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This article operationalizes garbage can theory into a stochastic process model for the case of a traditional Weberian bureaucracy. The purposes of the model are two: (1) to illustrate how ambiguity may impinge on decision making within a structural setting more familiar to classical organization theorists, and (2) to derive the managerial implications of garbage can theory.

Garbage can flows of issues are explicitly embedded within a differentiated chain-of-command hierarchy, and are affected by centralization and personnel policies, subunit conflict, information-processing routines, and standard operating procedures. The Presidential control implications of the model amount to unobtrusive management in the extreme. Structural design is emphasized more than tactical machinations.•

The "Garbage Can Model of Organizational Choice" was an attempt to push organizational decision theory into the previously uncharted territory of "organized anarchies." As described by Cohen, March, and Olsen (1972), Cohen and March (1974), and March and Olsen (1976), organized anarchies are organizations characterized by severe ambiguity. Hence, organized anarchies do not have clear or consistent notions about what it is they are trying to do (problematic preferences), how it is they are supposed to do it (unclear technology), or who it is that should make the decisions (fluid participation). Educational and public sector organizations are frequently alleged to be afflicted with these traits (Pressman and Wildavsky, 1973; Cohen and March, 1974; March and Olsen, 1976; Sproull, Weiner, and Wolf, 1978). And most organizations may be beset at least occasionally with severe ambiguity, especially during periods of crisis or "value instability" (Mohr, 1978).

Garbage can theory attempted to describe how decisions are made under these trying circumstances. The thrust of this theory's approach was to focus less on the details of individual decision making, and more on the aggregate flows of people, problems, and solutions through organizational networks. These flows determine the perceived issue or meaning context of choice, and in turn are constrained by access structures, energy loads, and attention-focusing rules.

Despite the originality of this approach, some reviewers and critics have found it difficult to reconcile garbage can thinking with more traditional organization theory concerns. For one thing, the structural underpinnings of the theory do not seem very convincing. Garbage can processes seem curiously divorced from the familiar structural phenomena of organizational differentiation, centralization policy, and standard operating procedures of traditional concern to classical organization theorists. This relative lack of emphasis on "the stable, the routine, and the channeling effects that rules have on behavior" (Perrow, 1977) encourages the misperception that the organized anarchy paradigm can be usefully applied only to highly decoupled and unorthodox organizational systems.

A second, more normative feature of garbage can theory which inhibits diffusion is that theory's apparent managerial

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implications. A superficial reading of the Cohen-March-and-Olsen research leaves one with the impression either that the world is so contextual, idiosyncratic, and capricious that management is by definition impossible, or that the only hope lies with the astute tactician who, due to a masterful sense of timing and diversion, can influence decisions on an ad hoc basis (Argyris, 1976). I would suggest, however, that the rather anecdotal "Eight Elementary Tactics of Administrative Action" offered by Cohen and March (1974: 205–215) do not fulfill the managerial promise of garbage can theory. Once again, the problem I believe stems from an insufficiently systematic concern with the structural setting within which garbage can processes operate.

This article seeks to speak to these two concerns, and hence to speed the diffusion of organized anarchy concepts, by illustrating via a simple mathematical model the operation of garbage can processes within a fairly traditional and bureaucratic organizational structure. Hence,
(1) a garbage can-like stochastic process model of organizational decision making is developed for the case of a hierarchical organization *without* fluid participation, and
(2) the implications of this model for various strategies of Presidential control are explored.

Hierarchical garbage can systems without fluid participation are examined because most organizations, most of the time, are characterized by a more rigid role structure than is suggested by the image of unrestricted decision access within constraints. It is possible to represent lateral flows of issues and people across divisional boundaries within the model to be developed below. However, the goal here will be to embed garbage can flows explicitly within the more classical bureaucratic constraints of hierarchical differentiation, standard operating procedures, and centralized control. Since confusion and ambiguity can afflict even the most tightly structured organization, the features of problematic preferences and unclear technology will remain prominent.

The criterion of Presidential control is not the only perspective from which organized anarchy models can be examined, but this perspective does speak to normative concerns about managerial implications. A number of strategic dimensions will be explored here, including centralization policy, hiring policies, conflict among hierarchical levels, structural assignment of programs to divisions, and direct Presidential intervention. Given unorthodox theories, it is perhaps not surprising that resultant managerial recommendations are similarly unorthodox. And indeed, one of the primary conclusions of the model to be developed below will be that the President maximizes control over organizational decision outcomes the most, from the point of view of his or her own preferences, by personally making no decisions whatsoever. The thrust of the managerial recommendations to be deduced from the model emphasize unobtrusive structural design, rather than active tactical maneuvering.

The article develops these arguments as follows: First, an overview of the basic verbal and formal elements of the hierarchical garbage can model is presented. Next, the information processing, decision outcome, and decision flow conse-

quences of the model are derived for the case of arbitrary stochastic, yet stationary organizational environments. The core issue of Presidential control is then investigated. Finally, possible extensions of the model are discussed.

A HIERARCHICAL GARBAGE CAN MODEL

Imagine an organization whose formal structure is fairly traditional. There is a President (or Chief Executive Officer) who oversees L departments (or divisions). Each department ℓ is headed by a Secretary (or Vice President) and contains a possibly unique K_ℓ number of programs. Each program k, in turn, is managed by one program chief and has a staff of analysts attached to it. The analysts' jobs are to monitor incoming environmental information about the issues j "relevant" to program decision making. At the lowest program level of decision making, the set of "relevant" issues $\{1, ..., j, ..., j_K\}$ is well defined by organizational routines.

Within this simple, four-level hierarchical organization, decisions are produced in a straightforward chain-of-command manner. Analysts continually monitor the environment and evaluate the current status of the issues under their jurisdiction. Each time period, program chiefs translate these issue evaluations into preliminary recommendations of "program need" according to standard operating procedures. Secretaries then review these recommendations and do one of two things: (1) If the recommendation represents only a "minor" change from the status quo, Secretaries merely rubber stamp the program chief's recommendation. (2) However, if the recommendation represents a "major" change from the status quo, Secretaries take the decision under more active review and evaluate the program choice on the basis of some broader subset of issues, drawn from the department's entire K_ℓ span of jurisdiction. In other words, if the recommendation is major, Secretaries "coordinate" by considering those cross-program implications which they personally view as "relevant." The threshold distinction between "major" and "minor" change from the status quo is defined by organizational centralization policy.

Presidents review Secretarial recommendations and likewise either rubber stamp them or take them under active review, depending upon a perhaps different definition of "minor" versus "major." Presidential active review potentially can consider the relevance of any issue within the entire organization, regardless of jurisdiction. However, Presidents are not omniscient and hence rely upon their Secretarial advisers to draw up a more narrowly defined set of "relevant" issues for Presidential consideration. Within this advisor subset of issues for any program under active review, Presidents make their own choices about "relevant" issues based upon their own substantive priorities. Presidential "recommendations" are of course the final organizational decisions for the current time period.

So far, the picture is one of a traditional organization proceeding in a traditional manner: Organizations are hierarchies. Decisions are produced by the chain of command. Organizations monitor multiple issue environments. Behavior is constrained by standard operating procedures, jurisdictional boundaries, and centralization policy.

Now, however, consider the distinctive role of ambiguity: (1) Secretaries and the President are characterized by "problematic preferences," in that they do not know for certain what are "the relevant issues" for the program decision under active review. Within their respective jurisdictional and advisory constraints, Secretaries and the President have only ideological predispositions or probabilities of perceiving particular issues confronting them as relevant. This stochastic process of deciding the issue context of choice generates, in turn, a probabilistic flow of issues up the hierarchical chain of command.

(2) Analysts are characterized by "unclear technology," in that they have no clear cognitive model of the environment with which to interpret incoming information. In lieu of causal understanding, analysts evaluate information according to cybernetic "adaptive expectations" principles.

The grounding of this model in garbage can theory should be apparent. The heart of both approaches is a mapping of issues or problems onto choices. Explaining this changing "meaning context" of choice as a function of organizational processes operating under conditions of ambiguity is the core analytic task. In the present model, "relevant issue sets" are well defined by organizational routines at the lowest program chief decision level, and hence can be taken as analogous to Cohen, March, and Olsen's (1972) "access structure" of problems to choices. At higher decision levels, however, "problematic preferences" induce a contextual and temporally variable flow of issues to program choices.

The primary difference between this model and the original garbage can model is the present model's more explicit representation of routine organizational structure. Information-processing subroutines are explicitly broken out, and the boundary-spanning function of analysts is thereby highlighted. Decision makers are situated within hierarchical roles, and are thereby explicitly constrained by standard operating procedures, jurisdictional boundaries, and centralization policy. Fluid participation of people, but not issues, is suppressed.

