The Computer as Mediator:

LAW OF THE SEA AND BEYOND

James K. Sebenius

Occasionally, analytic models have found their way into complex policy negotiations. This article scrutinizes four such cases. When they appear independent and credible, models can play a variety of traditional mediating roles: They can foster learning, help define the negotiating agenda, stimulate communication, and suggest joint gains. These constructs can also offer artificial common ground for proposals to be tested, disputants' differences to be dovetailed, and adversaries 'convinced' to move from entrenched positions without "conceding" to bargaining opponents. Yet, where the negotiators' basic values or ideologies actively clash, the special kind of rationality provided by models may prove to be irrelevant.

Public policies are born in many ways. Sometimes they are created out of the quiet reflections of experts. More often, they are hammered out by adversaries groping to define that common ground whose lure has brought them to the negotiating table. The atmosphere around the negotiating table is commonly chaotic and unstructured; there is disagreement, confusion on the facts, murky definition of the areas of conflict and mutual interest. Yet, here and there, the work of experts on analytic models has found its way into the tumult of the negotiating process. However, the effects of models on these processes hardly consist of the passive provision of knowledge generated by a pristine search for truth. While this role is sometimes important, even critical, models can play much more complex parts in negotiations. Four such cases form the core of this article.

The insights from these cases are meant for would-be modelers, who may aspire for their creations to affect policy, as well as for those struggling to forge policy, who may (or, sometimes, should) be tempted to introduce analytic models into the process. Modeling is an increasingly important way of seeking knowledge, while
negotiation often characterizes the resolution of policy disputes. A look at the intersection of these two processes can help illuminate the uncertain connection between academic research and public choice.¹

The models considered pertain to the substance of the negotiations, not to game-theoretic or psychological aspects of the bargaining behavior itself. The experience of a seabed mining model in the Law of the Sea negotiations comes first. Three more brief examples qualify and amplify some of the resulting observations. The settings range from international megaconferences to traditional labor negotiations to land-use disputes. These examples contain a host of specific implications that may be integrated into a more general view of how models may be used in negotiations. Before delving into the cases, it is useful to characterize three related aspects of negotiating situations that may lead to the use of models.²

First and most obvious, bargainers often find the situation under consideration to be complex and confusing. All sides may see a need for learning, communication, and the discovery of joint gains.

A second factor, however, often intervenes to frustrate this need. Negotiations usually involve adversarial elements. Strong incentives work on bargainers to misrepresent their interests and to distort relevant information. Even if they do not in fact do so, it may be impossible to quell the deep suspicions of opponents.

Finally, negotiators commonly try to make commitments to current, incompatible positions. With internal constituencies, audiences, or opponents, or with third parties, each side tries to publicize the costs that it will incur upon “backing down.” Such costs typically entail the loss of “face,” apparent power in the present or future negotiations, status, or reputation. The more convincingly those losses can be portrayed, the harder it is supposed to be to dislodge the committed side. Sometimes, however, this tactic backfires and a party may become unwillingly stuck. Negotiations deadlock. A closer look at how the commitments were made, however, often reveals them to be conditional implicitly on the party’s current information about issues and interests. An appeal to powerful norms of “new analysis” or “superior information” may unstick the commitment and reduce the costs of movement.

If a model can be portrayed as independent of adversarial negotiation elements and as offering new information, it can affect the process significantly. In this case, communication and learning can occur more readily, possibly leading to a mutually beneficial agreement. But, whether real learning occurs or genuine joint gains in fact are found, negotiators may use the model to escape from frozen positions by appealing to the norm of superior information.

