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4 August 2009

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August 4, 2009

Abstract

We reconstruct Cohen, March and Olsen's Garbage Can model of organizational choice as an agent-based model. In the original model, the members of an organization can postpone decision-making. We add another means for avoiding making decisions, that of buck-passing difficult problems to colleagues. We find that selfish individual behavior, such as postponing decision-making and buck-passing, does not necessarily imply dysfunctional consequences for the organizational level.

The simulation experiments confirm and extend some of the most interesting conclusions of the Garbage Can model: Most decisions are made without solving any problem, organization members face the same old problems again and again, and the few problems that are solved are generally handled at low hierarchical levels. These findings have an implication that was overseen in the original model, namely, that top executives need not be good problem-solvers.

Keywords: Organizational Decision Making, Garbage Can Model, Postponing Decisions, Buck-Passing

1 Introduction

The Garbage Can Model of organizational decision-making proposed by Cohen, March and Olsen in 1972 (henceforth GCM) [4] is possibly the most widely cited article in simulation-based Organization Science. It is also the best known example of a piece of organizational theory developed through computer simulation. In the original article, verbal theoretical statements are followed by a fairly detailed explanation of the corresponding lines of computer code, and these details entail important theoretical assumptions. Simulation results are presented as the implications of the theory, and the code is made publicly available as an appendix.

However, in the subsequent decades the example of the GCM has been rarely imitated. A large parte of Organization Theory ignored Computational Science, and the GCM itself has been seldom discussed in its computational details. Its conclusions have been quoted as pertaining to a paradoxical world, and the GCM has been understood as the prototype of what an organization *should not* be.

With this article we want to show that the GCM highlights surprising but logical consequences of sensible assumptions, and that both assumptions and consequences are deeply rooted in organizational theory and practice. We do so by re-writing the GCM as an agent-based model, which is a straightforward operation because the GCM is perhaps the first example of an organization theory developed explicitly through hypotheses about the behavior of discrete objects (our agents) rather than hypotheses on relations among variables.

In reproducing the original GCM we realized that the original model is at the same time incomplete and redundant. It is incomplete in the scope of the hierarchical structures that it assumes, and at the same time redundant in the kinds of structures that it allows to the experimenter. The model is also redundant in the number of indicators that it adopts as measures of performance. We corrected these obvious shortcomings by limiting the model to those structures that produce interesting results, by enabling all agents in the model to adopt these structures, and by devising a minimum number of indicators that capture all interesting properties of the model.

The original GCM has a means for avoiding a difficult problem, which consists of attaching it to another opportunity for decision-making. We interpreted this mechanism as postponing decision-making, and we remarked that the literature [10] has identified *two* means for avoiding a difficult problem, namely, (*i*) postponing decision-making, and (*ii*) passing it to someone else. The original GCM did not implement buck-passing, but our agent-based GCM can easily do it. We found the surprising implication that organizations may be more similar to markets than previously thought. In fact, it appears that selfish behavior, such as postponing decisions as well as buck-passing, may be beneficial for the organization as a whole. As in the case of markets, a kind of invisible hand seems to be at work.

The rest of this article is organized as follows. Section (2) describes the main features of the original GCM, while section (3) expounds our agent-based setting. Section (4) illustrates our extensions to the basic GCM. Section (5) points to the new issues that our extended GCM identifies and allows to investigate. Section (6) illustrates our results. Finally, section (7) discusses our results and embeds them within wider considerations.

2 Cohen, March and Olsen's Garbage Can

According to Cohen, March and Olsen [4], Garbage Can -like decision situations are induced by the simultaneous presence of three elements. The first is *fluid participation*. Fluid participation means that the attention that participants typically dedicate to any one issue is highly variable. This notion also captures the observation that organizational members tend to enter and exit decision situations according to processes that are not necessarily related to the problems at hand. The second factor is *unclear decision technology*. Unclear decision technology refers to the fact that causal relations underlying specific organizational decision problems are frequently ambiguous, and only ex-post are reconstructed in the form of well specified means-end chains [11] [13]. The third factor is *problematic preferences*, a term that Cohen, March and Olsen introduced to capture the general tendency of decision makers to discover their preferences through action rather than acting on the basis of pre-defined and unchanging preferences [4]. Organizations characterized by fluid participation, unclear decision technologies and problematic preferences were labeled by Cohen, March and Olsen "organized anarchies" [4].

Four classes of agents populate the GCM: participants (decision-makers), choice opportunities, solutions and problems. All these agents exist independently of one another and, although they might disappear as a consequence of decision-making, their existence is independent of time. Note that the assumption that solutions exist independently of problems is a clear departure from the assumptions of rational decision-making, implying that solutions are schemes that decision-makers apply to any problem they meet rather than specific responses to specific problems.

According to the GCM, decision situations characterized by fluid participation, unclear decision technology and problematic preferences generate three possible outcomes, only two of which are decision styles: [1]

- The first decision style is characterized by the fact that a problem is actually solved. This is called decicion-making *by resolution*. It is the only decision style considered legitimate by the theory of rational decision-making [16]. According to the GCM, decisions are made by resolution if: (*i*) the participants to the decision process are sufficiently able; (*ii*) a sufficiently efficient solution is available to them, and (*iii*) the problems that they are called to solve are sufficiently simple.
- The second decision style is defined by decisions that are made without any attention to existing problems. It is just sufficient that a participant, a choice

[1] Our interpretation of resolution, oversights and flights rests on the verbal description of the GCM made by Cohen, March and Olsen at the beginning of their paper [4]. Subsequently, Cohen, March and Olsen start to call flights "a third decision style." This happens because, at a certain point, they assume that all flights generate resolutions: "Some choices involve both flight and resolution — some problems leave, the remainder are solved. These have been defined as resolution, thus slightly exagerating the importance of that style. As a result of that convention, the three styles are mutually exclusive and exhaustive with respect to any one choice." We shall see that assuming that all flights cause resolutions is by no means a "slight exageration." Apart from this, calling flights "a decision style" creates a sharp divide between the introductory conceptual claims and the computational model. This confusion is responsible of many misunderstandings in the subsequent litterature.

opportunity and a solution are there: no problem is solved, because no problem is considered. Cohen, March and Olsen called this decision style *by oversight*. We interpret decisions by oversight as due rituals that confirm the legitimacy of an organization, as highlighted by the neo-institutional litterature [12] [7]. They make sense because any organization is embedded in a wider society, that requires them. As a typical example one may think of a firm that complies with screening procedures in order to obtain a favorable classification by a rating agency, though these procedures do not provide any immediate benefit. More in general, compliance to safety, environmental, fiscal and many other institutional rules helps gaining acceptance, recognition and trust by stockholders, banks, the Government and the general public.

The third outcome, *flight*, is no decision in itself. It is a means to escape from too difficult a problem.

In Cohen, March and Olsen's GCM, participants shy away from a difficult problem by removing the most difficult problem from the agenda of the current choice opportunity to attach it to another choice opportunity, one that will be due at a later time. We interpret this procedure as postponing decision-making. Once the most difficult problem is no longer under consideration, a participant can easily make a decision on the remaining problems.

The participants in the GCM are characterized by an "ability" as as decision-makers [2], the solutions are endowed with "efficiency", and problems have a "difficulty" [3]. Let A_i denote the ability of the ith participant. Let e_j denote the efficiency of the jth solution. Let D_k denote the difficulty of the kth problem. Let us consider a generic opportunity for decision-making and let us denote it by an index l.

A decision is made by resolution if at least one participant, at least one solution and at least one problem are attached to opportunity l, and if the sum of the abilities of these participants, multiplied by the efficiency of the most efficient among these solutions, is greater than or equal to the sum of the difficulties of these problems:

$$\left(\sum_{I \in I_l} A_i \right) \max_{j \in \mathcal{J}_l} e_j \ \geq \ \sum_{k \in \mathcal{K}_l} D_k \tag{1}$$

where I_l is the set of participants on opportunity l, $\mathcal{J}_l$ is the set of solutions on opportunity l and $\mathcal{K}_l$ is the set of problems on opportunity l.

In contrast, a decision is made by oversight if at least one participant and at least one solution are attached to opportunity l, but no problem is attached to l. Neither the ability of participants nor the efficiency of solutions matter in this case. If several solutions are available, one of them is selected at random.

There remains the case where at least one participant, at least one solution and at least one problem are attached to opportunity l, but condition 1 is not satisfied. In this case, participants are blocked on an opportunity plagued by too difficult problems.

On such occasions, participants may decide to get rid of difficult problems. A flight occurs when participants succeed to attach the most difficult problem to a different

[2] "Ability" was actually called "energy" in the original model

[3] "Difficulty" was also called "energy" in the original model

opportunity. If the remaining problems are sufficiently simple, a decision is then made by resolution. If no problem is left after the flight, a decision is made by oversight. If the remaining problems are still sufficiently difficult to block any decision, another flight will be attempted on the next occasion.

The basic GCM described so far has no organizational structure in any conventional sense. In order to overcome this shortcoming Cohen, March and Olsen devised the possibility that either opportunities and participants, or opportunities and problems, or all of them together, receive an exogenous ordering by "importance". The *decision structure* specifies which participants are allowed to make a decision in which choice opportunities (e.g., only the directors may be allowed to attend the board of directors). The *access structure* specifies which problems can access which opportunities (e.g., shop-floor problems may not be allowed to reach the CEO).

3 An Agent-Based Garbage Can Model

The computational model designed by Cohen, March and Olsen [4] has been criticized for being a loose mapping of the underlying theoretical narrative [1]. In fact, the computational model does not have an independent set of solutions (only participants, opportunities and problems interact), it is tailored to a very special sequence of opportunities and problems entering the organization and, most importantly, it is designed so that at each step all participants and all problems will converge on one single opportunity.