Given this verbal overview, let us now translate this hierarchical garbage can model into more precise mathematical language. An illustrative small garbage can hierarchy is presented in Figure 1.

Decisions

Call the program chief's recommendation for program k at time period t $\hat{x}_{kt}$; the Secretary's recommendation $\hat{\hat{x}}_{kt}$; the President's "recommendation" $\hat{\hat{\hat{x}}}_{kt}$; and the final organizational decision x_{kt}. Theoretically these choices can be considered as having been selected from either a discrete or a continuous space of underlying alternatives, but I will develop the case of continuous alternatives. Hence, x_{kt} could be considered a budget choice, a procurement choice, a production choice, a policy choice along some arbitrary Downsian "issue space" dimension, or any other choice from a continuous array. For illustrative purposes only, I will take as my example the annual budgetary decisions for the Urban Renewal program in the U.S. Department of Housing and Urban Development.

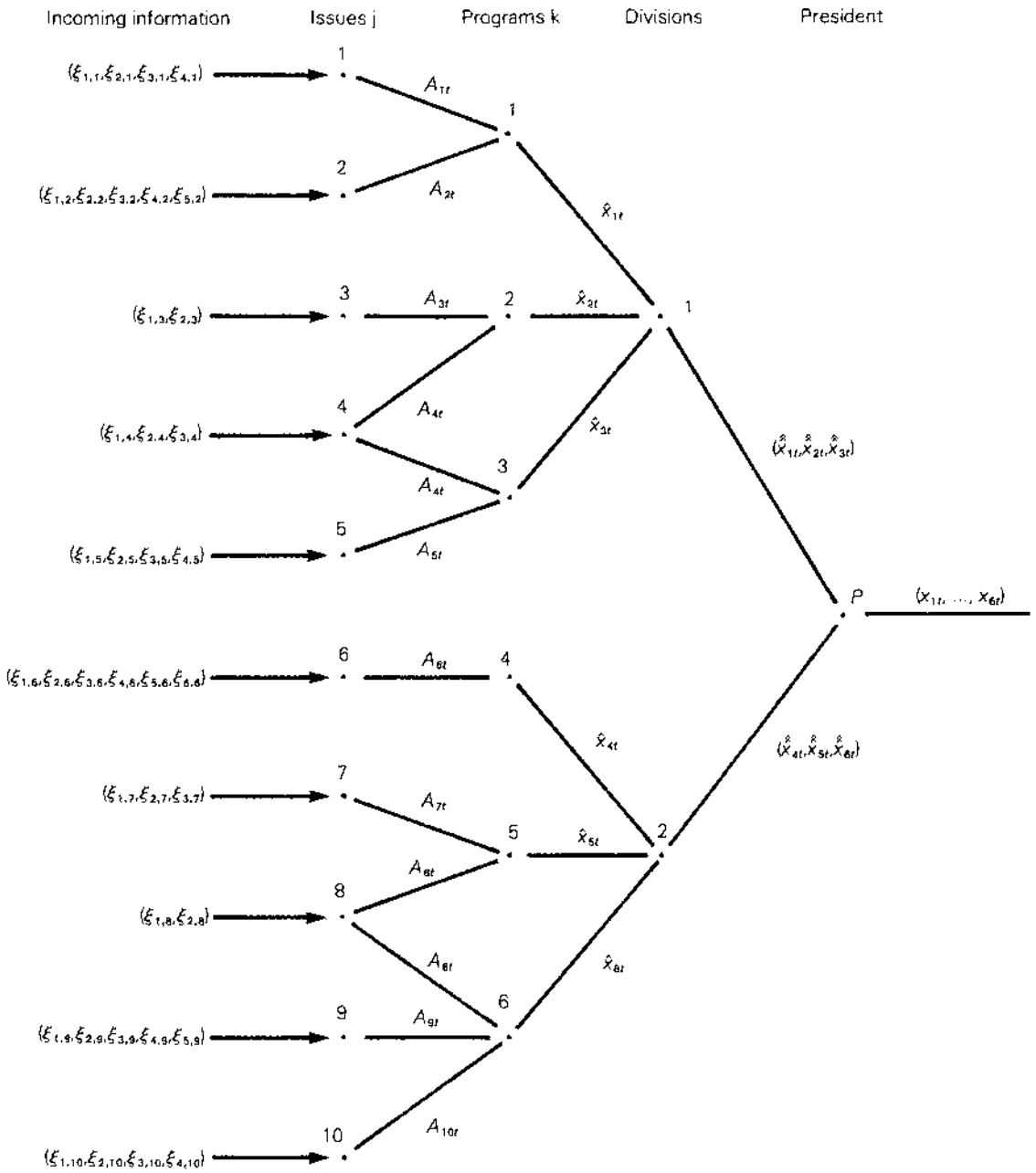

Figure 1. Illustrative garbage can hierarchy (for one time period *t*).

Information Processing

Analysts are bombarded with information from the outside world regarding each issue j. At the program level, there are a fixed j_k such "relevant" issues: $\{1, 2, \ldots, j, \ldots, j_k\}$. For my Urban Renewal example, these could be anything from the projected application demand, to the capacity of cities to effectively administer projects, to overall fiscal climate, to shifting Presidential urban initiatives. If analysts receive i_t pieces of information regard j during time period t, then these information inputs can be represented as $\{\xi_{1j}, \ldots, \xi_{ij}, \ldots, \xi_{i_t j}\}$. The i_t quantity and the ξ_{ij} content of this incoming information could be specified to have various properties, but all that will be presumed here is that these are random variables which are gen-

erated by the environment in accordance with some arbitrary but unknown stationary probability distribution — that is, $\xi_{ij} \sim p(\mu_j, \sigma_j^2)$. The stationarity assumption will be relaxed in the final section.

The analyst's task is to evaluate this information and come up with an estimate of the current status of issue j. Call this analyst's estimate, at time period t, A_{jt}.

According to the "unclear technology" assumptions of this model, analysts have no clear cognitive models of reality through which to filter this information. They are forced to fall back on cybernetic "short-run feedback rules" (Cyert and March, 1963), which successively revise and update earlier estimates to take into account the implications of each new piece of information received. A classic representation of such an evaluation process, which is well established in the econometrics literature (Kmenta, 1971), is the "adaptive expectations" model. This process can be expressed for the current context as follows:

$$A_{ij} = A_{i-1,j} + (1 - c_j)[\xi_{ij} - A_{i-1,j}].$$

This equation means that, given some current estimate of an issue's status, an analyst reacts to each newly received piece of information by adjusting that estimate some proportion of the way toward the implications of the new information.

The parameter c_j here ($0 \leq c_j \leq 1$) controls the sensitivity or speed of the analyst's revision of the old estimate, $A_{i-1,j}$, in response to new information. Hence, the parameter c_j can be interpreted as the "confidence" the analyst places in his or her own earlier estimate.

To express the final analyst opinion at the end of the current time period in terms of the previous period opinion, we cumulate the above adjustment equation over all i_t pieces of information received:

$$A_{jt} = c_j^{i_t} A_{j,t-1} + (1 - c_j) \sum_{i=0}^{i_t} c_j^{i_t - i} \xi_{ij},$$

(where by convention $\xi_{0j} = 0$). It is clear from the $c_j^{i_t - i}$ term that the analyst has a marked tendency to discount old information which has been superseded many times. This property of course is quite plausible for an analyst interested in generating the most up-to-date evaluations possible.

Program Chief Decision Making

Program chiefs, being the lowest level of the decision-making hierarchy, are heavily constrained by standard operating procedures (SOP's). The j_k number of "relevant" issues considered by the program chief is typically small, and is defined unambiguously by organizational routines. In this structural setting, program chiefs simply take the issue evaluations of the analysts on their staff and translate them into preliminary program recommendations which essentially are standard operating procedure definitions of perceived "need." For simplicity, we can assume that there is one analyst in charge of each of the j_k "relevant" program issues.

This program chief SOP decision process can be represented as:

$$\hat{x}_{kt} = \sum_{j=1}^{j_k} \gamma_{jk} A_{jt}.$$

Here, the γ_{jk} parameters represent organizational standard operating procedures which define the decision implications of various issues. In terms of my Urban Renewal budgeting example, the γ_{jk}'s embody the staff work involved in "costing out" various issues.

Under this formulation, program chiefs always mechanically map all "relevant" issues into their recommendations, without making any discretionary judgments about the priority of different relevant issues (apart from the priorities which may be indirectly embedded in the SOP's). Each $\gamma_{jk}A_{jt}$ can be interpreted as one argument or justification component of the program chief's overall recommendation.