Where basic values or ideologies conflict, however, bargainers will often find themselves obliged to spend much of their time in search of an overall “formula” that can provide the basis for agreement. The formula need not resolve the underlying conflict;
indeed, it may be susceptible to differing interpretations. However, as long as it is maintained by the parties, negotiations over critical subsidiary issues can proceed. It is typically in this phase that analytic models can be used most effectively. Models can offer an artificial common ground for proposals to be tested, differences to be dovetailed by ingenious analysis, and disputants to be "convinced" to move to new-found accommodation. Yet, while models can offer such rationality, it may be a rationality "in the small," vulnerable to resurgent ideological conflict or value reappraisal that changes or jettisons the supporting general formula. In such cases, even the most rationally contrived agreement, replete with modeling-inspired joint gains, may be swept away.

THE MIT MODEL AND THE LAW OF THE SEA

Nobly, coal-like lumps called "manganese nodules" are strewn in vast quantities over much of the deep ocean floor. The nodules are composed of commercially and strategically promising quantities of copper, cobalt, nickel, and manganese. Several industrial nations depend heavily on a few, possibly unstable land sources for these critical minerals. In the mid-1960s, a number of mining consortia began spending large sums to develop the sophisticated technology necessary to lift the nodules and to transport them to land for processing.

Because the richest and most abundant grounds for mining nodules in the deep sea are outside the limits of any nation's jurisdiction, the question of nodule "ownership" grew in step with their emerging commercial potential. In 1970, without opposition, the United Nations General Assembly declared these deep sea resources to be the "common heritage of mankind," and proposed the creation of an international regime for the seabed that would ensure "equitable sharing by States in the benefits derived therefrom." Meanwhile, an enormous increase in the use of the oceans for commercial and military transport, fishing, energy production, and scientific research repeatedly led to frictions and conflicts that pointed up the inadequacies of existing international laws of the sea. To address this situation, the General Assembly convened the Third United Nations Conference on the Law of the Sea (LOS) in 1973. As an integral part of their agenda, the participants in these mammoth negotiations faced the task of giving substance to the "common heritage" principle.

Developed countries that expected to mine the seabed had a genuine preference at that time for an international framework over one composed of a few like-minded mining nations. In the early days of the LOS negotiations, they argued strongly for a seabed "authority" that would primarily register claims and permit the orderly development of mining. Some revenue from the operations would be shared with the world community in deference to the common heritage principle. In the LOS forum, however, working out the conditions for seabed mining was tightly linked to renegotiation of the legal regimes governing a spectrum of other ocean uses. Important maritime countries saw these
nonseabed issues as crucial. Thus, the numerous coastal developing states in particular could exercise bargaining leverage on the resolution of seabed questions. Among the linked issues were the extent of national territorial seas and economic zones, eroding rights of commercial and military navigation, fishing rights, offshore hydrocarbon jurisdictions, continental shelves, natural and artificial islands, straits, archipelagos, marine environmental protection, and peaceful dispute settlement procedures on all these questions.

At the outset of the LOS negotiations, the major coalition of Third World representatives (the “Group of 77”) demanded that an international body should be the sole exploiter of seabed resources. With this idea in opposition to the claims registry concept espoused by most of the developed world, negotiations on the subject came to an impasse. By 1976, however, conference participants began to coalesce behind a “split-the-difference” formula endorsed by Henry Kissinger. This conception became known as the “parallel” system. On one “side” of the proposed system, private and state organizations could mine, while on the other side, an entity would be established to mine directly on behalf of the international community. For the compromise to have meaning, it was necessary to ensure that this entity could in fact carry out seabed mining. Among other things, it needed access to mining areas, technology, and finances.

By 1978, these negotiations—the largest, the longest running, and, according to Kissinger, one of the “most important international negotiations which has ever taken place”—had reached agreement on some 90 percent of its contentious issues. Delegates expected the fate of the proposed treaty to turn on the resolution of seven issues which the members of the conference designated as “critical” and assigned to special groups for negotiation.

Prominent among these intractable issues was a system of financial payments to the international community to be required of future miners in return for the right to mine. The resolution of these financial questions constitutes the focus of this article. A large group with divergent interests and ideologies—active conference membership included over 140 countries—carried out the financial deliberations. The divergencies were in several directions, distinguishing developing from developed countries, socialist from market-economy countries, land-based producers from consumers of ocean minerals, and countries with seabed technology from those without.