Given these deficiencies, all conclusions concerning the meetings of participants and problems do not emerge out of the theoretical assumptions but are hard-wired in the model [1]. Furthermore, the emergent properties of the model may not correspond to its theoretical assumptions. Thus, we set out to design a computational model where participants, opportunities, solutions and problems are autonomous agents that interact in a virtual space as the verbal statements of the GCM suggest.

In our view, a substantial part of the deficiencies of the original implementation of the GCM stem from the fact that it is a piece of procedural code (FORTRAN). In 1972, this was this was the only possible choice. However, the GCM has a feature that makes it quite ahead of its time. Rather than specifying a set of equations, it defines a set of agents that interact with one another: the participants, the opportunities, the solutions and the problems. Two decades in advance, the GCM was specified as an agent-based model, and we claim that an agent-based implementation is more faithful to the spirit of the GCM than the original procedural implementation of Cohen, March and Olsen [4].

An agent-based implementation allows to represent decision-making as random encounters of basic components as envisioned by Cohen, March and Olsen's verbal theory. In this setting, it is easy to avoid the simplifications and unwarranted assumptions that plague the original implementation.

In our agent-based GCM, participants, opportunities, solutions and problems are placed on a torus. A lattice is superimposed on the torus; agents are necessarily at the center of the lattice square where they are. Agents eventually move by one square during one simulation step, either north, east, west or south of their current position.

Agents meet if they find themselves on the same square. If at least one participant, an opportunity and at least one solution are on the same square, and no problem is there, then a decision by oversight is made. If it happens that at least one participant, an opportunity, at least one solution and at least one problem are on the same position, and the inequality 1 is satisfied, then a decision is made by resolution.

If, on the contrary, the ability of participants is not sufficient given the difficulty of problems and the efficiency of solutions, then decision-making is blocked. As we shall see in the ensuing § (4), a blocked decision process may be unlocked by a flight.

Our computational tool enables a thorough exploration of the GCM-style of decision-making. The user of the model can choose whether participants, opportunities, solutions or problems exit the organization after a decision is made. Exogenous in- or outflows of participants, opportunities, solutions and problems can be added to the endogenous dynamics of the model. Ability, difficulty and efficiency can be distributed to participants, problems and solutions according to several deterministic or stochastic criteria. Finally, hierarchical structures can be imposed on the basic model.

Our agent-based model is based on the *NetLogo* platform. [4] A detailed description of the commands is available in the "Information" section of our simulator, as well as in [8], publicly available on-line. The ensuing § (4) explains what features pertain to the original GCM and what improve on it.

4 Theoretical Improvements

Besides transposing the original GCM in an agent-based framework, we improved on it in two respects. The first one concerns the structures that can be imposed upon the model. The second one concerns the mechanism by which flights take place.

4.1 Anarchies and Hierarchies

In the original GCM, certain exogenous structures could be imposed upon the model. First, opportunities, participants and problems were ranked. Subsequently, one could eventually forbid participants of lower rank to exploit opportunities of higher rank (decision structure), or forbid problems of lower rank to be handled in opportunities of higher rank (access structure). In both cases, imposing a structure means specifying what participants and problems of given rank can do with respect to opportunities of given rank.

Symmetry and completeness require that a similar structure can be imposed to solutions as well. Thus, we introduced an *availability structure* that specifies what solutions are available on what opportunities.

Once participants, opportunities, solutions and problems are ranked the following structures can be imposed on our new agent-based version of the GCM:

[4] *NetLogo* is available at: <http:// ccl.northwestern.edu/ netlogo>. The code of our model is available on the *NetLogo* web site under the rubric *NetLogo User Community Models*, as well as on a web page devoted to computer code for the GCM: <http:// www.cs.unibo.it/ ∼fioretti/ garbageCan>. The code is distributed under the GNU public license.

Decision Structure A decision structure specifies which opportunities each participant is allowed to explore;

Availability Structure An availability structure specifies which solutions can be available at each opportunity;

Access Structure An access structure specifies which opportunities can be accessed by each problem.

In our new agent-based version of the GCM, each of these structures can take one of the following forms:

Anarchy A decision structure is an anarchy if any participant is allowed to make decisions on any choice opportunity. An availability structure is an anarchy if any solution can be employed in any choice opportunity. An access structure is an anarchy if any problem can access any opportunity.

Hierarchy A decision structure is a hierarchy if participants are only allowed to make decisions on choice opportunities that are equally or less important than their own hierarchical level. An availability structure is a hierarchy if solutions are only allowed to enter choice opportunities that are equally or less important than their own hierarchical level. An access structure is a hierarchy if problems are only allowed to access opportunities that are equally or less important than their own hierarchical level.

Figure (1) illustrates a decision structure, an availability structure and an access structure for an anarchy and a hierarchy, respectively. As in Cohen, March and Olsen's GCM, structuring requires that there are at least as many opportunities as participants, solutions and problems, respectively.

Both the anarchy (with the name of "non-segmented structure") and the hierarchy existed in Cohen, March and Olsen's GCM [4]. We deem that "anarchy" is an apprpriate name, also because called the organizational arrangement ensuing from a non-segmented structure an "organized anarchy".

Cohen, March and Olsen's GCM included also a third possibility, called "specialized structure". If the decision structure was specialized, partcipants were allowed to make decisions on opportunities of exactly their same rank, but not on opportunities of lower rank. The specialized access structure had a similar meaning. We dropped specialized structures after checking that they do not yield qualitatively different results from hierarchical structures [8] [9].

Drawing from the original model by Cohen, March and Olsen [4], we consider the three following distributions of ability, efficiency and difficulty in our improved agent-based GCM:

Random Abilities are randomly distributed to participants according to a uniform distribution. Efficiencies are randomly distributed to solutions according to a uniform distribution. Difficulties are randomly distributed to problems according to a uniform distribution.

A N A R C H Y

	opportunities							opportunities							opportunities					
participants	1	1	1	1	1	1	solutions	1	1	1	1	1	1	problems	1	1	1	1	1	1
	1	1	1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1
	1	1	1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1
	1	1	1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1
	1	1	1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1
	1	1	1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1

H I E R A R C H Y

	opportunities							opportunities							opportunities					
participants	1	1	1	1	1	1	solutions	1	1	1	1	1	1	problems	1	1	1	1	1	1
	0	1	1	1	1	1		0	1	1	1	1	1		0	1	1	1	1	1
	0	0	1	1	1	1		0	0	1	1	1	1		0	0	1	1	1	1
	0	0	0	1	1	1		0	0	0	1	1	1		0	0	0	1	1	1
	0	0	0	0	1	1		0	0	0	0	1	1		0	0	0	0	1	1
	0	0	0	0	0	1		0	0	0	0	0	1		0	0	0	0	0	1
	decision structure							**availability structure**							**access structure**					

Figure 1: In the decision structure, ones (zeros) mean that the participant in the corresponding row is (not) allowed to make a decision in the opportunity on the corresponding column. In the availability structure, ones (zeros) mean that the solution in the corresponding row can (not) be used in the opportunity on the corresponding column. In the access structure, ones (zeros) mean that the problem in the corresponding row can (not) be handled in the opportunity on the corresponding column. The figure illustrates an example with six participants, six opportunities, six solutions and six problems.

Competence If a hierarchical structure is imposed on participants, those participants that are higher up in the hierarchy have the greatest ability. If a hierarchical structure is imposed on solutions, those solutions that are higher up in the hierarchy have the greatest efficiency. If a hierarchical structure is imposed on problems, those problems that are higher up in the hierarchy have the greatest difficulty.

Incompetence If a hierarchical structure is imposed on participants, those participants that are higher up in the hierarchy have the lowest ability. If a hierarchical structure is imposed on solutions, those solutions that are higher up in the hierarchy have the lowest efficiency. If a hierarchical structure is imposed on problems, those problems that are higher up in the hierarchy have the lowest difficulty.

The random distribution is an extension of the case where, in Cohen, March and Olsen's GCM [4], all participants had the same ability, all solutions had the same efficiency (represented by an aggregate efficiency coefficient), and all problems had the same difficulty [5]. Cohen, March and Olsen's case can be obtained by selecting the same values for the two extremes of the uniform random distribution.

The distribution by competence [6] implements the way ability, efficiency and difficulty should be assigned according to common wisdom, i.e., those participants who are high in a hierarchy should be the most able to solve problems, the most efficient solutions should be available to them, and these people should be concerned with the most difficult problems. In the original GCM efficiency could not be assigned by competence, for solutions were subsumed by an aggregate coefficient. It appears that endowing the GCM with heterogeneous solutions is a due extension, which brings the GCM closer to its verbal theoretical statements.

The distribution by incompetence [7] implements the opposite rationale, i.e., those participants who are high up in a hierarchy should be the least able to solve problems, only the least efficient solutions should be available to them, and these people should be only concerned with the least difficult problems. These arrangements may seem paradoxical, but they actually reflect a deep understanding of organizational decision-making. In fact, those who are on top of a hierarchy may be called to make those very important decisions by oversight that legitimate the organization in front of its stakeholders. In order to do so, they do not need to be able to solve problems — a popular dictum says that the managers are those who entertain guests while the others are working. As in the previous case, the possibility of assigning heterogeneous efficiency was not contemplated by Cohen, March and Olsen's GCM.

All three distributions of ability, efficiency and difficulty did exist in the original GCM, though they were not labelled with these names. However, Cohen, March and Olsen did not explore the implications of the distribution by incompetence. On the contrary, we discovered that a comparison between the distribution by competence and the distribution by incompetence offers profound insights.