Secretarial Decision Making

Secretaries do one of two things with the K_t recommendations they receive each period from the program chiefs under their jurisdiction. If the recommendation represents only a "minor" change from the status quo, the Secretary simply rubber stamps the recommendation and accepts it without question. That is,

if $|\hat{x}_{kt} - x_{kt-1}| < \Delta\bar{x}_k$, then $\hat{\hat{x}}_{kt} = \hat{x}_{kt}$.

The attention-focusing threshold variable $\Delta\bar{x}_k$ embodies the structural rules for Secretarial discretion under which the organization operates. These rules reflect the organization's centralization policy since a high $\Delta\bar{x}_k$ threshold represents a fairly decentralized approach to Secretary decision making, with much discretion remaining in the hands of the program chief. A low $\Delta\bar{x}_k$ threshold represents a more centralized approach to decision making, with active intervention on the part of the Secretary more likely.

The Secretary takes the program policy choice "under active review" if the program chief recommends a "major" change from the status quo — that is, if $|\hat{x}_{kt} - x_{kt-1}| \geq \Delta\bar{x}_k$. What "active review" means is that Secretaries develop their own recommendations on the basis of all of the available issues from within their jurisdictions, which they personally consider to be "relevant," and not just on the basis of the more narrowly defined set of issues under the program chief's jurisdiction. This is what I take to be the meaning of "coordination." The total set of potentially relevant Secretarial issues is

$$\{1, \ldots, j, \ldots, j_l\} = \bigcup_{k=1}^{K_l} \{1, \ldots, j_k\}.$$

In terms of my Urban Renewal budgeting example, this might mean that if Public Housing and Mass Transit programs also happened to be within the Secretary's bailiwick, then the Secretary might consider the Urban Renewal recommendation in the context of various housing for the poor and transportation issues as well as in the context of just mainline Urban Renewal issues.

Under active review, Secretaries develop recommendations in a manner roughly comparable to that of program chiefs, with one critical difference. Secretaries do not mechanically accept all issues within their jurisdiction as "relevant" prima facie, but rather accept or reject their relevance in accordance with their own "problematic preferences." Such problematic preferences will be modeled by a set of probabilities, $\{\beta_{lj}\}$, which embody the relative priority or saliency of different is-

sues to the Secretary personally. That is, with a probability of accepting an issue as "relevant" equal to β_{ij}, Secretary i monitors all issues under his or her jurisdiction for each program decision which he or she intervenes in.

Hence, if we represent the event of active Secretarial intervention as $S_{kt} = 1$ (and the rubber stamp approach as $S_{kt} = 0$), then the Secretary's active intervention decision process is as follows:[1]

if $|\hat{x}_{kt} - x_{kt-1}| \geq \Delta\bar{x}_k$, then

$$E(\hat{\hat{x}}_{kt}|S_{kt} = 1) = \sum_{j=1}^{j_i} \beta_{ij}\gamma_{jk}A_{jt}.$$

Here, as before, cross-program γ_{jk}'s represent the SOP work of central staff charged with "costing out" the implications of Secretarially mandated "relevant" issues. It is assumed that Secretaries can obtain any analyst evaluations upon request, regardless of program affiliations.

Presidential Decision Making

The President behaves pretty much as Secretaries do. That is, given a Presidential discretion policy $\Delta\bar{\bar{x}}_k$ (which presumably the President sets), the President rubber stamps Secretarial recommendations which represent only "moderate" changes from the status quo — i.e., if $|\hat{\hat{x}}_{kt} - x_{kt-1}| < \Delta\bar{\bar{x}}_k$, then $x_{kt} = \hat{\hat{x}}_{kt} = \hat{\hat{\hat{x}}}_{kt}$. (It is implicitly assumed that centralization policies are not degenerate in the sense of $\Delta\bar{\bar{x}}_k < \Delta\bar{x}_k$.)

However, if the Secretary's recommendation is for a "major" policy change, then Presidents take matters into their own hands and consider all of the issue arguments presented by the Secretaries, acting in their role of advisers. Presidential dependence upon advisers to point out "relevant" issues for their consideration is an important feature of the model.

As long as all Secretaries act as advisers, potentially "relevant" issues for the President span the entire space of issues over the whole organization —

$$\{1, \ldots, j, \ldots, j_p\} = \bigcup_{i=1}^{L} \bigcup_{k=1}^{K_i} \{1, \ldots, j_k\}.$$

The President's own "problematic preferences" over these j_p issues, in turn, are $\{\beta_{pj}\}$. Hence, under the convention that the event of active Presidential intervention is represented by $P_{kt} = 1$, active Presidential decision making can be modeled as:

if $|\hat{\hat{\hat{x}}}_{kt} - x_{kt-1}| \geq \Delta\bar{\bar{x}}_k$, then

$$E(\hat{\hat{\hat{x}}}_{kt}|P_{kt} = 1) = \sum_{j=1}^{j_p} \beta_{pj}\beta_{ij}\gamma_{jk}A_{jt}.$$

Interpretation is as before. The President stochastically accepts or rejects as relevant issues that Secretarial advisers present. If the President decides an issue is relevant, staff personnel "cost out" the implications, drawing upon the evaluations of analysts wherever they are located within the organization. Presidential dependence upon advisers is manifest in the above equation by the potential filtering effect of the terms $\{\beta_{ij}\}$.[2]

This model of hierarchical decision making represents a fairly traditionally structured organization operating under conditions of ambiguity. Interpretation of incoming information is

1

For those not familiar with probability notation, the symbol $E(x|y)$ means "the expected value of x, conditional on the value of y."

2

It is easy to complicate the model by permitting Secretaries to be subject to filtering as well as the President. One would simply permit program chiefs to act as Secretarial advisers and give them their own stochastic set of problematic preferences. Then, the President would become subject to two levels of filtering, rather than one. However, in the present article, I ignore this second-order effect since, given reasonably sized divisional jurisdictions, Secretarial bounded rationality limitations will not be taxed as severely as the cognitive constraints of the President, who must oversee a much wider range of cross-program implications.

unclear. And, except at the lowest level of the organization, most of the decision action centers around the discovery of the "relevant" meaning context of choice. To investigate the behavior of this system, we will start with an analysis of information processing and build toward an analysis of Presidential control.

DECISION OUTCOME AND FLOW IMPLICATIONS

Adaptive Expectations Information Processing

What are the long-run properties of the unclear technology information evaluation process posited here? In particular, how well can analysts grope their way toward the true but unknown "objective" issue status μ_j? To answer this question requires an evaluation of the bias and efficiency properties of the analysts' "adaptive expectations" estimation process.

Bias is simply $E(A_{jt} - \mu_j)$. Of particular interest is the long-run $E(A_{jt})$ as the number of time periods becomes large. We have to begin with that

$$A_{jt} = c_j^{i_t} A_{jt-1} + (1 - c_j) \sum_{i=1}^{i_t} c_j^{i_t - i} \xi_{ij}$$

and likewise for A_{jt-1}, A_{jt-2}, etc. Hence, by repeated substitution and iteration over n time periods,

$$A_{jt} = c_j^{I_n} A_{jt-n} + (1 - c_j) \sum_{i=1}^{I_n} c_j^{I_n - i} \xi_{ij},$$

where I_n is the total number of pieces of information received over all n time periods (i.e., $I_n \equiv \sum_{s=0}^{n} i_{t-s}$).

Now, taking expectations for fixed values of I_n and A_{jt-n}, for the case of a probabilistically stationary world,

$$\begin{aligned} E(A_{jt}|I_n) &= c_j^{I_n} A_{jt-n} + (1 - c_j) \sum_{i=1}^{I_n} c_j^{I_n - i} E(\xi_{ij}) \\ &= c_j^{I_n} A_{jt-n} + \mu_j (1 - c_j) \left(\frac{1 - c_j^{I_n}}{1 - c_j} \right) \\ &= \mu_j + (A_{jt-n} - \mu_j) c_j^{I_n}. \end{aligned}$$

The unconditional expectation, therefore, is

$$E(A_{jt}) = \mu_j + (A_{jt-n} - \mu_j) E(c_j^{I_n}).$$

Hence, our first important result is that since, as n approaches infinity, the expected number of pieces of information goes to infinity and $E(c_j^{I_n}) \to 0$,

$$\lim_{n \to \infty} E(A_{jt}) = \mu_j.$$

That is, the adaptive expectations estimation process is, in the long run, *unbiased*. Therefore, even though analysts do not have any clear cognitive model of reality with which to understand issues, for old programs with long histories, analysts are capable of zeroing in, on average, to the right answer. For old programs, somewhat mindless analyst-groping behavior is not such a bad idea.