Conference delegates and observers all agreed that resolution would be extremely difficult. Yet, despite the doubts often expressed in conventional wisdom, two years of intense bargaining finally overcame the impasse on these “financial arrangements.” In fact, during the summer of 1980, the tired negotiators hammered out what they felt to be a nearly final agreement on the entire text, which has come to be called the LOS treaty.

For a time, the deal appeared to hold. The parallel system formula seemed to compromise the conflict between international
and private exploitation of the seabed's "common heritage" resources. A unique aspect of the financial side of this deal was the exhaustive and explicitly "rational" exploration of their interests by the adversary parties, in part, by means of a computer model. Nevertheless, the entire agreement came under sudden and serious review by the new American administration in March 1981. It is too early to gauge the full implications of this sharp action. But the fact that such a review could have brought these multilateral negotiations of six years' standing to a shuddering standstill suggests inherent limitations of the process that led to the putative agreement and points up a basic lesson for the place of models in negotiation.

The MIT Model

A team of ocean engineers and management scientists at the Massachusetts Institute of Technology (MIT) developed the computer model of a deep seabed operation that was to prove significant in the LOS debates. It may seem something of a puzzle that this U.S.-built model gained credibility in the conference's sharply politicized environment. A few of the early negotiating sessions when the financial issues became prominent provide a good starting point for analysis.

Detailed debate on the financial arrangements did not begin until the 1977 New York session. At the time, there was no general agreement on the likely economics of seabed mining. Available studies were highly aggregated, typically were based on industry sources, and produced highly varied results. Many representatives from developing countries took it as an article of faith that mining would be profitable, so profitable in fact that front-end payments from private miners could be a virtual engine of Third World economic development. Representatives from developed countries seemed to expect more modest economic results.

Two financial proposals were offered in New York. They were formulated by conference opposites—the United States and India—and, if anything, served to define the extreme limits of a bargaining range. On every dimension these two financial proposals reflected divergent philosophies. The U.S. proposed a modest profit-sharing system, to be calculated only on the (mining) activities that take place in the deep sea; India suggested high fixed payments, to be levied on the entire mining, transportation, and subsequent processing operations, even where these operations occurred on land.

By the 1978 Geneva session, most other treaty issues had been resolved. The "financial arrangements" were designated as one of seven critical remaining subjects. Special negotiating groups were formed to deal with each of these contentious questions. The Permanent Representative of Singapore to the United Nations, Ambassador T.T.B. Koh, chaired the financial group. Koh brought some unusual credentials to the task: Singapore, Harvard, and Cambridge educated, he had been the youngest ambassador ever appointed to the U.N.; he had been the dean of the University of Singapore's Law School in his early thirties; he had been active in
the LOS Asian group; and he had been instrumental in the successful negotiations on other crucial articles of the draft convention. His appointment significantly raised the political level of the financial discussions, which, like the other key subjects, were widely attended and simultaneously translated into six languages. (When the long-time president of the entire LOS Conference died recently, the delegates elected Koh to the top post, in part because of his skillful work on the tough financial questions.)

Shortly before the 1978 Geneva session, the MIT group published the report describing its model of a seabed operation. It is hard to overestimate the effect of this model upon the financial deliberations in Geneva and in subsequent sessions. In his report, Koh stated:

In the group of financial experts we were immediately confronted with the need to agree on a set of assumptions. Without an agreed framework of assumptions it would not have been possible for us to carry on with our deliberations. We agreed that the best study to date was that undertaken by the MIT, entitled, "A Cost Model of Ocean Mining and Associated Regulatory Issues."14

Such references to the study and repeated use of its assumptions abound in the remainder of Koh’s report, reflecting their role in the deliberations. A discussion of the model itself helps to understand its early use.