[5] The random distribution was labelled "1" in Cohen, March and Olsen's GCM.

[6] The distribution by competence was labelled "0" in Cohen, March and Olsen's GCM.

[7] The distribution by incompetence was labelled "2" in Cohen, March and Olsen's GCM.

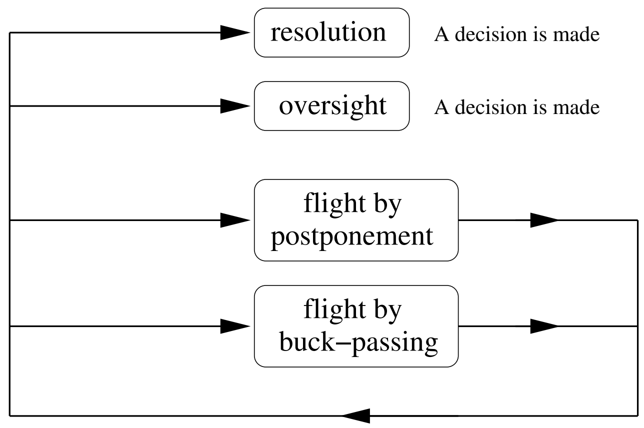

Figure 2: The flow chart of the GCM with two kinds of flight: flight by postponement and flight by buck-passing. Resolutions and oversights mark the end of a decision process, whereas flights make it start again.

4.2 Postponement and Buck-Passing

In Cohen, March and Olsen's GCM, a flight from a difficult problem could only occur by attaching the difficult problem to another opportunity, which amounts to postpone the problem. However, the subsequent litterature on organizational decision-making suggests that a second mechanism may serve the same aim. This second mechanism is buck-passing [10]. A flight by buck-passing would mean that a participant attaches a difficult problem to another participant, rather than to another opportunity.

Possibly, buck-passing was not explored in the original model because participants moved in block from one opportunity to another, a circumstance that has been sharply criticized because it is clearly at odds with the verbal theoretical statements of the GCM [1]. On the contrary, buck-passing can be easily implemented in our agent-based version, where no such distortion exists.

Figure (2) depicts a flowchart of postponing decision-making, buckpassing, making decisions by resolution and making decisions by oversight. Its purpose is to make clear that flights are not styles of decision-making, but rather tricks that may enable decision-making at a subsequent step.

A flight by postponement takes place when a second opportunity comes across a blocked decision process. One of the blocked problems is attached to one of the two opportunities, and goes away with it. If the blocked problems have different difficulties, then the most difficult among the blocked problems is selected. If opportunities are ordered by a hierarchical structure, then the least important among the two available opportunities is selected.

A flight by buck-passing takes place when a second participant comes across a blocked decision process. One of the blocked decision problems is attached to one of the two participants, and goes away with it. If blocked problems have different difficulties, then the most difficult among the blocked problems is selected. If the two participants have different abilities, then the most difficult among the blocked problems is attached to the least able participant.

We chose to have flights by buck-passing as the second alternative to flights by postponement. That is, if both a second opportunity and a second participant become available at a blocked decision process, then the most difficult among the problem is attached to an opportunity and goes away with it (flight by postponement); if, after doing so, the decision process is still blocked, then the most difficult among the blocked problems is attached to the least able participant (flight by buck-passing). However, this is quite an unlikely case.

In our agent-based version of the GCM we want to explore what happens if both flights by postponement and by buck-passing are allowed, as well as what happens if only one kind of flight is allowed. Note that if flights by buck-passing are allowed, the very nature of blocked decision processes is modified. In fact, if flights by buck-passing are not allowed it may occur that several participants are blocked on a decision process. On the contrary, if flights by buck-passing are allowed this possibility cannot occur for each participant receives a problem to go away with.

5 What to Look For

Cohen, March and Olsen concluded from their simulations that organizational decision-making is characterized by eight properties, of which the following five were confirmed by subsequent tests [4] [8] [9]: [8]

1. Only a few decisions solve problems. Most decisions are made by oversight.
2. If opportunities are ordered by importance (i.e., if there is a hierarchy), then the most important opportunities are least likely to solve problems.
3. Participants and problems chase one another across choice opportunities. Thus, the participants have the impression of facing always the same problems.
4. In an organized anarchy some problems stay unsolved for a long time, independently of the structures of decisions and accesses.
5. The efficiency (number of decisions by resolution) of an organization depends on the difficulty of the problems that it is called to solve.

The first three properties point to very interesting features of organizational decision-making. They may be rephrased and commented as follows:

1. Decisions by oversight are very common, much more common than decisions made in order to solve problems. This result suggests that the rational mode of decision-making is a very rare case. Most decisions are socially induced acts made with the purpose of obtaining legitimacy by conforming to required rituals.

[8] The sequence and numbering of these properties is neither as in [4], nor as in [8] [9].

2. If there is a hierarchy, then top executives are busy with gaining legitimacy for their organization by means of decisions by oversight, whereas the bottom line cares about solving problems.

3. Organizations make themselves busy with a few problems that present themselves again and again. So participants have the impression of facing always the same problems.

On the contrary, properties (4) and (5) are much less interesting. In fact, property (4) is implied by property (3), for if problems are met again and again, then they stay unsolved for a long time. Property (5) is quite obvious, for difficult problems make decisions by resolution rare.

Henceforth, properties (4) and (5) will be ignored. We shall focus on properties (1), (2) and (3) instead, which entail interesting insights for organizational decision-making.

Cohen, March and Olsen supported their claims by means of twenty-one indicators [4]. Most of them are redundant, and strongly correlated with one another. Henceforth, we shall test each property by means of one single indicator especially designed to highlight it.

Property (3) deserves a special discussion. Cohen, March and Olsen presented it as an outcome of the model, but they actually embedded it explicitely in their algorithm. This fact has been sharply criticized in the subsequent literature [1], and never settled in spite of a reply by Olsen himself [13]. In our agent-based GCM, we are able to oberve (3) as an emergent property arising naturally from the assumption of the model. [9]

In the end, the three properties (1), (2) and (3) will be analyzed by means of the following three indicators:

1. Property (1) will be proven by observing the fraction of decisions that are made by oversight and by resolution;

2. Property (2) will be proven by comparing the ratio of decisions by oversight to decisions by resolution at low and high hierarchical levels;

3. Property (3) will be proven by comparing: (*i*) the ratio of meetings between participants and opportunities that they already met, to total meetings between participants and opportunities; (*ii*) the ratio of meetings between participants and solutions that they already met, to total meetings between participants and solutions, and (*iii*) the ratio of meetings between participants and problems that they already met, to total meetings between participants and problems.

The following magnitudes will be observed. Some of them will be used to compute the above indicators. Others have been added in order to provide a better picture of the decision process:

[9] In previous publications [8] [9], where we aimed at reproducing an agent-based GCM that would be as close as possible to the original model, we were bound to use Cohen, March and Olsen's twenty-one indicators. Thus, although we did derive (3) as an emergent property, we had to prove it by means of an approximate analytical procedure.

- The number of decisions by resolution, the number of decisions by oversight, the number of flights by postponement and the number of flights by buck-passing;
- The average number of blocked decision processes and their average size (number of agents involved), as well as number of agent *not* involved in blocked decision processes per simulation step;
- The average number pairs opportunity-problem (stemming from flights by postponement) and the average number of pairs participant-problem (stemming from flights by buck-passing) during a simulation step;
- The average life of blocked decision processes, of pairs opportunity-problem and of pairs participant-problems, measured in terms of simulation steps;
- If there is a hierarchy, the number of decisions by oversight and by resolution taking place at opportunities ranked in the lower half and the upper half of importance, respectively;
- The number of meetings between participants and opportunities, solutions and problems and the number of meetings with opportunities, solutions and problems that they have already met, summed over all 5,000 simulation steps.

6 The Simulations

We carried out simulations with 100 participants, 100 opportunities, 100 solutions and 100 problems. We imposed that opportunities, solutions and problems die once they had been involved in decision-making, but not participants. This choice has been made because it allows to check whether participants meet the same problems again and again, as well as the same solutions and the same opportunities.

Whenever opportunities, solutions and problems died, they were immediately replaced with agents created with the same initial conditions. This makes sense, because an organization continuously faces new problems that arise in its environment, conceives new solutions and finds new opportunities for making a choice.

With these assumptions, the number of agents was constant over time. Each run lasted 5,000 steps. Values were obtained by averaging the outcomes over 100 runs.

The following arrangements will be explored in the corresponding subsections. In all arrangements ability and difficulty range in the $[0, 10]$ interval, whereas efficiency ranges in the $[0, 1]$ interval.

- Anarchical decision structure, anarchical availability structure and anarchical access structure, with random assignments of ability, efficiency and difficulty to participants, solutions and problems, respectively. This arrangement is closest to Cohen, March and Olsen's "organized anarchy", to which no structure is imposed. The only difference is that ability, efficiency and difficulty are assigned at random rather than being homogeneous across participants, solutions and problems, respectively. Thus, we call this arrangement the "random anarchy".