But what happens to newer programs with short histories? Clearly here, analysts' opinions are not unbiased, but depend upon their initial uninformed guess A_{jt-n}, the rate of information bombardment $E(i_t)$, and their degree of confidence in their opinions c_j. Not surprisingly, things are not too bad if their initial guess just so happened to turn out to be close to

the right answer, and if the rate of information bombardment is very high. More interesting is the bias' dependence upon analyst self confidence, c_j. For c_j close to zero, the rate of convergence of $E(c_j^{I_n}) \rightarrow 0$ will be very rapid regardless of information flow properties; but if c_j is close to 1 this rate of convergence will be much slower. In other words, for new programs the last thing you want are analysts who think they know what they are doing. Overt acceptance of one's ignorance is a highly valued trait when experience is short.

A second desirable property of estimation procedures, besides a lack of bias, is efficiency. That is, not only does one want a procedure which on the average yields the right answer, but also one wants a procedure whose errors around the mean have a low variance.

Efficiency properties of adaptive expectations can be derived as follows. Conditional variance is:

$$\mathrm{Var}(A_{jt}|I_n) = (1 - c_j)^2 \sum_{i=1}^{I_n} c_j^{2(I_n - i)} \mathrm{Var}(\xi_{ij})$$

$$= \sigma_j^2 (1 - c_j^{2I_n}) \left(\frac{(1 - c_j)^2}{1 - c_j^2} \right).$$

And unconditional variance is:[3]

$$\mathrm{Var}(A_{jt}) = \sigma_j^2 \left(\frac{(1 - c_j)^2}{1 - c_j^2} \right) (1 - E(c_j^{2I_n})) + (A_{jt-n} - \mu_j)^2 \mathrm{Var}(c_j^{I_n}).$$

It is apparent that in the long run, where $E(c_j^{I_n}) \rightarrow 0$,

$$\lim_{n \rightarrow \infty} \mathrm{Var}(A_{jt}) = \sigma_j^2 \left(\frac{1 - c_j}{1 + c_j} \right).$$

One immediate conclusion follows from the fact that $\mathrm{Var}(A_{jt})$ remains finite and does not approach zero even as the amount of information goes to infinity. Analysts' opinions do not converge on μ_j with certainty but rather fluctuate perpetually around this answer no matter how much information is received. No conceivable amount of information can ever completely eliminate ambiguity in this process, and changing opinions are always manifest.

The degree of such fluctuations, however, is not independent of the analysts themselves. In particular, the more confident analysts are about their own previous opinions, the less their evaluations will fluctuate. Hence, in the long run where there exists a great deal of experience to draw upon, lack of responsiveness to incoming information is actually an asset. Efficiency is thereby improved.

Thus, we have a tradeoff of sorts in the degree of analysts' confidence which is desirable as a function of the age of the program. For old, well-established programs it is more desirable to have rigid and unresponsive analysts whose evaluations not only will be unbiased but also will be more efficient. For relatively new programs, which in fact may have higher salience to upper level executives, it is desirable to have analysts who are quite accepting of their own ignorance. This suggests an appropriate personnel policy for hiring analysts in garbage can systems, where causal understanding is unclear and reliance upon cybernetic short-run feedback rules is widespread.

3

Here, the two following general formulas are used: $\mathrm{Var}(X) = E_Y[\mathrm{Var}(X|Y = y)] + \mathrm{Var}_Y[E(X|Y = y)]$, and $\mathrm{Var}(X) = E(X^2) - E(X)^2$. See Woodroofe (1975: 282, 215).

Decision Outcomes

Given analyst inputs, what decisions does the hierarchical garbage can model in fact produce? In particular, what are the means and variances of program chief recommendations, Secretarial recommendations, Presidential "recommendations," and final organizational choices? This question will be answered using only the limit evaluation results derived above. Derivation of the short-run results is straightforward with the above full-blown conclusions, but the consequent more complicated equations do not appear sufficiently more informative to warrent their presentation here.

Program chiefs behave according to simple standard operating procedures which mechanically process all of the organizationally defined "relevant" issues under their jurisdiction. Derivation of the mean and variance properties of program chief recommendations is as simple as the SOP's which produce them:

$$E(\hat{x}_{kt}) = \sum_{j=1}^{j_k} \gamma_{jk} E(A_{jt})$$
$$= \sum_{j=1}^{j_k} \gamma_{jk} \mu_j.$$

Call this particular result x_k^{1*}, which is the program chief's "optimal" or "implicitly preferred" decision outcome (whether she realizes this to be her preference or not).

Likewise, for the variance:

$$\mathrm{Var}(\hat{x}_{kt}) = \sum_{j=1}^{j_k} \gamma_{jk}^2 \mathrm{Var}(A_{jt})$$
$$= \sum_{j=1}^{j_k} \gamma_{jk}^2 \sigma_j^2 \left(\frac{1 - c_j}{1 + c_j}\right) \equiv \mathrm{Var}(x_k^{1*}).$$

Derivation of the mean and variance properties of Secretarial recommendations is slightly more subtle, since the Secretaries either can rubber stamp the program chiefs' recommendations or can more actively develop their own recommendations. If $|\hat{x}_{kt} - x_{kt-1}| \geq \Delta\tilde{x}_k$ and the Secretary takes the decision under active review, derivation of mean and variance is once again straightforward:

$$E(\hat{\hat{x}}_{kt} | S_{kt} = 1) = \sum_{j=1}^{j_l} \beta_{lj} \gamma_{jk} \mu_j \equiv x_k^{2*}$$

$$\mathrm{Var}(\hat{\hat{x}}_{kt} | S_{kt} = 1) = \sum_{j=1}^{j_l} \beta_{lj}^2 \gamma_{jk}^2 \sigma_j^2 \left(\frac{1 - c_j}{1 + c_j}\right) \equiv \mathrm{Var}(x_k^{2*}).$$

x_k^{2*} is, as before, the Secretary's "optimal" or "implicitly preferred" decision outcome, since the Secretary's own problematic preferences as well as the true (but unknown) state of the world are folded in.

However, it is of course not always the case that Secretaries actively intervene. For now I will simply develop the unconditional mean and variance result merely by stating that the probability of Secretarial intervention is $P(S_{kt} = 1)$. The development $P(S_{kt} = 1)$'s explicit dependence on $\hat{x}_{kt}$ and $\Delta\tilde{x}_k$ will be postponed to the next section.

Under this convention, the unconditional expectation of Secretarial recommendation is:

$$E(\hat{\hat{x}}_{kt}) = x_k^{2*} P(S_{kt} = 1) + x_k^{1*} P(S_{kt} = 0)$$
$$= x_k^{1*} + (x_k^{2*} - x_k^{1*}) P(S_{kt} = 1).$$

The unconditional variance result is a bit more complicated:

$$\mathrm{Var}(\hat{x}_{kt}) = \mathrm{Var}(x_k^{1*})P(S_{kt} = 0) + \mathrm{Var}(x_k^{2*})P(S_{kt} = 1) + (x_k^{2*} - x_k^{1*})^2 P(S_{kt} = 1)P(S_{kt} = 0).$$

Repeating these steps for the case of Presidential "recommendations," it is apparent that:

$$E(\hat{x}_{kt}|P_{kt} = 1) = \sum_{j=1}^{j_p} \beta_{pj}\beta_{ij}\gamma_{jk}\mu_j$$

$$\mathrm{Var}(\hat{x}_{kt}|P_{kt} = 1) = \sum_{j=1}^{j_p} \beta_{pj}^2\beta_{ij}^2\gamma_{jk}^2\sigma_j^2\left(\frac{1 - c_j}{1 + c_j}\right).$$

However, in this case the expected outcome of active decision making is *not* equal to the President's own implicit preference, due to the filtering effects caused by Presidential dependence upon advisers to bring "relevant" issues to his or her attention. Rather, implicit Presidential preferences are:

$$x_k^{3*} \equiv \sum_{j=1}^{j_p} \beta_{pj}\gamma_{jk}\mu_j$$

$$\mathrm{Var}(x_k^{3*}) \equiv \sum_{j=1}^{j_p} \beta_{pj}^2\gamma_{jk}^2\sigma_j^2\left(\frac{1 - c_j}{1 + c_j}\right).$$

This fact will become important later in the analysis of Presidential control.

If all of the above results are assembled together, the expected behavior of the organizational system as a whole is as follows:

$$E(x_{kt}) = E(\hat{x}_{kt}|P_{kt} = 1)P(P_{kt} = 1, S_{kt} = 1) + x_k^{2*}P(P_{kt} = 0, S_{kt} = 1) + x_k^{1*}P(P_{kt} = 0, S_{kt} = 0)$$
$$= x_k^{1*} + (x_k^{2*} - x_k^{1*})P(S_{kt} = 1) + (E(\hat{x}_{kt}|P_{kt} = 1) - x_k^{2*})P(P_{kt} = 1).$$

The more tedious variance result is presented in the Appendix.