In 1976, a team led by J.D. Nyhart (Professor in the Sloan School and the Department of Ocean Engineering at MIT) initiated a request for funding from the Sea Grant program, a maritime educational arm of the U.S. Department of Commerce. The group wanted to develop a computer model that could compare the performance of a hypothetical deep ocean mining system under various conditions. Nyhart’s group received support without any direct connection to the LOS negotiations.

The model itself was framed in such a way as to be innocent of ideological questions. One of its sections worked out the engineering aspects of nodule recovery and processing; these physical results fed into a financial analysis routine. The MIT group developed cost figures on research and development; prospecting and exploration; capital investment in mining, transportation, and processing; and operating costs including energy, labor, materials, and indirect charges. A great deal of research effort was expended in deriving independent estimates of the 150-plus principal parameter values or sets of values for the model’s "baseline case." Of course, there was a great deal of uncertainty attached to many of these values. Sensitivity analyses—that is, observing the effect of changing one or more variables while holding the rest constant at their "baseline" values—constituted a major part of the study. Users could provide their own input assumptions for the model. The report stressed uncertainty but its methodology was deterministic; a given set of inputs produced a single answer rather than a probable range.15
The model had been the subject of two critical review conferences at which academics, technical representatives of all the major mining consortia, and assorted government scientists had offered detailed suggestions on its structure, equations, and parameter values. In the several months between review sessions, the model was completely reworked. The technical report itself made no reference to questions of ideology in the ultimate structuring of the seabed mining industry, and, in fact, made scant reference to the LOS Conference. The model had clearly not been designed originally for the international use to which it was being put. For example, the U.S. tax system was built directly into the economic routine, and there was little discussion of the financial provisions in an eventual LOS treaty. These characteristics, perhaps a bit paradoxically, tended to reinforce perceptions of the model's independence.

The "baseline" profitability results of the study projected about an 18-percent internal rate of return to an enterprise after domestic (U.S.) taxes or, equivalently, a zero net present value at an 18-percent real discount rate. These findings contradicted persistent claims by developed countries that their miners would be unable to pay certain proposed fees and royalties. At the same time, this comparatively modest profit prospect dashed the hopes of many developing countries that seabed mining would be a bonanza, capable of generating untold amounts of revenue for the world community. Because the model's early results fully pleased no delegation, it seemed to gain in general credibility.

Koh was charged with the responsibility of producing a text that might represent a consensus. He pushed participating countries to advance proposals. Disappointingly for the progress of the negotiation, however, these proposals were still quite far apart in their payment magnitudes and their relative emphases on fixed and contingent charges.

At this point, Minister Jens Evensen of Norway proposed a financial scheme defining the obligations of the prospective miners and the prospective mining authority. Evensen had a great deal of personal prestige, was from a developed country that enjoyed an ambiguous position on the issue of private enterprise and public ownership, and was widely respected as the architect of several major conference compromises. Although Evensen had not participated in the earlier deliberations of the financial group, he had seen an impasse arising and offered what can be described as a split-the-difference political compromise. As had been his style in other parts of the LOS Conference, Evensen then stood back to take the rhetorical heat and listen to the inevitable denunciations from all sides. His more central proposal, however, became a focal point for delegates' attention.

Early in the subsequent New York session, an important seminar was held under Quaker and Methodist auspices, away from the United Nations.16 Koh actively encouraged the seminar sponsors and buttonholed many delegates about attending. This seminar was held on neutral ground that seemed generally remote from the
ideological issues that were latent in the seabed mining negotiations. The two sponsoring groups were generally interested in Law of the Sea questions, had lobbied in favor of treaty provisions, had held numerous off-the-record educational seminars and lunches for delegates since the 1974 sessions, and had published a much-read conference newspaper. Delegates of all political persuasions packed the politically timely and visibly Koh-blessed "MIT Seminar," which featured the principal members of the MIT team. Over the course of the day, they explained their model and discussed factors affecting future seabed profitability. Listeners vigorously questioned many of the model's assumptions, and, in particular, its "baseline" values. The team's usual response to queries and challenges was to explain the source of the questioned assumption and to demonstrate the sensitivity of the model's results to the factor in question. That technique highlighted the underlying technical and economic uncertainties, but it also seemed to enhance the credibility of the effort.