- Hierarchical decision structure, hierarchical availability structure and hierarchical access structure. Common wisdom is that those who are high in the hierarchy should be more competent than those who are low in the hierarchy, that the most efficient solutions should be available to them and that they should deal with the most difficult problems. In this arrangement, ability, efficiency and difficulty are assigned according to this rationale. We call it the "competent hierarchy".
- Hierarchical decision structure, hierarchical availability structure and hierarchical access structure, with ability, efficiency and difficulty assigned with the opposite criterium as above. So the decision-makers who are on top of a hierarchy are the least able to solve problems, they apply inefficient solutions and they make themselves busy with the easiest among available problems. In this arrangement, ability, efficiency and difficulty are assigned according a rationale that we call the "incompetent hierarchy". Awkward as it may appear at first sight, this arrangement makes sense if one assumes that the main role of top managers is that of making decisions by oversight that legitimate their organization. Since no ability to solve problems is required in order to make decisions by oversight, the incompetent hierarchy is no absurdity.

In each arrangement, simulations are carried out (a) by allowing flights only by postponement, (b) by allowing flights both by postponement and buck-passing, (c) by allowing flights only by buck-passing, and (d) by allowing no flights. In this way, we investigate to what extent the properties (1), (2) and (3) of § (5) are affected by the kind of flight taking place.

6.1 The Random Anarchy

In the random anarchy, if both flights by postponement and flights by buck-passing are allowed, then flights by postponement outnumber flights by buck-passing (1,036.11 vs. 767.03). Experimentations clarified that the main reason is not our precedence assumption — i.e., the assumption that first a flight by postponement is attempted and only subsequently, if this was not possible, the conditions for a flight by buck-passing are examined. In order to understand why flights by postponement outnumber flights by buck-passing it is important to remark that flights do not necessarily occur some time after a decision process has been blocked. Flights may also occur at the very moment a decision process gets blocked, if more than one opportunity or more than one participant are involved in it.

Keeping this in mind, the fact that flights by postponement outnumber flights by buck-passing follows directly from eq. (1). In fact, a decision process is blocked if this inequality is not satisfied, and this is most likely to happen if only a limited number of participants are involved. In particular, quite often only one participant is involved in a blocked decision process: in all these cases, a flight by buck-passing cannot occur at the very moment the decision process is blocked. On the contrary, eq. (1) introduces no bias on the number of opportunities that may be involved in a blocked decision process. Thus, quite often a decision process may be blocked when two or more opportunities are present. In all such cases, a flight by postponement follows immediately.

Note also that if only flights by postponement are allowed, their number is slightly smaller than in the case where both kinds of flights are allowed (964.71 vs. 1,036.11). However, the average number of pairs opportunity-problem (generated by flights by postponement) in a simulation step when only flights by postponement are allowed is roughly the same as in the case both kinds of flights are allowed (19.06 vs. 19.31). This can be reconciled with the previous finding because their mean life is longer if only flights by postponement are allowed (131.84 vs. 120.84 simulation steps).

A remarkable finding is that if only flights by buck-passing are allowed their number increases appreciably with respect to the case when both kinds of flight are allowed (1,642.93 vs. 767.03). The average number of pairs participant-problem (generated by flights by buck-passing) increases as well (32.13 vs. 14.63). However, the mean life of these pairs increases only slightly (139.45 vs. 120.39 simulation steps).

The reason is that pairs participant-problem resulting from a flight by buck-passing, having been formed with the least able available participant and the most difficult available problem, are more likely to originate a blocked decision process than the pairs opportunity-problem resulting from a flight by postponement, that have been formed with the most difficult available problem but that must find a participant by means of random encounters. So flights by buck-passing generate more blocked decision processes (5.52 if only flights by buck-passing are allowed vs. 2.86 if both flights by postponement and by buck-passing are allowed), which in their turn generate more flights by buck-passing, and so forth. The consequence is that there are many more pairs participant-problem than pairs opportunity-problem, but that they do not live much longer.

If both flights by postponement and flights by buck-passing are allowed, the simulations yield an average of 420.28 decisions by resolution and 1,950.94 decisions by oversight during 5,000 steps. If only flights by postponement are allowed, the corresponding figures are 388.80 and 1,863.45, respectively. If only flights by buck-passing are allowed, these figures decrease further to 358.32 and 1,352.84, respectively. Finally, if no flights are allowed the number of decisions is lowest, with 43.90 decisions by resolution and 779.57 decisions by oversight. Thus, flights clearly help decision-making. The obvious reason is that flights help cracking blocked decision processes so the previously blocked agents become available.

This is not evident from the number of blocked decision processes per simulation step, which is even greater when flights are allowed with respect to the case when flights are not allowed (5.52 if only flights by buck-passing are allowed, 2.86 if both flights by postponement and by buck-passing are allowed, 2.83 if only flights by postponement are allowed vs. 2.16 if flights are not allowed). However, blocked decision processes persist much longer if flights are not allowed (9.58 steps if both kinds of flight are allowed, 16.37 steps if only flights by postponement are allowed, 21.49 steps if only flights by buck-passing are allowed vs. 1,268.63 steps if flights are not allowed). Flights do not decrease the number of blocked decision processes, but shorten their life.

It is clear that most decisions are made by oversight, as expressed by property (1) of § (5). This stems from the fact that it is much more likely that a participant, an opportunity and a solution meet on the same square, than that a participant, an opportunity and a problem meet on the same square and, furthermore, the inequality (1) is satisfied. Figure (3) shows that decisions by oversight (white bars) are far more common than

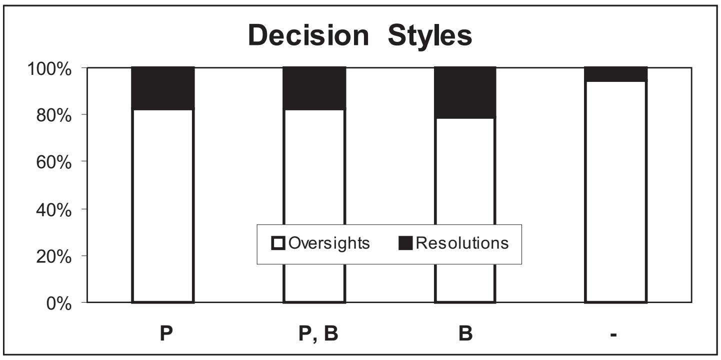

Figure 3: The fraction of decisions by oversight (white bars) and decisions by resolution (black bars) in the random anarchy. Left to right, only flights by postponement (P): oversights 82.74%, resolutions 17.26%; flights both by postponement and by buck-passing (P, B): oversights 82.28%, resolutions 17.72%; only flights by buck-passing (B): oversights 79.06%, resolutions 20.94%; no flights at all (–): oversights 94.67%, resolutions 5.33%.

decisions by resolution (black bars).

However, figure (3) also highlights that in the random anarchy the proportion of decisions by resolution is highest when flights take place, either by postponement, or by buck-passing, or both (compare the rightmost bar with the other three). In fact, by taking away the most difficult problems one at a time, flights are likely to lead to a decision by resolution unless the least difficult problem is still too difficult for the blocked participants. This can be proven by observing that among decisions made when blocked decision processes are unlocked by flights, the proportion of decisions by resolution is much higher than the average (57.55% if (P), 39.50% if (P, B), 60.63% if (B)).

If making a substantial portion of decisions by resolution is considered a positive feature of an organization [4], then the above remark is quite interesting. In fact, it implies that activities that are generally condemned at the individual level — such as postponing decision-making and passing the buck instead of taking responsibility — may actually have a positive impact on the organization as a whole.

Among the configurations favoring decisions by resolution, the one where only flights by buck-passing are allowed comes first (20.94% of decisions by resolution, third bar from the left), followed by the configuration where both kinds of flight are allowed (17.72% of decisions by resolution, second bar from the left) or only flights by postponement are allowed (17.26% of decisions by resolution, first bar from the left). This happens because flights by buck-passing are very many if this is the only kind of flight allowed (1,642.93 at (B), 767.03 at (P, B)). Furthermore, flights by buck-passing generate more blocked decision processes (5.52 if (B), 2.86 if (P, B), 2.83 if (P)). Consequently, more decisions by resolution occur when these blocked decision processes are unlocked.

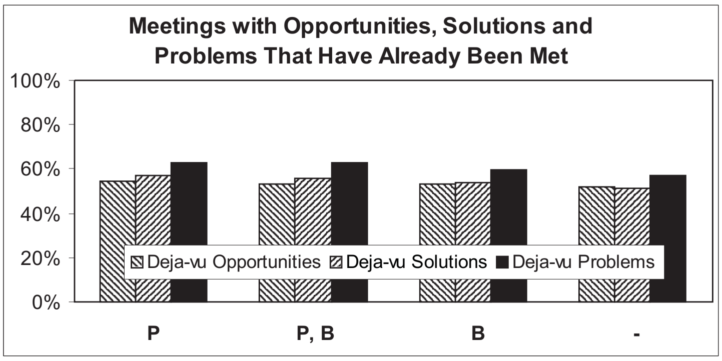

Figure 4: In the random anarchy: (*i*) the ratio of meetings with solutions that have already been met to total meetings with solutions (downward stripes); (*ii*) the ratio of meetings with solutions that have already been met to total meetings with solutions (upward stripes), and (*iii*) the ratio of meetings with problems that have already been met to total meetings with problems (black). Left to right, these three ratios are depicted when only flights by postponement are allowed (P): 54.59%, 57.06% and 62.52%, respectively; when both flights by postponement and flights by buck-passing are allowed (P, B): 53.12%, 55.87% and 62.89%, respectively; when only flights by buck-passing are allowed (B): 53.27%, 53.58% and 59.76%, respectively; when no flights at all are allowed (–): 51.79%, 51.59% and 56.89%, respectively.

Property (2) cannot be observed in a random hierarchy, for it refers to hierarchical levels. Let us consider property (3), i.e., that participants have the impression of meeting the same problems again and again.