This result will be used heavily in my investigation into optimal Presidential control strategies. However, on the broadest qualitative level, it is apparent that expected final organizational choices are determined by the patterns of decision flows up the hierarchy, as represented by $P(S_{kt} = 1)$ and $P(P_{kt} = 1)$, and by the implicit conflict within the organization, as represented by differences among x_k^{1*}, x_k^{2*}, and $E(\hat{x}_{kt}|P_{kt} = 1)$. These two process-oriented attributes of the organization, however, do not exist in a vacuum. Internal conflict and decision flows are the interactive result of three sets of social structural factors: (1) external issue environments, as represented by incoming information patterns (μ_j and σ_j^2); (2) personnel ideologies, as represented by problematic preferences (β_{ij} and β_{pj}) and analysts' confidence (c_j); and (3) organizational structure, as represented by centralization policy ($\Delta\bar{x}_k$ and $\Delta\bar{\bar{x}}_k$), standard operating procedures (γ_{jk}), issue access constraints (j_k, j_i and j_p), and jurisdictional assignments of programs to divisions.

Decision Flows

The last major pieces that need to be put into this puzzle before the managerial implications become apparent are the decision flow properties of the model — $P(S_{kt} = 1)$ and $P(P_{kt} = 1)$. Decision flow results will be presented here in their most general forms, which are applicable to any probabilistic pattern of information bombardment whatsoever.

Fully general conclusions, independent of any specific environmental distributional assumptions, can be derived using the Chebyshev inequality:[4]

$P\{|Z| \leq z\} \leq z^{-2}E(Z^2)$.

For our $P(S_{kt} = 1)$ case, this inequality is

$P(S_{kt} = 1) = P\{|\hat{x}_{kt} - x_{kt-1}| \geq \Delta\bar{x}_k\} \leq E[(\hat{x}_{kt} - x_{kt-1})^2]/\Delta\bar{x}_k^2$,

which simplifies to

$P(S_{kt} = 1) \leq \{\mathrm{Var}(x_k^{1*}) + (x_k^{1\wedge} - x_{kt-1})^2\}/\Delta\bar{x}_k^2$.

Hence, the maximum probability that the Secretary will intervene is inversely related to the discretion granted to the program chief (not surprisingly). Also, however, the Secretary is more likely to have to intervene the more volatile the incoming program information inputs are and the farther the program chief's implicit preferences are from the status quo.

As long as $\Delta\bar{x}_k > \Delta\bar{\bar{x}}_k$, no program chief "end runs" to the President are possible in this hierarchical model. Therefore,

$P(P_{kt} = 1) = P(P_{kt} = 1|S_{kt} = 1)P(S_{kt} = 1)$,

and the analogous decision flow result for the case of Presidential intervention is

$$P(P_{kt} = 1) \leq \{\mathrm{Var}(x_k^{2*}) + (x_k^{2*} - x_{kt-1})^2\} \cdot \{\mathrm{Var}(x_k^{1*}) + (x_k^{1*} - x_{kt-1})^2\}/(\Delta\bar{x}_k^2 \cdot \Delta\bar{\bar{x}}_k^2).$$

The implications of these decision flow results are as follows:

(1) The greater the volatility of the environmental information impinging upon the organization, and the less confident analysts are in interpreting this information, the more likely program decisions are to flow upward in the organization's chain of command.

(2) The larger the set of "relevant" issues which are permitted to program level decisions, the greater the upward decision flow.

(3) The more salient program-related issues are to the Secretary, the more likely associated decisions are to be brought to the President's attention.

(4) The greater the underlying conflict in the organization, the more likely program chief and Secretarial preferences are to deviate from previous outcomes. This also causes more decisions to flow up the hierarchy.

Volatility, access, lack of confidence, and issue saliency (high β_{ij}) are four attributes of program heterogeneity, all of which have the consequence of pushing the same programs up the hierarchy over and over again. Even more interestingly, higher level intervention in the face of conflict tends to force the next period's status quo to be farther from the program chief's implicit preference than it otherwise would. This increases the probability of the program chief's next recommendation being "major," and hence of the program decision going up the hierarchy again in the future. Collectively, therefore, these conclusions imply over time that "intervention begets intervention" for both heterogeneity and contagion reasons. This result is parallel to the Cohen, March, and Olsen conclusion that "one would expect decision makers who have a feeling that they are always working on the same

4

The notation here is that Z refers to any arbitrary random variable (with finite variance), and that z refers to any possible fixed outcome of that random variable (Feller, 1971: 151–152).

problems in somewhat different contexts, mostly without results" (1972: 10). In the present model, however, these decision flows can be substantially modulated by structural centralization policy, which is embedded in the $\Delta\bar{x}_k$ and $\Delta\bar{\bar{x}}_k$ rules of discretion.

PRESIDENTIAL CONTROL

We are now at a point where we can investigate the main policy question of this article: Given a garbage can hierarchy, what management strategies should Presidents adopt in order to maximize their own control over the final decision outcomes produced by the organization?

Here, Presidential "loss of control" will be taken to be the expected divergence of the organization's final decision outcome from the President's own implicit preference — that is, $E(x_{kt} - x_k^{3*})$. According to the results presented above, Presidential loss of control equals the following:

$$\begin{aligned} E(x_{kt} - x_k^{3*}) &= E(x_{kt}) - x_k^{3*} \\ &= (x_k^{1*} - x_k^{3*}) + (x_k^{2*} - x_k^{1*})P(S_{kt} = 1) \\ &\quad + (E(\hat{\hat{x}}_{kt}|P_{kt} = 1) - x_k^{2*})P(P_{kt} = 1). \end{aligned}$$

Obviously, the President would like to come up with a set of managerial strategies which minimizes this expression and, if possible, sets it equal to zero. The various strategies to be explored here will be of both the structural and the personnel varieties.

To investigate what set of managerial strategies achieves this $E(x_{kt} - x_k^{3*}) = 0$ goal, let us assume to begin with that access structure and Secretarial personnel are given, and hence that x_k^{1*} and x_k^{2*} are fixed. If the goal is to be achieved, the following relationships must hold between Presidential decision flow and Secretarial decision flow:

$$P^*(P_{kt} = 1) = \frac{(x_k^{1*} - x_k^{3*}) + (x_k^{2*} - x_k^{1*})P^*(S_{kt} = 1)}{(x_k^{2*} - E(\hat{\hat{x}}_{kt}|P_{kt} = 1))}$$

or equivalently,

$$P^*(P_{kt} = 1|S_{kt} = 1) = \frac{(x_k^{1*} - x_k^{3*}) + (x_k^{2*} - x_k^{1*})P^*(S_{kt} = 1)}{(x_k^{2*} - E(\hat{\hat{x}}_{kt} = 1|P_{kt} = 1))P^*(S_{kt} = 1)},$$

(where the notations $P^*(P_{kt} = 1)$ and $P^*(S_{kt} = 1)$ refer to optimal decision flows from the point of view of Presidential control).

To explore the meaning of this equation, consider two extreme examples: a completely dictatorial approach to Presidential control, and a completely hands-off approach to Presidential control. Under the dictatorial regime, Presidents centralize all "power" into their hands by adjusting $\Delta\bar{x}_k$ and $\Delta\bar{\bar{x}}_k$ to make $P(P_{kt} = 1|S_{kt} = 1) = P(S_{kt} = 1) = 1$. Even leaving aside the possible objection that this approach requires virtually an infinite decision-making capacity on the part of the President, substituting these values into the loss of control expression yields

$$E(x_{kt} - x_k^{3*}) = E(\hat{\hat{x}}_{kt}|P_{kt} = 1) - x_k^{3*}.$$

But this expression can never equal zero since, due to the President's lack of omniscience and subsequent dependence upon advisers, $E(\hat{\hat{x}}_{kt}|P_{kt} = 1) \neq x_k^{3*}$. Therefore, the intuitively plausible dictatorial approach at the very least will not be opti-

mal and may indeed be positively disastrous from the President's own point of view, depending upon the strength of the filtering effects induced by $\{\beta_{ij}\}$.