Criticism of the MIT model at the seminar came from various quarters, but all the criticisms were couched in technical—not ideological—terms. For example, EEC members referred to a competing set of estimates—the "European Base Case"—which was considerably less optimistic than the MIT study. In addition, the fact that an independent source of technical information had been provided to the government obviously had annoyed some industry representatives. Whatever the motivations, most of the attacks at the seminar by representatives from developed countries, whether government or industry, elicited fairly straightforward technical responses and seemed to strengthen the confidence of many developing country delegates in the model's usefulness.

The MIT group had not planned to risk politicizing its seminar presentation by analyzing any of the existing financial arrangements proposals. Minister Evensen, however, was not at all averse to having his proposal examined, critically, in order to "demonstrate the model's capability." The team easily showed several economic and technical scenarios under which Evensen's ad hoc compromise would reduce a project's profitability severely. At the conclusion of the presentation, Evensen acknowledged the critique, thanked the group, and indicated that he might consider modifying his proposal.

Curiosity was aroused among some of the other delegates as to the economic feasibility of different proposals. In particular, the eminent Indian delegate, Dr. Jagota, praised the team at the end of the seminar and then inquired as to the effect of the Indian proposal. The analysis had already been performed, and, not surprisingly, the impact on profitability of a $60 million payment some five or more years before commercial production was to begin, along with a 20-percent tax on gross revenues, was devastating. Jagota, too, indicated that a reconsideration might be in order. In neither case did Evensen or Jagota have to admit the correctness of "opponents'" arguments to justify a possible move. Instead, each could point to an outside, seemingly objective analysis
as a reason for considering a new position. Offers at the conclusion of the seminar by MIT team members to modify the model to handle future financial proposals as well as their offer to maintain constant contact with conference members were generally well received.

Evensen and members of the Norwegian delegation soon after made a trip to MIT, where they had a chance to discuss seabed economics more fully. While in Cambridge, Evensen asked team members to analyze several possible proposals. Upon his return to New York, Evensen made a new proposal that conspicuously leaned on the MIT analysis. Much of the subsequent discussion centered on Evensen’s second proposal. By the end of the session, Koh felt for the first time that he could make his own proposal, one that was very similar to the new Evensen proposal. Koh also had relied heavily on the baseline case of the MIT study to fashion his scheme. As he stated in his report:

There are two fundamental ways in which my compromise proposal can be evaluated. First, we can compare it with financial provisions in national laws for mining contracts. The second way is to monetize my proposal. For the purposes of monetizing my proposal, I have looked at both the MIT cost model and the European Base Case. I have used the MIT Model because it is a much more detailed and comprehensive study than the European Base Case. I think the majority in the Negotiating Group, both from developed and developing countries, will agree that the MIT model is the most reliable estimate we have of the costs, expenditures, and revenues of seabed mining.\textsuperscript{17}

Paul Engo of the Cameroon, the politically adept chairman of the negotiations on the overall seabed regime, provided indirect evidence on the extent to which the model had permeated Conference consciousness and how the locus of political power was shifting to the technocrats. He lamented that

[w]e have ourselves been dragged into adopting models and systems of calculations on fictitious data that no one, expert or magician, can make the basis of any rational determination . . . We get more and more engrossed with each session and have been reduced to mere spectators in the inconclusive tournament among experts.\textsuperscript{18}

Many intricate turns and switchbacks of the negotiating road led slowly and painfully to agreement in the summer of 1979. The existence of the model may well have deflected the minds of delegates away from the possibility of more fundamental differences to the more value-free questions that the model could handle. In any event, as the sessions progressed, delegates became less and less satisfied with the baseline analysis that early on had seemed to offer some certainty about the economic profile of this yet unborn industry. The deterministic character of the model—the fact that it only offered point estimates of payments and
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profits—paradoxically emphasized the uncertainty that confronted all parties.