Figure (4) illustrates three ratios: (*i*) the ratio of meetings with opportunities that have already been met to total meetings with opportunities (downward stripes); (*ii*) the ratio of meetings with solutions that have already been met to total meetings with solutions (upward stripes), and (*iii*) the ratio of meetings with problems that have already been met to total meetings with problems (black). These three ratios are repeated, left to right, in the case only flights by postponement are allowed (P), in the case both flights by postponement and flights by buck-passing are allowed (P, B), in the case only flights by buck-passing are allowed (B), and in the case no flights are allowed at all (–).

According to figure (4), about 60% of the times participants meet problems that they have already met. Thus, Cohen, March and Olsen's claim is confirmed. Notably, this is an emergent property of the GCM, as Cohen, March and Olsen claimed it should be, but did not do in their 1972 simulations [4].

However, we discovered that more than 50% of the times participants meet opportunities and solutions, they meet opportunities and solutions that they had already met. Thus, meeting the same agents again and again is quite a general property of the GCM, although this property is strongest when it regards problems.

The reason is that this property obtains because opportunities, solutions and problems have been assumed to die and to be replaced once they have been involved in decision-making, which occurs quite often. However, problems die less often than opportunities and solutions because they are only involved in decisions by resolution, that are rare. Thus, it is easier to meet a problem that has already been met than meeting an opportunity or a solution that has already been met.

A striking feature of figure (4) is that the four groups of bars (P), (P, B), (B), (–) are nearly indistinguishable from one another, meaning that the property concerning meeting agents that have already been met is essentially independent of flights. This is due to the fact that, by unlocking blocked decision processes, flights increase both the number of meetings with agents that have already been met (because the number of decisions increases from 823.47 if (–) to 1,711.16 if (B), to 2,252.25 if (P) and 2,371.22 if (B, P)) and the overall number of meetings (because the average size of a blocked decision process decreases from 101.21 if (–) to 14.81 if (B), to 7.56 if (P, B) and 5.82 if (P)). Being these the two terms of a ratio, their increases cancel one another.

However, a feature of figure (4) that clearly depends on flights is that flights by postponement enhance the difference between meeting the same opportunities and meeting the same solutions again and again (compare the two pairs of striped bars on the left to the two pairs of striped bars on the right of figure (4)). The data show that this is not due to the denominator of the ratios illustrated in figure (4) (meetings with opportunities and solutions, respectively: (P) 37,759.97 vs. 38,764.00; (P, B) 33,243.95 vs. 33,267.41; (B) 23,258.25 vs. 23,451.05; (–) 21,551.69 vs. 21,505.82), but to the numerator (meetings with opportunities and solutions that have already been met, respectively: (P) 20,616.57 vs. 22,119.94; (P, B) 17,660.41 vs. 18,591.20; (B) 12,402.68 vs. 12,578.51; (–) 11,330.99 vs. 11.268.55).

The explanation starts with the observation that many flights occur at the very step a decision process gets blocked. If flights by postponement are allowed, at the very moment a decision process gets blocked they take away opportunities that may be used by other participants for decision-making. So we find that if flights by postponement are allowed, the number of non-blocked opportunities is greater than the number of non-blocked solutions ((P): 97.03 non-blocked opportunities vs. 92.80 non-blocked solutions; (P, B): 96.90 non-blocked opportunities vs. 93.62 non-blocked solutions), whereas if flights by postponement are not allowed, the number of non-blocked opportunities is roughly the same as the number of non-blocked solutions ((B): 72.49 non-blocked opportunities vs. 73.14 non-blocked solutions; (–): 53.44 non-blocked opportunities vs. 53.06 non-blocked solutions). Decisions cause both opportunities and solutions to be replaced, decreasing the probability of meeting again the same opportunity or the same solution. However, if the set of non-blocked solutions is smaller than the set of non-blocked opportunities, it is more likely that a solution is used and replaced before it is met again than an opportunity is used and replaced before it is met again. Hence the observed pattern.

Another differentiation can be observed in figure (4) regarding the height of the black bars, where the fourth one is lowest ((P): 62.52%; (P, B): 62.89%; (B): 59.76%; (–): 56.89%). Not all participants measure what opportunities, solutions and problems are met again and again, but only those participants who are neither involved in a blocked decision process, nor are carrying a problem as a result of a flight by buck-passing.

6.2 The Competent Hierarchy

With respect to the relative frequency of flights by postponement and by buck-passing, the behavior of the competent hierarchy is opposite to that of the random anarchy. In fact, if both are allowed, then flights by buck-passing outnumber flights by postponement (372.22 vs. 131.91).

It is necessary to remark that, in order for a flight to take place, a pair opportunity-problem or participant-problem must be able to leave the place where a decision problem is blocked. In a hierarchy, for a pair opportunity-problem this means finding a neighboring position where there is no lower-ranking participant, no lower-ranking solution and no lower-ranking problem. For a pair participant-problem this means finding a neighboring position where there is no higher-ranking opportunity. The first requirement is much stricter than the second one. Thus, if agents are arranged in hierarchies flights by buck-passing are much easier than flights by postponement.

As in the random anarchy, if only flights by postponement are allowed their number decreases with respect to the case where both are allowed (77.47 vs. 131.91). Contrary to the random anarchy, both a lower number of pairs opportunity-problem (2.59 vs. 3.60) and their longer life (285.61 vs. 208.90 steps) concur to this effect.

If only flights by buck-passing are allowed, their number increases with respect to the case where both are allowed, though less impressively as in the random anarchy (471.46 vs. 372.22). The average number of pairs participant-problem increases as well (23.35 vs. 18.89), and so does their mean life (393.59 vs. 381.65). The number of blocked decision processes is greater in (B) than in any other configuration, though the difference is not as large as in the random anarchy (2.28 if (B) vs. 1.66 if (P), 1.57 if (P, B) and 1.48 if (–)). The explanation is the same as in the random anarchy, namely, that flights by buck-passing generate pairs made by a low-ability participant and a high-difficulty problem, which are most likely to block other decision processes and generate other flights by buck-passing.

If both flights by postponement and flights by buck-passing are allowed, the simulations yield an average of 130.59 decisions by resolution and 757.80 decisions by oversight during 5,000 steps. If only flights by buck-passing are allowed, the corresponding figures are 123.42 and 626.31, respectively. If only flights by postponement are allowed, these figures decrease further to 60.17 and 610.23, respectively. Finally, if no flights are allowed the number of decisions is lowest, with 24.82 decisions by resolution and 461.94 decisions by oversight. So in the competent hierarchy as in the random anarchy, flights favor decision-making by liberating blocked agents.

Similarly to the random anarchy, this mechanism does not work through the number of blocked decision processes per simulation step, which is not appreciably different with and without flights ((P): 1.57; (P, B): 1.66; (B): 2.28; (–): 1.48), but rather through the time blocked decision processes remain in their condition ((P): 17.10; (P, B): 288.02; (B): 35.32; (–): 1035.76). This time is much longer if flights are not allowed.

Also in the competent hierarchy most decisions are made by oversight, as expressed by property (1) of § (5). As in the random anarchy, this is due to the fact that it is much more likely that a participant, an opportunity and a solution meet on the same square, than that a participant, an opportunity and a problem meet on the same square and,

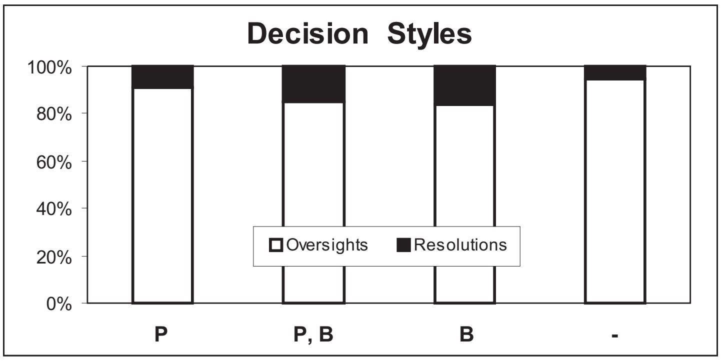

Figure 5: The ratio of decisions by oversight (white bars) to decisions by resolution (black bars) in the competent hierarchy. Left to right, flights only by postponement (P): oversights 91.02%, resolutions 8.97%; flights both by postponement and by buck-passing (P, B): oversights 85.30%, resolutions 14.70%; flights only by buck-passing (B): oversights 83.54%, resolutions 16.46%; no flights at all (–): oversights 94.90%, resolutions 5.10%.

furthermore, the inequality (1) is satisfied. Figure (5) shows that decisions by oversight (white bars) are far more common than decisions by resolution (black bars).

Figure (5) highlights that, similarly to the random anarchy, flights enhance the proportion of decisions by resolution (compare the rightmost bar to the other three). As in the case of the random anarchy, this is due to the fact that by taking away the most difficult problems one at a time, flights are likely to lead to a decision by resolution unless the least difficult problem is still too difficult for the blocked participants. Also in the competent hierarchy this can be proven by showing that where a decision process used to be blocked, flights obtain much higher proportions of decisions by resolution ((P): resolutions 77.82%; (P, B): resolutions 55.54%; (B): resolutions 71.09%).

However, a notable difference is that in the competent hierarchy flights by buck-passing, either alone or in conjunction with flights by postponement, are much more effective than flights by postponement in increasing the proportion of decisions by resolution (compare the two bars in the middle to the first one from the left). The reason is that — as explained at the beginning of this section — in the competent hierarchy flights by buck-passing always outnumber flights by postponement.

As in the case of the random anarchy, these results are strongly counterintuitive. In particular, it does not seem to square with common wisdom that in the competent hierarchy passing the most difficult problems to the least competent participants — those at the bottom levels — has beneficial consequences for the organization as a whole.