Consider now, the counterintuitive and completely opposite approach — the President makes absolutely no decisions whatsoever ($P(P_{kt} = 1|S_{kt} = 1) = 0$). Under this completely "hands-off" approach, made possible by setting $\Delta\bar{x}_k = \infty$,

$$0 = \frac{(x_k^{1*} - x_k^{3*}) + (x_k^{2*} - x_k^{1*})P^*(S_{kt} = 1)}{(x_k^{2*} - E(\hat{\bar{x}}_{kt} = 1|P_{kt} = 1)P^*(S_{kt} = 1)}$$

$$P^*(S_{kt} = 1) = \left(\frac{x_k^{3*} - x_k^{1*}}{x_k^{2*} - x_k^{1*}}\right).$$

This is a very important result. It states that optimal Presidential control can be achieved, regardless of filtering effects, by adopting a completely hands-off approach and by adjusting Secretarial discretion rules (i.e., centralization policy) according to the above formula. Moreover, this optimal control can be attained without the President doing any decision-making work at all. The only catch is that for this strategy to work, implicit preferences have to be such that the constraint $0 \leq P^*(S_{kt} = 1) \leq 1$ is not violated.

In particular, this hands-off strategy will not necessarily work if

$x_k^{3*} > x_k^{2*} > x_k^{1*}$, if $x_k^{3*} > x_k^{1*} > x_k^{2*}$,

if $x_k^{1*} > x_k^{2*} > x_k^{3*}$, or if $x_k^{2*} > x_k^{1*} > x_k^{3*}$.

This is where personnel and hiring strategies come in. The President's own implicit preferences and the program chief's implicit preferences are fixed (since the program chief behaves according to SOP's). However, this still leaves Presidents free to hire Secretarial advisors according to their own liking. In particular, to maintain complete control and to give themselves plenty of free time to pursue personal interests, Presidents have to hire Secretaries who satisfy either $x_k^{1*} > x_k^{3*} > x_k^{2*}$ or $x_k^{1*} < x_k^{3*} < x_k^{2*}$.

Call programs where $x_k^{3*} > x_k^{1*}$ "high saliency" programs (since Presidents in this case are more favorably disposed toward the program than "need"), and call programs where $x_k^{3*} < x_k^{1*}$ "low saliency" programs (since Presidents here are more conservative than "need"). Then these recommended personnel policies mean that for high saliency programs Presidents should hire Secretaries who are even more liberal than themselves, but for low saliency programs Presidents should hire Secretaries even more conservative than themselves. If a President follows this approach, then he or she can adjust Secretarial discretion rules essentially to "play off" the relatively more conservative program chief against the relatively more liberal Secretary, or vice versa, and can get them collectively to come out with, on average, the President's own implicitly optimal choice. Hence lies the road to nirvana in a world of confusion.

One structural fact, however, can cloud this otherwise rosy picture. If the organization is differentiated in such a way that both high- and low-saliency programs coexist in the same division, then finding a Secretary who is simultaneously more liberal than the President for high saliency programs and more conservative than the President for low saliency programs

may be a very tricky matter. This is not a problem of cognitive dissonance in the Secretary; it is a structural problem induced by the fact that Secretaries are mandated to consider the relevance of all the issues within their jurisdictions, including high saliency issues for low-saliency programs and low-saliency issues for high saliency programs. The Secretary is only one person, whose β_{ij} issue preferences cannot be expected to shift with each program under consideration. And γ_{ij} standard operating procedures are structurally fixed, at least in the short run. Therefore, the recommended Secretarial personnel policy requires the $\beta_{ij} > \beta_{pj}$ terms to exceed in joint effect the $\beta_{ij} < \beta_{pj}$ terms for high-saliency programs (thereby producing $x_k^{2*} > x_k^{3*}$), and just the opposite for low-saliency programs. In general, this may be no mean feat, but it is nonetheless essential to avoid the outcome of high-saliency programs being hurt by their mere membership in a generally low-saliency division (and vice versa).

There are a number of strategic options the President can follow to avoid this problem.

(1) The President can be extremely picky in his or her choice of Secretaries. This, however, is asking the President to walk a possibly extremely narrow tightrope.

(2) The President can try to manipulate the issue access structure in order to minimize Secretarial cross-program issue considerations. This, however, is undercutting the essence of the Secretary's job, which is coordination. Or,

(3) the President can reorganize.

This last approach seems the most desirable. Specifically in his or her reorganization efforts, the President wants insofar as is possible to group only low-saliency programs into divisions and only high-saliency programs into divisions. For then the President can simply hire a generally hard-nosed Secretary or a generally activist Secretary to oversee these respective divisions, with no major problem following. Control will once again be optimized, and the President will have plenty of free time.

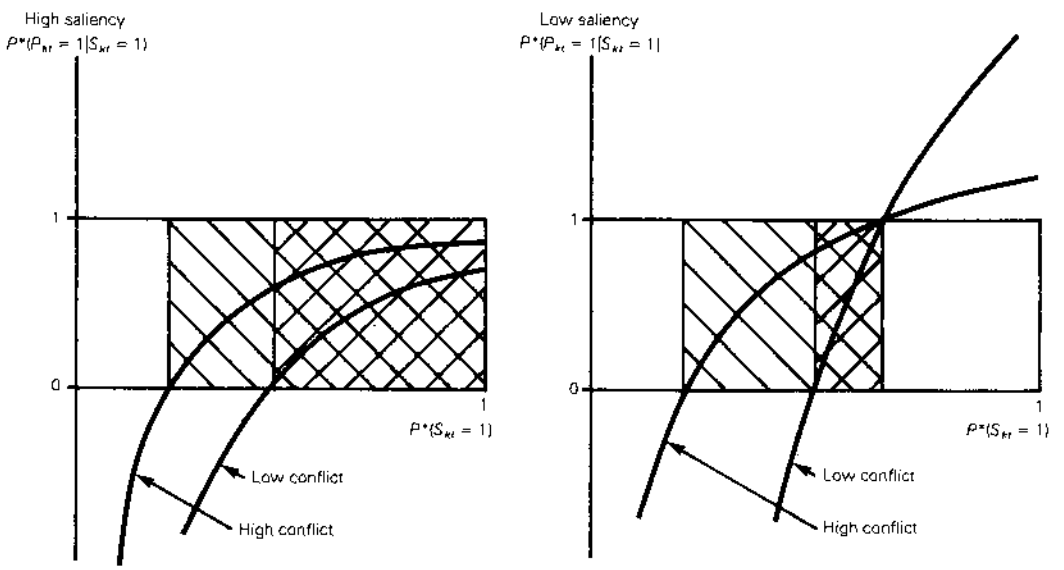

Figure 2. Loci of optimal Presidential control.

As one final note, let us assume that, free time notwithstanding, the President actually wants to make decisions and for symbolic, entertainment, or macho reasons resists the recommended "hands off" policy. How far can the President deviate from this approach without adverse control consequences?

The answer to this question is best illustrated graphically by a simple numerical example. Assume, for purposes of illustration, that $x_k^{3*} = 1.5$ and $E(\hat{x}_{kt}|P_{kt} = 1) = 1.2$. Then two high-saliency programs can be illustrated by $x_k^{1*} = 1.0$ and $x_k^{2*} = 2.0$ (the case of low conflict between program chief and Secretary) and by $x_k^{1*} = 1.0$ and $x_k^{2*} = 3.0$ (the case of high conflict between program chief and Secretary). Likewise, two low-saliency programs can be illustrated by $x_k^{1*} = 2.0$ and $x_k^{2*} = 1.0$ (low conflict) and by $x_k^{1*} = 2.0$ and $x_k^{2*} = 0.0$ (high conflict). With these illustrative numerical parameters, the loci of decision flow strategies necessary to maintain optimal Presidential control are shown in Figure 2. The shaded areas represent the feasible regions of strategy choices.

Hence, while the dictator approach is never feasible, Presidents can indeed intervene somewhat if they so desire and still maintain control. In general, what is required is to liberalize Secretarial discretion rules somewhat, but also to carefully tune Presidential discretion rules to match. Notice, however, that the feasible range for such adjustments is broader for high-saliency programs than it is for low-saliency programs. Also, the greater the conflict between Secretaries and program chiefs, the more feasible Presidential intervention becomes.

So Presidents can intervene moderately into the decision process if they insist and if they are aware of the above constraints. Such intervention, however, definitely strains cognitive capacity more heavily than does the hands-off approach. The hands-off approach only requires knowledge about underlying conflict within the organization, which in principle Presidents can estimate simply by observing patterns of choice within the organization (since $x_k^{1*} = E(\hat{x}_{kt})$ and $x_k^{2*} = E(\hat{x}_{kt}|S_{kt} = 1)$), and by knowing their own problematic preferences. More active Presidential intervention, however, requires the additional knowledge of filtering effects, which may be quite difficult to estimate. The rather steep fall-off of the graphs implies, moreover, that if the President misestimates these filtering effects, loss of control consequences can be rather severe.