Increasing challenges to the baseline results invoked several factors: uncertain capital costs of a new high-technology venture proposed to operate for 20-plus years in a hostile physical environment; uncertain operating costs that depended on energy, chemical, and labor prices; as well as uncertain revenues that were at the mercy of volatile metal markets. Gradually, the apparent certainty that had attracted delegates to the study in the first place gave way to appreciation that the uncertainty was inescapable. As a result, the negotiators began to turn their attention from payment schemes that were based on relatively fixed charges to more contingent methods that adapted to a variety of economic circumstances. While the specific numerical results of the model became less important, its structure and method for project evaluation (using discounted cash flow analysis) were increasingly understood and ultimately suggested a compromise. The concept of "profitability" in a long-term venture began to be thought of as more than an annual matter but one that involves the timing and magnitude of cash flows with an appropriate discount rate.

The remaining differences, on which both sides "conceded," were of a kind that appeared remarkably value-free. Despite the common framework introduced by the MIT model emphasizing the uncertainties of any long-term prediction, many developing-country delegates believed that mining would be quite profitable. Meanwhile, delegates from the developed countries held more to the view that seabed profitability would be relatively modest. The final negotiated compromise in effect reflected the divergent expectations by an ingenious scheme. Two basic payment schedules would apply: The first had a low royalty and profit share; the second had much higher royalties and profit-sharing rates. (There were also intermediate steps and a small annual fixed fee.) The second schedule would be triggered when the overall cash flow of the operation, cumulated forward with a 10-percent real interest rate, was sufficient to recover the investment (also cumulated forward with interest). In effect this meant that until a project reached a positive present value at a modest discount rate, its payments would be relatively low. Higher rates would apply to projects as their overall risks diminished.

Rather than denying the uncertainty of seabed economics by trying to pick a single set of rates, the compromise payment scheme adapted to it in a way that both sides saw as advantageous, given their different expectations about the future. The developed countries seemed to expect a modest level of profits; accordingly, the high rates that apply for bonanza projects are not much of a concession. Many developing countries professed to expect high profits; agreeing to low rates of taxation for normal profit levels was no great concession. And, whatever the ultimate outcome, the figures were not so favorable to one side or the other that the system would be seen as egregiously unfair. In short, the scheme with two payments schedules offered joint gains once the different
expectations of each side were taken into account. Moreover, projects would pay taxes on a relatively low schedule as long as the invested funds were still at risk; a significantly higher schedule would come into effect after investment and interest charges were recovered. This arrangement took advantage of the apparently higher risk aversion of companies (whose mining investments would be significant in relation to corporate assets) than that of the international “syndicate” of recipient countries (whose revenue shares would be modest relative to their national incomes). In return for protection against the risk of high tax rates on marginal projects, companies in effect would pay an attractive “premium” in the form of stiffer charges on very successful operations. In many ways, the negotiators came up with a scheme that is far more sophisticated than traditional mining agreements. 20

The model played a significant role in fashioning this accord. By requesting and examining simulations, some delegates became rather good at analyzing which factors decisively influenced the rates of return and which ones affected the timing and amounts of the payments to the Authority. In the words of a former U.S. negotiator:

It should be noted, however, that the idea of raising the figures over time was in part based on the MIT analysis, which gives far greater weight to dollars paid earlier than to those paid later in the contract. By raising the royalty rate over time, the Chairman—in a constructive attempt to combine Western economics and Group of 77 politics—has created a system which requires the lowest payments at the greatest time of risk and the highest payments in the cheapest dollars. 21

The model was a vehicle for educating the negotiators. It provided a coherent framework in which delegates could explore the myriad of interacting factors affecting the economic and technical success of ocean mining projects. The model also offered measures to evaluate the negotiations themselves—rates of return, present values, payments to the international community—measures which supplied a precise language for the debate and which came to frame the issues in a clear, nonideological form.

