated, the test statistics and a description of the statistical tests, and all related computations and final results.**

**The parties shall provide summary requests of all input data and, upon request, the actual input data. The party holding the data may charge a reasonable amount to cover the costs of transferring the data.**



**These costs may include the cost of transmission and technician's time used to complete the transfer.**

#### CONCLUSION

Many federal agencies and parties appearing before regulatory bodies use computer models for policy formulation. The use of well-documented models simplifies review procedures because the public can examine the assumptions and information that administrators used to ensure that the agency did not abuse its discretion.

Currently, there are no comprehensive requirements detailing what information agencies must release when they make decisions based upon computer-generated simulations. This information includes the assumptions, methodology, and data used to construct the model. The disclosure of this information would improve the policy process by providing the public and the courts with greater insight into the rationale and justification for administrative agency decisions.

*—John P. Barker*