Therefore, Presidents who insist on making decisions may do so in moderation, but only if they are aware of the structural as well as the personal biases in the system. The safest and simplest approach remains to stick with the pure hands-off policy.

EXTENSIONS

This stochastic model of a hierarchical garbage can system can be extended in a number of ways. Secretarial filtering can be introduced by letting program chiefs be Secretarial advisers and by giving them their own set of problematic preferences. "Fluid participation" of Secretaries can be introduced by granting them lateral access to issues outside their own ju-

risdictional boundaries. The implications of short-run analyst bias for new programs can be carried through in more detail. Various analyst hiring/firing mechanisms can be investigated.[5]

Only three such questions will be addressed here, however: What if Presidents are constrained in their reorganization flexibility? What if stochastic information inputs are not stationary, but rather have a tendency to drift due to history? What if a President has some other objective besides minimizing loss of control?

If the President cannot reorganize, then the fixity of short-run Secretarial preferences will cause high-salience programs in generally low-saliency divisions to be hurt, and low-salience programs in high-saliency divisions to gain more than is desirable. Some loss of control in this situation is inevitable, and the only issue is how to keep such a loss within bounds. The second-best strategy is to make an exception for these outlier programs only, and to fall back in these cases on one of two approaches: (1) decentralize completely at the program chief level (by $\Delta\bar{x}_k = \Delta\bar{\bar{x}}_k = \infty$) if $|x_k^{1*} - x_k^{3*}| < |E(\hat{\hat{x}}_{kt}) - x_k^{3*}|$, or (2) centralize completely at the Presidential level (by $\Delta\bar{x}_k = \Delta\bar{\bar{x}}_k = 0$) if $|E(\hat{\hat{x}}_{kt}) - x_k^{3*}| < |x_k^{1*} - x_k^{3*}|$. The Secretary, who in these outlier cases will be wildly out of synch with Presidential preferences, must be frozen out.

Of course, it should be reiterated that Presidents who rely heavily upon this "management by exception" approach are Presidents who have lost control of their organization (to the extent $\min(|x_k^{1*} - x_k^{3*}|, |E(\hat{\hat{x}}_k) - x_k^{3*}|)$). Structural reorganization, toward the goal of keeping exceptions to a minimum, should be a high-priority component of the President's job.

The role of history can be investigated within the framework of this model by positing nonstationary information inputs. In the Appendix, I investigate the case of linear time trends — that is, instead of $\xi_{ij} \sim p(\mu_j, \sigma_j^2)$, posit $\xi_{ij} \sim p(t \cdot \mu_j, \sigma_j^2)$. In this case, if the pure hands-off policy is adopted, programs will on average lag behind the world by a fixed amount. This can be interpreted as a tendency toward bureaucratic inertia. If Presidents are not particularly worried about lagging behind the world in this fashion, then they may go ahead and treat the world as if it were stationary. Bias does not cumulate explosively over time.

However, Presidents can in fact do better than this if they want to. The organization can be manipulated into being more "innovative" than it otherwise would, and optimal Presidential control can be maintained at the same time, simply by hiring Secretaries who are even more biased in the liberal direction than they otherwise would be, and by adjusting the hands-off rules of discretion according to the formulas given in the Appendix. Thus, by consciously inducing greater conflict into the system, personnel biases can be used to the advantage of a President interested in forcing a laggard organization to keep up with a changing world.

Finally, what happens if the President is also interested in "keeping programs on an even keel," and therefore in minimizing variance in final choice, as well as in minimizing loss of control? In the Appendix, I investigate one possible Mean Squared Error (MSE) approach to this problem. The results in-

5

The last extension has already been done by Carley (1979) in her APL simulation program which builds upon this model.

dicate that it is usually possible to improve on MSE, and thus increase stability at the cost of greater loss of control, by restricting decision making exclusively to one or another of the three hierarchical levels. The optimal hierarchical level depends upon the idiosyncracies of the program in question, although there will usually be more decentralized programs than centralized programs.

There is one simple reason, however, for why these MSE results, while mathematically accurate, should not be taken seriously. Choice of optimal hierarchical level, according to the MSE criterion, requires an unrealistic amount of accurate information to implement. Not only must implicit conflict and filtering biases be known, but also variances of choice at all levels must be known. However, these multiple-level factors literally are impossible to estimate if choice is restricted to only one level. The costs, moreover, of mistakenly choosing the wrong level of centralization may be quite high. The pure optimization MSE approach has no self-correcting feedback mechanism, as does the hands-off approach which allows $\Delta\bar{x}_k$ to be adjusted in accordance with updated estimates (based on observable choices) of Secretarial and program chief implicit preferences.

The primary value of investigating the alternative MSE objective function, therefore, is to establish that the hands-off approach is usually the second best in terms of stability, in addition to being the best in terms of control. No large stability costs are incurred by the managerial strategy advocated here. The hands-off strategy is simple; it is fairly stable; and it permits continual feedback adjustments without disrupting personnel, using a policy lever over which the President has control (i.e., $\Delta\bar{x}_k$). The strategy implies that Presidents should attend more to structural design and to "ecological control," and less to tactical machinations and decision making.

SUMMARY

This article has had two purposes. On the theoretical level, an attempt was made to extend the recent and highly innovative organized anarchy paradigm to a domain more comprehensible to classical organization theorists. As Perrow (1977) has argued, Cohen, March, and Olsen's "Garbage Can Model of Organizational Choice" seems curiously divorced from the familiar world of hierarchical authority, organizational differentiation, standard operating procedures, and centralization policy known to us all. The present article has proposed a very simple model of a Weberian-type bureaucracy which is nonetheless plagued with ambiguity. Causal interpretation of environments is unclear, and construction of the issue or meaning contexts of choice is both problematic and temporally variable. The flows of issues to choices are central, but these both are embedded within classical bureaucratic chain-of-command constraints and operate through more explicit, if simplified, individual-level models of information processing and decision making. In short, organizations do not have to be idiosyncratic and decoupled in structure for the organized anarchy paradigm to be at least potentially applicable.

On a more practical level, the article has derived a number of managerial recommendations for the President or Chief Executive interested in controlling a confused hierarchy.

(1) Hire rigid analysts for old programs, but hire uncertain and insecure analysts for new programs.

(2) To the extent possible, reorganize program assignments to divisions in order to segregate high-saliency programs from low-saliency programs.

(3) Hire only Secretaries even more liberal than yourself to run your high-saliency divisions, and only Secretaries even more conservative than yourself to run your low-saliency divisions.

(4) *Never make any decisions yourself.* You may do so only at your own risk.

(5) Rather, concentrate instead on manipulating Secretarial rules of discretion (i.e., centralization policy) in order to balance off your conflicting Secretaries and program chiefs.

(6) Don't fight subunit biases and internal conflict. Use them to force your laggard organization to keep up with a changing world.

These policy recommendations amount to "unobtrusive management" in the extreme. The emphasis is on structural design and personnel selection, rather than on tactical machinations. Hierarchical garbage can systems, hence, are best dealt with by attending carefully to personnel and structural matters, and then by walking away from them. Not only does this strategy ensure a President plenty of free time, but also it represents the best chance for maintaining optimal control, from the point of view of his or her own preferences.

These managerial conclusions may appear to be unorthodox. However, the implication of garbage can theory is not to expect orthodoxy where ambiguity is salient, even in the case of a traditional Weberian bureaucracy.

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APPENDIX

A. Nonstationary Information

Instead of $\xi_{ij} \sim p(\mu_j, \sigma_j^2)$, posit the linear time trend: $\xi_{ij} \sim p(t \cdot \mu_j, \sigma_j^2)$. The expected rate of information bombardment each time period is λ_j. Then:

$$
\begin{aligned}
E(A_t|A_{t-n}) &= c_j^{n\lambda_j} A_{t-n} + (1 - c_j^{\lambda_j}) \sum_{k=1}^{n} c_j^{k\lambda_j}(t-k)\mu_j \\
&= c_j^{n\lambda_j} A_{t-n} + \mu_j(1 - c_j^{\lambda_j}) \left\{ t \sum_{k=0}^{n} c_j^{k\lambda_j} - \sum_{k=0}^{n} k c_j^{k\lambda_j} \right\} \\
&= c_j^{n\lambda_j} A_{t-n} + \mu_j(1 - c_j^{\lambda_j}) \left\{ t \left(\frac{1 - c_j^{(n+1)\lambda_j}}{1 - c_j^{\lambda_j}} \right) \right. \\
&\quad \left. - \left(\frac{c_j^{\lambda_j} - (n+1)c_j^{(n+1)\lambda_j} + n c_j^{(n+2)\lambda_j}}{(1 - c_j^{\lambda_j})^2} \right) \right\} \\
&= c_j^{n\lambda_j} A_{t-n} + \mu_j \left\{ t(1 - c_j^{(n+1)\lambda_j}) - \left(\frac{c_j^{\lambda_j}}{1 - c_j^{\lambda_j}} \right) (1 - (n+1)c_j^{n\lambda_j} \right. \\
&\quad \left. + n c_j^{(n+1)\lambda_j}) \right\}.
\end{aligned}
$$

Therefore, as $n \to \infty$,

$$\lim_{n \to \infty} E(A_t) = \mu_j t - \mu_j \left(\frac{c_j^{\lambda_j}}{1 - c_j^{\lambda_j}} \right).$$

Thus, analysts lag behind the "true" state of the world, $\mu_j t$, by a fixed amount. The less confident analysts are, the less the lag.