Here, then, was a complex negotiation that did not proceed in ignorance. Rather, the deliberations of dozens of delegates from various foreign, mining, and finance ministries constituted a lengthy mutual education process. A great deal of information was exchanged and a powerful tool was generally available to analyze proposals, to help invent new ones, and to lay out implications for the parties’ economic interests. While pure bargaining necessarily took place in tandem with analytic investigation, it is hard to imagine a more intensely rational process in a negotiation among so many nations. Yet this rationality could only produce useful results within a larger, agreed framework. The resurgence of American misgivings about the entire parallel system/common heritage formula not only signaled a reevaluation of policy, but also pointedly reminded modelers of their derivative role.
Brief accounts follow of three different modeling efforts, each in a
distinct negotiation. Aspects of these cases complement and chal-
lenge some of the generalizations that one might be tempted to
draw from the Law of the Sea.

Another United Nations megaconference provides the setting for a
second example.22 This time the subject is a program for stabilizing
and perhaps raising the price of numerous commodities that are
often exported by developing countries. The actors are roughly the
same as in the LOS Conference, although in the United Nations
Conference on Trade and Development (UNCTAD), the North–
South split is paramount.

In the UNCTAD Conference, commodity modeling efforts and
analyses are undertaken by the Secretariat staff. The staff’s work
has little credibility with developed countries, which typically
view it as ideologically biased toward market control, technically
incompetent, and strongly oriented toward developing-country
interests.23 Apparently the staff was very influential in the intel-
lectual effort of constructing the overall Third World positions with
respect to commodities.22 This was a case of modeling efforts being
used by all but one side with very little chance of becoming the
basis of a consensus.

For the internal negotiation among members of the coalition of
developing countries (the Group of 77) no strong ideological
differences surfaced. Nevertheless, the modeling apparently had
an effect very different from that of the LOS model. Analyses
showed repeatedly that there were significant losers as well as
winners in the developing-country coalition. The interests of the
various members of the Group of 77 were much less congruent
than was originally hoped. Since the effect of this modeling
information could have strained the unity of the coalition, the
Secretariat tried to make it a policy not to distribute analyses of
gains and losses for individual countries.25 When an early staff
study was released inadvertently showing more than 40 develop-
ing countries as net importers of the relevant commodities, the
findings reportedly generated substantial problems.26 Informa-
tion of that sort could destroy the group’s cohesion and open them up to
divide-and-conquer tactics from the developed countries.

Of course, new modeling information need not lead to the
identification of joint gains: depending on the analytic outcome,
the issue may be revealed as having parallel gainers and losers
among the competing parties. In such a case, the use of models
may prevent agreements based on false premises of interest.
Whatever were the implications of the commodity modeling in this
regard, the UNCTAD case seems to counterbalance the LOS
experience in origins, sponsors, uses, and effects.

A third example, like the MIT/LOS case, finds a clear analytic
model submerged in murky political waters: Here, computer
simulations were used in several rounds of collective bargaining in
the public sector. Part of the RAND Corporation’s extensive consulting relationship with New York City during the Lindsay administration in the late 1960s involved construction of models relevant to Fire Department operations. For some time, RAND’s modeling efforts on outbreaks of fire and departmental response capability proceeded without much notice. Concurrently, however, there was a tremendous increase in the problem of overwork for city firemen. In August 1968, the firefighters’ union demanded that the city hire an additional 2500 full-time firemen. Part-timers, of course, were anathema to the union tradition. In November 1968, the quasi-judicial Board of Collective Bargaining ruled that the city must negotiate with the union on ways of reducing the firemen’s workload.