The fact is that, in a competent hierarchy, buck-passing helps the participants on top of the hierarchy to make decisions. Essentially, the rationale is that by sacrificing its least able members with “impossible missions”, an organization may perform better.

Let us consider property (2), i.e., that the top managers of a hierarchy are mostly

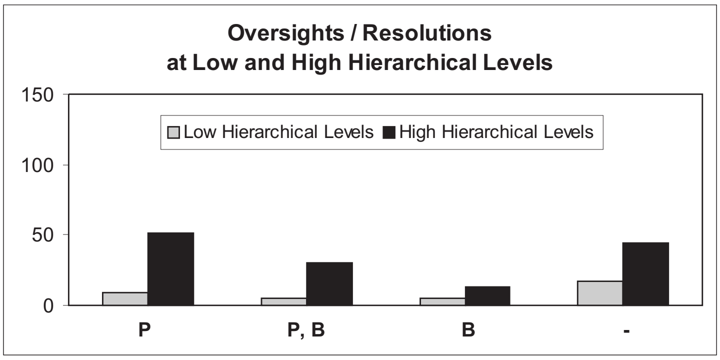

Figure 6: The competent hierarchy. The ratio of the number of decisions by oversight to the number of decisions by resolution, measured on the lower half of the hierarchy (grey) and the upper half of the hierarchy (black). Left to right, these ratios are shown in the case only flights by postponement are allowed (P): 8.89, 51.36; when both flights by postponement and flights by buck-passing are allowed (P, B): 5.06, 29.73; when only flights by buck-passing are allowed (B): 4.57, 13.38; and when no flights are allowed at all (–): 16.93, 44.55.

concerned with decisions by oversight, whereas the few decisions by resolution that are made in the organization are mostly made at the bottom levels. Figure (6) illustrates the ratio of decisions by oversight to decisions by resolution at low hierarchical levels (grey bars) and high hierarchical levels (black bars), for all combinations of kinds of flights.

It is evident that this property is confirmed, for black bars are always higher than grey bars. It descends from the very fact that a participant, an opportunity and a solution suffice to make a decision by oversight whereas a participant, an opportunity, a solution and a problem are required for a decision by resolution. Thus, the probability of making a decision by oversight at a particular square is the product of three probabilities, one for each of the three agents required to be there, whereas the probability of making a decision by resolution is the product of four probabilities. Hierarchical structures make movements more difficult, so the probability of an agent to be on a specific square is smaller. By multiplying four smaller numbers the outcome decreases to a larger extent than by multiplying three smaller numbers. Thus, hierarchies decrease the probability of a decision by resolution to a greater extent than they decrease the probability of a decision by oversight.

According to our interpretation, decisions by oversight represent rituals that are made in order to fullfill social requirements [12] [7]. They do not originate from real problems, and they require none. Thus, it should not be not a surprise that this kind of actions is a main task of top hierarchical levels. Put it differently, the GCM suggests that there is some truth in the dictum that “Managers are those who entertain guests while the others are working”, but also that the meaning of the dictum — denigrating top executives — is wrong.

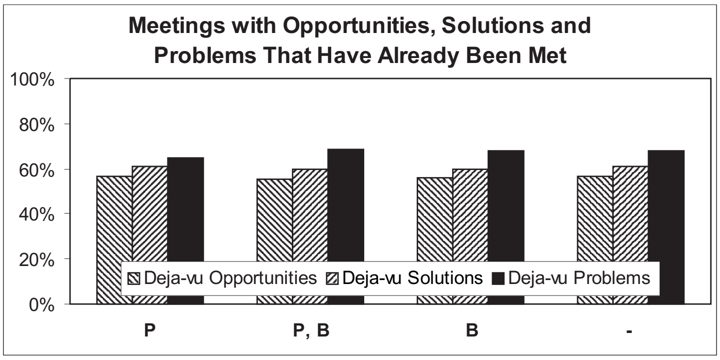

Figure 7: In the competent hierarchy: (*i*) the ratio of meetings with solutions that have already been met to total meetings with solutions (downward stripes); (*ii*) the ratio of meetings with solutions that have already been met to total meetings with solutions (upward stripes), and (*iii*) the ratio of meetings with problems that have already been met to total meetings with problems (black). Left to right, these three ratios are depicted when only flights by postponement are allowed (P): 56.58%, 60.79% and 64.80%, respectively; when both flights by postponement and flights by buck-passing are allowed (P, B): 55.19%, 59.82% and 68.62%, respectively; when only flights by buck-passing are allowed (B): 55.72%, 59.71% and 67.67%, respectively; when no flights at all are allowed (–): 56.44%, 60.85% and 67.69%, respectively.

The first three pairs of bars of figure (6) decrease left to right; the fourth pair increases. This is coherent with figure (5), where the same pattern is evident for white bars. It happens simply because the bars of figure (6) represent ratios of oversights to resolutions while the white bars of figure (5) represent percentages of oversights to total decisions.

Let us consider property (3), i.e., that participants meet the same problems again and again. Figure (7) illustrates three ratios: (*i*) the ratio of meetings with opportunities that have already been met to total meetings with opportunities (downward stripes); (*ii*) the ratio of meetings with solutions that have already been met to total meetings with solutions (upward stripes), and (*iii*) the ratio of meetings with problems that have already been met to total meetings with problems (black). These three ratios are repeated, left to right, in the case only flights by postponement are allowed (P), in the case both flights by postponement and flights by buck-passing are allowed (P, B), in the case only flights by buck-passing are allowed (B), and in the case no flights are allowed at all (–).

According to figure (7), about 65% of the times participants meet problems, they meet problems that they had already met. Thus, Cohen, March and Olsen's claim is confirmed to an even greater extent than in the random anarchy. Also the percentages of meetings with opportunities and solutions that have already been met are quite high (about 55% and 60%, respectively), confirming that this is quite a general property of the GCM. As in the random anarchy, the reason for meeting the same problems more often than the same opportunities and solutions is that problems are only involved in decisions by resolution, whereas opportunities and solutions are involved in all decisions.

Figure (7) shows that in the competent hierarchy it is always more likely to meet solutions that have already been met than meeting opportunities that have already been met, independently of flights. In the random anarchy this difference was smaller, and it occurred only when flights by postponement were allowed to take place.

The impact of flights by postponement on the number of non-blocked opportunities is negligible in the competent hierarchy, because flights by postponement are much fewer than in the random anarchy (77.47 vs. 964.71 if (P); 131.91 vs. 1036.11 if (B, P)). The data show that, contrary to the random anarchy, both the number of meetings and the number of meetings with items that have already been met differ considerably between opportunities and solutions. In particular, while the number of meetings with solutions is close to the values attained in the random anarchy, the number of meetings with opportunities is much lower in all configurations of flights (meetings with opportunities and solutions, respectively: (P) 17,030.37 vs. 35,415.8; (P, B) 17,963.29 vs. 33,773.31; (B) 15,703.40 vs. 30,102.66; (–) 13,809.98 vs. 29,594.78). So in the competent hierarchy another mechanism must be at work.

In a hierarchical structure such as has been defined in § (4.1), participants can meet any solution, but they are only allowed to meet opportunities that are lower than their own hierarchical level. The participants of high hierarchical level can meet all opportunities, measuring a ratio of meetings with opportunities that have already been met that is akin to the one measured in the random anarchy. On the contrary, the participants of low hierarchical level are only allowed to meet a correspondingly small subset of low-importance opportunities. These opportunities are involved in decision-making much more often than the high-importance opportunities (decisions at low hierarchical levels vs. decisions at high hierarchical levels: (P) 577.73 vs. 92.67; (P, B) 766.99 vs. 121.40; (B) 648.51 vs. 101.22; (–) 417.98 vs. 68.78). Thus, it is quite likely that these opportunities are used and replaced before many participants can meet the several times. Hence the observed pattern.

All percentages of meetings with agents that have already been met are higher in the competent hierarchy than in the random anarchy. The reason is that in the competent hierarchy fewer decisions are made ((P): 670.40 vs. 2,252.25; (P, B): 888.39 vs. 2,371.22; (B): 749.73 vs. 1,711.16; (–): 486.76 vs. 823.47), so fewer agents are replaced.

As in the random anarchy, the property of meeting the same agents again and again is roughly independent of flights. The reason is the same: by unlocking blocked decision processes, flights increase both the number of meetings with agents that have already been met (because the number of decisions increases from 486.76 if (–) to 670.40 if (P), to 749.73 if (B) and 888.39 if (P, B)) and the overall number of meetings (because the average size of a blocked decision process decreases from 61.29 if (–) to 35.79 if (P), to 12.81 if (B) and 6.88 if (B, P)). Being these the two terms of a ratio, their increases cancel one another.

6.3 The Incompetent Hierarchy

The incompetent hierarchy, by design, runs contrary to common wisdom. And yet, the GCM suggests that this organizational arrangement is not absurd. In fact, "competence" refers to the ability to solve problems, but this may not be the kind of ability required from top executives. Executives, and particularly top executives, may be mostly concerned with establishing and maintaining social relations within their own organization as well as between their organization and the outer world. These activities aim at obtaining social legitimacy for the organization; they are not concerned with solving problems, but rather with preventing them [12] [7].

In the GCM, these social activities reflect into the decisions by oversight. Since decisions by oversight involve no problem, they do not require the ability to solve them. Thus, having managers that are not good at solving problems may not be as absurd as it seems at first sight. Possibly, managers should be good at social networking rather than at problem solving.

Cohen, March and Olsen did not investigate the incompetent hierarchy, though they did define this arrangement. On the contrary, we focus our attention on its properties and their implications.