Define the following preference and lag decision variables:

$$x_k^{1*} \equiv \sum_j \gamma_{jk}\mu_j t; \quad x_k^{1L} \equiv \sum_j \gamma_{jk}\mu_j \left(\frac{c_j^{\lambda_j}}{1 - c_j^{\lambda_j}} \right);$$

$$x_k^{2*} \equiv \sum_j \beta_{1j}\gamma_{jk}\mu_j t; \quad x_k^{2L} \equiv \sum_j \beta_{1j}\gamma_{jk}\mu_j \left(\frac{c_j^{\lambda_j}}{1 - c_j^{\lambda_j}} \right);$$

$$x_k^{3*} \equiv \sum_j \beta_{0j}\gamma_{jk}\mu_j t; \quad x_k^{3F} \equiv \sum_j \beta_{1j}\beta_{0j}\gamma_{jk}\mu_j t; \text{ and } x_k^{3L} \equiv \sum_j \beta_{1j}\beta_{0j}\gamma_{jk}\mu_j \left(\frac{c_j^{\lambda_j}}{1 - c_j^{\lambda_j}} \right).$$

Using this notation, Presidential loss of control equals the following:

$$
\begin{aligned}
E(x_{kt} - x_k^{3*}) &= (x_k^{1*} - x_k^{1L} - x_k^{3*}) + \{(x_k^{2*} - x_k^{2L}) - (x_k^{1*} - x_k^{1L})\}P(S_{kt} = 1) \\
&\quad + \{(x_k^{3F} - x_k^{3L}) - (x_k^{2*} - x_k^{2L})\}P(S_{kt} = 1)P(P_{kt} = 1|S_{kt} = 1).
\end{aligned}
$$

This implies the following relationship among optimal decision flows:

$$P^*(P_{kt} = 1|S_{kt} = 1) = \frac{(x_k^{1*} - x_k^{1L} - x_k^{3*}) + \{(x_k^{2*} - x_k^{2L}) - (x_k^{1*} - x_k^{1L})\}P^*(S_{kt} = 1)}{\{(x_k^{2*} - x_k^{2L}) - (x_k^{3F} - x_k^{3L})\}P^*(S_{kt} = 1)}.$$

The optimal hands-off Presidential strategy is:

$$P^*(S_{kt} = 1) = \frac{(x_k^{3*} - x_k^{1*} + x_k^{1L})}{(x_k^{2*} - x_k^{2L} - x_k^{1*} + x_k^{1L})}; \text{ and } P^*(P_{kt} = 1|S_{kt} = 1) = 0.$$

Therefore, the hands-off strategy is still feasible for the case of linear nonstationary information, as long as the following Secretarial hiring constraints are fulfilled:

(1) If the program is high saliency $(x_k^{3*} > x_k^{1*})$, then

$$(x_k^{2*} - x_k^{2L}) > x_k^{3*} > x_k^{1*}.$$

That is, the Secretary not only must be more liberal than the President $(x_k^{2*} > x_k^{3*})$, but also must be at least x_k^{2L} more liberal than the President.

(2) If the program is low saliency $(x_k^{3*} < x_k^{1*})$, but also experiences very large lags due to rapid historical change (i.e., $x_k^{3*} > x_k^{1*} - x_k^{1L}$), then

$$(x_k^{2*} - x_k^{2L}) > x_k^{3*} > x_k^{1*} - x_k^{1L}.$$

Interpretation is as before.

(3) If the program is low saliency $(x_k^{3*} < x_k^{1*})$, but only experiences moderate lags (i.e., $x_k^{3*} < x_k^{1*} - x_k^{1L}$), then

$$(x_k^{2*} - x_k^{2L}) < x_k^{3*} < x_k^{1*} - x_k^{1L}.$$

Secretaries must be more conservative than $x_k^{2*} + x_k^{2L}$.

Thus, more liberal Secretarial biases can be used to offset analyst inertia. Laggard organizations can be forced to keep up with a changing world.

B. Alternative Mean Squared Error Criterion

Variance of final organization choice in the stationary case is as follows:

$$\begin{aligned}\mathrm{Var}(x_{kt}) = {} & \mathrm{Var}(x_k^{1*}) + \{(\mathrm{Var}(x_k^{2*}) - \mathrm{Var}(x_k^{1*})) + (x_k^{2*} - x_k^{1*})^2\}P(S_{kt} = 1) \\ & + \{(\mathrm{Var}(\hat{\hat{x}}_{kt}) - \mathrm{Var}(x_k^{2*})) + (E(\hat{\hat{x}}_{kt}) - x_k^{2*})(E(\hat{\hat{x}}_{kt}) + x_k^{2*} - 2x_k^{1*})\} \\ & \cdot P(P_{kt} = 1) - \{(x_k^{2*} - x_k^{1*})P(S_{kt} = 1) + (E(\hat{\hat{x}}_{kt}) - x_k^{2*})P(P_{kt} = 1)\}^2.\end{aligned}$$

The Mean Squared Error (MSE) objective function is:

$$\mathrm{MSE}(x_{kt}) = \mathrm{Var}(x_{kt}) + E(x_{kt} - x_k^{3*})^2.$$

Given these complicated expressions, it can be shown that the following alternative decision strategies yield MSE's as follows:
(1) Decisions centralized exclusively at the program chief level (i.e., $P(S_{kt} = 1) = P(P_{kt} = 1) = 0$) yield:

$$\mathrm{MSE}(x_{kt}) = \mathrm{Var}(x_k^{1*}) + (x_k^{1*} - x_k^{3*})^2.$$

(2) Decisions centralized exclusively at the Secretarial level (i.e., $P(S_{kt} = 1) = 1$ and $P(P_{kt} = 1) = 0$) yield:

$$\mathrm{MSE}(x_{kt}) = \mathrm{Var}(x_k^{2*}) + (x_k^{2*} - x_k^{3*})^2.$$

(3) Decisions centralized exclusively at the Presidential level (i.e., $P(S_{kt} = 1) = P(P_{kt} = 1) = 1$) yield:

$$\mathrm{MSE}(x_{kt}) = \mathrm{Var}(\hat{\hat{x}}_{kt}) + (E(\hat{\hat{x}}_{kt}) - x_k^{3*})^2.$$

(4) The hands-off strategy (i.e., $P(P_{kt} = 1) = 0$ and $P(S_{kt} = 1) = [x_k^{3*} - x_k^{1*}]/[x_k^{2*} - x_k^{1*}]$) yields:

$$\begin{aligned}\mathrm{MSE}(x_{kt}) = {} & \left(\frac{x_k^{2*} - x_k^{3*}}{x_k^{2*} - x_k^{1*}}\right)\mathrm{Var}(x_k^{1*}) + \left(\frac{x_k^{2*} - x_k^{1*}}{x_k^{2*} - x_k^{1*}}\right)\mathrm{Var}(x_k^{2*}) \\ & + (x_k^{3*} - x_k^{1*})(x_k^{2*} - x_k^{3*}).\end{aligned}$$

Not surprisingly, the hands-off MSE is essentially a weighted average of approaches (1) and (2).

The usual empirical case is $\mathrm{Var}(x_k^{1*}) < \mathrm{Var}(x_k^{2*}) < \mathrm{Var}(\hat{\hat{x}}_{kt})$, since the expected number of issues considered typically increases as one goes up the hierarchy. Thus, decentralization at the program chief level will usually yield the most stable (lowest variance) choice outcomes, and the hands-off approach will yield the second most stable choice outcomes.

The minimum MSE strategy can be calculated from the above formulas if one knows conflict, filtering, and choice variances at all levels. However, as is mentioned in the text, practical estimation of all of these factors is exceedingly problematic if choices are restricted exclusively to one level. The MSE approach requires omniscience to implement, and the stability of the hands-off strategy is usually second best in any event.