In the incompetent hierarchy, as in the competent hierarchy, if both flights by postponement and flights by buck-passing are allowed, then flights by buck-passing outnumber flights by postponement (632.97 vs. 283.18). The reason is the same as in the competent hierarchy. In any hierarchy, leaving the place where a decision is blocked means for a pair opportunity-problem finding a neighboring position where there is no lower-ranking participant, no lower-ranking solution and no lower-ranking problem. For a pair participant-problem, it means finding a neighboring position where there is no higher-ranking opportunity. The first requirement is stricter than the second one.

However, in the incompetent hierarchy the most difficult problems are dealt by the participants at the lowest hierarchical levels. Thus, most of blocked decision processes find themselves at the bottom of the hierarchy. From there, it is easier to move away if the conditions for a flight arise. Thus, flights are less than in the random anarchy, but more than in the competent hierarchy.

Similarly to the random anarchy and the competent hierarchy, if only flights by postponement are allowed their number decreases with respect to the case where both kinds of flights are allowed (124.16 vs. 283.18). As in the competent hierarchy, both a lower number of pairs opportunity-problem (4.45 vs. 7.25) and their longer life (335.43 vs. 209.32) concur to this effect.

If only flights by buck-passing are allowed, their number increases with respect to the case where both are allowed (668.35 vs. 632.97). The average number of pairs participant-problem increases as well (30.69 vs. 22.24), and so does their mean life (371.09 vs. 256.48). The number of blocked decision processes is greater in (B) than in any other configuration (3.53 if (B), 2.65 if (P, B), 2.45 if (–), 2.24 if (P)). The explanation is the same as in the random anarchy and the competent hierarchy, namely, that flights by buck-passing generate pairs made by a low-ability participant and a high-difficulty problem, which are most likely to block other decision processes and generate other flights by buck-passing.

If both flights by postponement and flights by buck-passing are allowed, the sim-

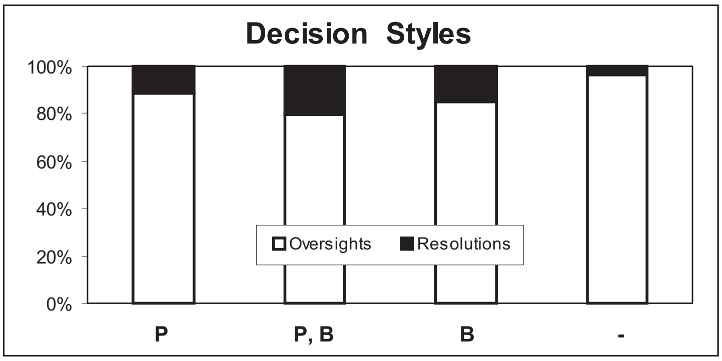

Figure 8: The ratio of decisions by oversight (white bars) to decisions by resolution (black bars) in the incompetent hierarchy. Left to right, flights only by postponement (P): oversights 88.86%, resolutions 11.13%; flights both by postponement and by buck-passing (P, B): oversights 79.73%, resolutions 20.27%; flights only by buck-passing (B): oversights 85.11%, resolutions 14.89%; no flights at all (–): oversights 96.15%, resolutions 3.85%.

ulations yield an average of 153.02 decisions by resolution and 601.82 decisions by oversight during 5,000 steps. If only flights by postponement are allowed, the corresponding figures are 63.68 and 508.19, respectively. If only flights by buck-passing are allowed, these figures decrease further to 52.8 and 301.84, respectively. Finally, if no flights are allowed the number of decisions is lowest, with 7.71 decisions by resolution and 192.77 decisions by oversight. It is clear that in the incompetent hierarchy, just like in the competent hierarchy and the random anarchy, flights favor decision-making by liberating blocked agents.

Similarly to the random anarchy, this mechanism does not work through the number of blocked decision processes per simulation step, which is not appreciably different with and without flights ((P): 2.24; (P, B): 2.65; (B): 3.53; (–): 2.45), but rather through the time blocked decision processes remain in their condition ((P): 274.52; (P, B): 40.66; (B): 35.32; (–): 1920.01). This time differs across flight configurations, but it is clear that it is much longer if flights are not allowed.

A more important remark is that in the incompetent hierarchy, as in the competent hierarchy and the random anarchy, most decisions are made by oversight as expressed by property (1) of § (5). As in the competent hierarchy and the random anarchy, this depends on the fact that a meeting of a participant, an opportunity and a solution is more likely than a meeting of a participant, an opportunity and a problem and, furthermore, satisfy inequality (1). Figure (8) shows that decisions by oversight (white bars) are far more common than decisions by resolution (black bars).

Similarly to the random anarchy and the competent hierarchy, flights increase the proportion of decisions by resolution (compare the rightmost bar to the other three). As in the case of the random anarchy and the competent hierarchy, this is due to the fact that by taking away the most difficult problems one at a time, flights are likely to lead to a decision by resolution unless the least difficult problem is still too difficult for the blocked participants. In fact, where a blocked decision process is unlocked by a flight one observes proportions of decisions by resolution that are much higher than average ((P): resolutions 74.59%; (P, B): resolutions 51.75%; (B): resolutions 71.09%).

In the incompetent hierarchy, similarly to the competent hierarchy but contrary to the random anarchy, flights by buck-passing, either alone or in conjunction with flights by postponement, are more effective than flights by postponement in increasing the proportion of decisions by resolution (compare the two bars in the middle to the first one from the left). The reason is that in the incompetent hierarchy, as in the competent hierarchy, flights by buck-passing outnumber flights by postponement.

Following Cohen, March and Olsen [4], we take the proportion of decisions by resolution as an indicator of the efficiency of an organization. Our discussion of the meaning of the incompetent hierarchy may suggest that this choice is inconsistent with the idea that decisions by oversight, by obtaining legitimacy for the organization, are at least as useful as decisions by resolution. Indeed, if decisions by oversight are useful, then an organization does *not* maximize efficiency by *not* making any decisions by oversight at all.

However, decisions by oversight make only an indirect contribution to an organization's well-being. In § (2) we introduced decisions by oversight with the example of a firm that complies with the procedures required by a rating agency. It is evident that this is an important and positive activity for a firm, but also that decisions by oversight should be ancillary to the more basic decisions by resolution. Thus, it makes sense to take the proportion of decisions by resolution as an indicator of efficiency.

Let us now compare the efficiency of the random anarchy, the competent hierarchy and the incompetent hierarchy (figures (3), (5) and (8)). If we consider the average percentage of decisions by resolution in the four configurations (P), (P, B), (B) and (–), it turns out that the random anarchy is the most efficient arrangement (15.31%), followed by the incompetent hierarchy (12.53%) and finally by the competent hierarchy (11.31%). If we rank the peaks of efficiency, we find first the random anarchy when only buck-passing is allowed (20.94%), closely followed by the incompetent hierarchy when both postponement and buck-passing are allowed (20.27%), then again the random anarchy when both kinds of flight are allowed (17.72%) and when only postponement is allowed (17.26%), and only fifth the competent hierarchy when only buck-passing is allowed (16.46%). On the whole it appears that hierarchies are generally not efficient in fostering decisions by resolution, although incompetent hierarchies can perform fairly well if both postponement and buck-passing occur.

Let us consider property (2) of § (5), i.e., that the top managers of a hierarchy are mostly concerned with decisions by oversight, whereas the few decisions by resolution that are made in the organization are mostly made at the bottom levels. Figure (9) illustrates the ratio of decisions by oversight to decisions by resolution at low hierarchical levels (grey bars) and high hierarchical levels (black bars).

It is evident that this property is confirmed also in the incompetent hierarchy, for black bars are always higher than grey bars. In fact, since three agents suffice to make a decision by oversight whereas four agents are required for a decision by resolution, the probability of a decision by oversight at a particular square is the product of three probabilities, one for each of the three agents required to be there, whereas the probability

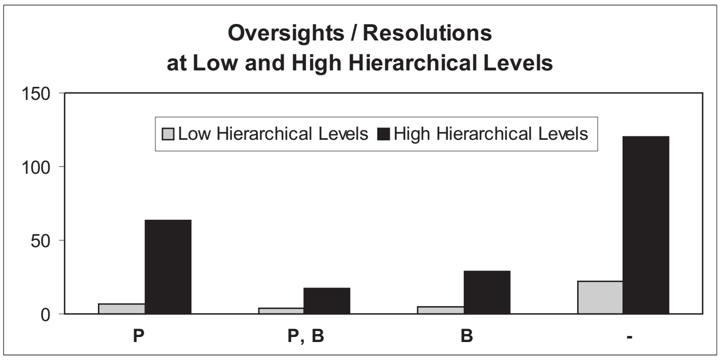

Figure 9: The incompetent hierarchy. The ratio of the number of decisions by oversight to the number of decisions by resolution, measured on the lower half of the hierarchy (grey) and the upper half of the hierarchy (black). Left to right, these ratios are shown in the case only flights by postponement (P) are allowed: 6.91, 63.05; when both flights by postponement and flights by buck-passing (P, B) are allowed: 3.55, 17.20; when only flights by buck-passing (B) are allowed: 5.20, 28.51; and when no flights are allowed at all (–): 22.20, 120.36

of a decision by resolution is the product of four probabilities. Hierarchical structures make movements more difficult, so the probability of an agent to be on a specific square is smaller. By multiplying four smaller numbers the decrease of the outcome is larger than by multiplying three smaller numbers. Thus, hierarchies decrease the probability of a decision by resolution to a greater extent than they decrease the probability of a decision by oversight.

The pairs of bars of figure (9), decrease and increase following the same pattern as the white bars of figure (8). This happens simply because both the bars of figure (9) and the white bars of figure (8) are proportional to decisions by resolution. Note that in the case of the competent hierarchy the minimum is reached at (B) — see figure (6) — whereas in the case of the incompetent hierarchy the minimum is reached at (P, B) — see figure (9).

Let us consider property (3), i.e., that participants meet the same problems again and again. Figure (10) illustrates three ratios: (*i*) the ratio of meetings with opportunities that have already been met to total meetings with opportunities (downward stripes); (*ii*) the ratio of meetings with solutions that have already been met to total meetings with solutions (upward stripes), and (*iii*) the ratio of meetings with problems that have already been met to total meetings with problems (black). These three ratios are repeated, left to right, in the case only flights by postponement are allowed (P), in the case both flights by postponement and flights by buck-passing are allowed (P, B), in the case only flights by buck-passing are allowed (B), and in the case no flights are allowed at all (–).

According to figure (10), about 60%–70% of the times participants meet problems, they meet problems that they had already met. Thus, Cohen, March and Olsen's claim

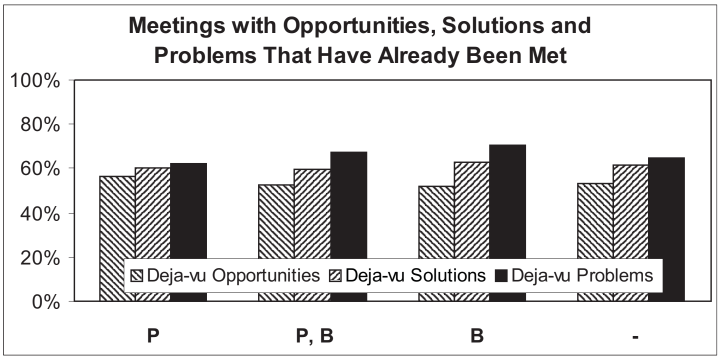

Figure 10: In the incompetent hierarchy: (*i*) the ratio of meetings with solutions that have already been met to total meetings with solutions (downward stripes); (*ii*) the ratio of meetings with solutions that have already been met to total meetings with solutions (upward stripes), and (*iii*) the ratio of meetings with problems that have already been met to total meetings with problems (black). Left to right, these three ratios are depicted when only flights by postponement are allowed (P): 56.46%, 60.28% and 62.48%, respectively; when both flights by postponement and flights by buck-passing are allowed (P, B): 52.68%, 59.41% and 67.53%, respectively; when only flights by buck-passing are allowed (B): 52.04%, 63.06% and 70.34%, respectively; when no flights at all are allowed (–): 53.15%, 61.41% and 65.00%, respectively.

is confirmed to an extent that is often greater than in the competent hierarchy, and much greater than in the random anarchy. Also the percentages of meetings with opportunities and solutions that have already been met are quite high (about 50%–55% and about 60%, respectively), confirming once again that this is quite a general property of the GCM. As in the competent hierarchy and the random anarchy, the reason for meeting the same problems more often than the same opportunities and the same solutions is that problems are only involved in decisions by resolution, whereas opportunities and solutions are involved in all decisions.

Figure (10) shows that in the incompetent hierarchy, just like in the competent hierarchy, it is always more likely to meet solutions that have already been met than meeting opportunities that have already been met, independently of flights. The explanation is essentially the same.

In a hierarchical structure such as has been defined in § (4.1), participants can meet any solution, but they are only allowed to meet opportunities that are lower than their own hierarchical level. The participants of high hierarchical level can meet all opportunities, measuring a ratio of meetings with opportunities that have already been met that is akin to the one measured in the random anarchy. On the contrary, the participants of low hierarchical level are only allowed to meet a correspondingly small subset of low-importance opportunities. These opportunities are involved in decision-making much more often than the high-importance opportunities (decisions at low hierarchical levels vs. decisions at high hierarchical levels: (P) 494.37 vs. 77.50; (P, B) 676.93 vs.

77.91; (B) 320.41 vs. 34.23; (–) 173.78 vs. 26.70). Thus, it is quite likely that these opportunities are used and replaced before many participants can meet the several times. Hence the observed pattern.

The average level of the percentages of meetings with agents that have already been met in the incompetent hierarchy (0.60) is roughly the same as in the competent hierarchy (0.61), and both are higher than in the random anarchy (0.56). The reason is that the incompetent hierarchy make approximately the same number of decisions as the competent hierarchy, whereas in the random anarchy more decisions are made so more agents are replaced. Consequently, it is less likely to meet them again.

As in the random anarchy and the competent hierarchy the property of meeting the same agents again and again is roughly independent of flights, though possibly less so than in the previous cases. Also in the incompetent hierarchy flights increase both the number of meetings with agents that have already been met (because the number of decisions increases from 192.77 if (–) to 354.64 if (B), to 571.87 if (P) and 754.84 if (P, B)) and the overall number of meetings (because the average size of a blocked decision process decreases from 71.88 if (–) to 36.31 if (P), to 22.91 if (B) and 7.29 if (B, P)), so their increases cancel one another. However, this cancellation is less perfect in the incompetent hierarchy so we observe that flights by buck-passing, either alone or in conjunction with flights by postponement, increase the ratio of problems that had already been met to total problems that have been met.

7 Conclusions

Although the GCM is widely cited, citations often come along with misrepresentations. The GCM is often presented as a kind of "theater-of-the-absurd" interpretation of organizational decision-making. According to our reconstruction, such representations of the GCM fail to identify its most consequential and innovative aspects.

In order to restore the original meaning and richness of the GCM, we made an effort to present and extend the GCM by making reference to more recent streams of research in organizational decision-making. We stressed that the seemingly absurd "decisions by oversight" are nothing but activities carried out in order to obtain legitimacy and stability, as a wide stream of "new institutionalist" research has remarked. We explained that flying away from difficult problems by attaching them to another choice opportunity simply means postponing decision-making, and we added another plausible means for escaping from difficult problems, namely, buck-passing.

Our extensions have been made possible by the fact that we implemented the GCM as an agent-based model. We already stressed that this has been a straightforward operation, since the the original verbal description of the model fits perfectly with the agent-based technology.

Our extended GCM suggests that flights — both by postponement and by buck-passing — are beneficial to the organization, since they avoid that the members of an organization waste their time with problems that they cannot solve. This conclusion may strike as paradoxical, because it suggests that self-centered behavior might be beneficial to the organization as a whole. On the contrary, the general practice is that organizations encourage the identification of individual values with collective values.

A parallel may be made with markets, where selfish profit-oriented behavior is beneficial to the provision of private goods, and yet altruistic values are necessary for the provision of public goods. The underlying idea is that self-centered behavior is good so far an individual displays his abilities, though altruistic values are necessary in order to hold together a framework where individual abilities can operate. Likewise, flights serve organizations so far they channel the most difficult problems to the best problem-solvers, creating opportunities for them to display their abilities. However, this observation should not be brought to the point of encouraging any kind of selfish behavior in the belief that this will improve an organization's effectiveness. Such an advice would destroy organizations, and this is not the content of a model of organizational choice.

Indeed, at first sight the GCM questions the very rationale of organizations. So when Padgett [14] and Carley [3] [2] endowed the GCM with hierarchies with rigid communication channels, they found lower levels of efficiency with respect to the pure "organized anarchy" of the basic model. However, we went beyond this result. In fact, we found that the most efficient structure for the GCM is neither the kind of hierarchy suggested by common sense, nor the "organized anarchy".

The original GCM had already established that most problems are solved at low hierarchical levels, whereas the participants at high hierarchical levels make themselves busy with decisions by oversight. In our extended GCM we offered an interpretation of decisions by oversight as activities aimed at obtaining legitimacy, which explains why this sort of activities is mostly carried out by top managers. In fact, if legitimacy is obtained by conforming to rituals and procedures expected by institutions and peers, then we are dealing with activities that are best carried out by the representatives of an organization.

The GCM also posits that different people have different abilities in solving problems. Consequently, common wisdom suggests that on top of hierarchies should sit the most able members of an organization. However, the GCM forces us to ask ourselves what their ability should consist of. In fact, if decisions by oversight are important for obtaining legitimacy, then one may suggest that top managers should be good at obtaining legitimacy rather than at solving problems. So one may speculate that organizations should possibly be designed on the basis of criteria that are apparently opposite to those suggested by common wisdom, namely, leaving those who are good at solving problems at the bottom of the hierarchy while promoting the poorest problem-solvers to the top. This possibility did exist in the original GCM, but it was not explored by Cohen, March and Olsen.

Although we pictured decisions by oversight as a valuable and useful activity, we endorsed Cohen, March and Olsen's criterium of organizational efficiency, which is based on the idea that decisions by oversights should be as few as possible. According to a series of indicators based on this criterium, a hierarchy where the best problem-solvers are at the bottom really turned out as the most efficient arrangement. In fact, this organizational arrangement reaches the highest ratio of decisions by resolution to decisions by oversight if both flights by postponement and flights by resolution are allowed, and in this arrangement flights are most effective in limiting the number of decisions by oversight that must be made at high hierarchical levels. Finally, it is in the incompetent hierarchy with both kinds of flight that the impression of meeting the same problems again and again is strongest.

On the whole, our simulations suggest that it makes sense to have poor problem-solvers at the high hierarchical levels, particularly if decisions can be easily postponed and difficult problems can be easily passed on to other participants. However, incompetence at problem-solving should not be confused with incompetence *tout court*. Top decision-makers should be good at gaining legitimacy for their organization, which is possibly the kind of ability they should be selected for.

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