RAND’s modeling became relevant to the negotiations when, in January 1969, Chief O’Hagan asked it to devise workload measures. The RAND responses pleased him and the modeling group focused its subsequent efforts almost exclusively on the technically framed issues of workload and response times. Developing the capability to evaluate different response policies under varying conditions became the modelers’ aim.

Meanwhile the negotiations between the city and the union moved ahead. Proposals diverged; the union insisted on the hiring of large numbers of new firefighters; for budgetary reasons the city’s position emphasized a reduction in the size of the force that would comprise a “standard response” to fire alarms. At the time, this response consisted of sending a team of three engine and two ladder trucks. However, critically for the negotiations, both sides agreed on the goal of workload reduction without loss of safety.

By July 1969, the RAND group was ready to present its modeling results to the city. As with the MIT/LOS group, the analyses did not deal with the political debate, but to some extent technically undermined the proposals of each side. The crucial fact that emerged from the modeling was that, at peak times, busy stations were already unable to respond with the standard team. Thus, the union demands for adding a large number of firemen would not address significantly the problem of overwork: The new firefighters would simply fill out the now-unfulfilled teams’ responses without relieving current firemen. City proposals also suffered in the RAND analysis: A formal reduction of the standard response when a de facto reduction already existed would not solve the overwork problem. An obviously efficient solution to this dilemma was to add firefighters at peak times while reducing the standard response. The RAND work bore this out, and it also seemed to show that such a limited initial response policy supplemented as needed by additional equipment could actually provide a more effective response.

The models were refined over time and were used to examine the sequence of proposals emerging from the negotiation. With the parties agreed on the need for change, but bitterly opposed to each other’s proposals, it was significant that RAND’s modeling supported a:
recommendation for part-time fire companies . . . that made concessions to both sides in the workload dispute. For the unions, it represented a step toward the creation of additional firefighting units. For management, it promised a cost savings. The part-time units, according to RAND, would produce the same impact on workload as full-time companies at 40 percent of the expense.\textsuperscript{29}

Agreement finally was reached in September 1969. The standard response was to be reduced during peak hours; ten part-time companies (manned by volunteers) were to be created for that period; and eight new full-time companies were to be formed. A Fire Department official referred to the effect of RAND's simulation as its "supreme achievement in the city of New York."

RAND's work was initiated, directed, and financed by the city. The modeling group, however, wanted to act in a trusted advisory capacity to the union. It finally received reluctant permission from the Fire Department to make direct presentation to what turned out to be hypercritical union members. The group also cultivated a union official (later president) who had some training in management science. Yet, the union continually suspected that it was only getting laundered data while the city was getting the inside story.

That the modeling efforts did have a significant effect despite its strong ties to one side may have a set of interrelated causes. By their nature, the mathematical models did not intrude on the charged ground of union membership policies or larger budgetary tradeoffs. The initial modeling results, as in the MIT/LOS case, cut against the initial positions of both sides. Also like the MIT study, the RAND simulation offered precise, nonideological language (response time, workload measures) for framing the issues. Unlike the UNCTAD models, the RAND study clearly offered a technically efficient means of achieving joint gains. Yet, the proposals affirmed by RAND as superior to the negotiating positions of each side were hardly new proposals; they had apparently been around the union and department for years.\textsuperscript{30} In a sense, RAND did not "own" the proposals; it provided a formal way of verifying their effectiveness (and, of course, distinguishing them from other, plausible hunches that had been discussed). There was no need to concede that RAND, or, by extension, its sponsors, were right; the models were no more than a convenient proving ground.

The models also enjoyed a monopoly position in a world of otherwise hazy analysis. It was hard to ignore the proposals recommended by RAND given that they were the most studied and documented. Against the manipulated, distorted, and vague view of the world advanced by the adversary negotiators, the RAND study's independent existence created a powerful bias toward either its explicit or tacit use.

The RAND-inspired settlement soon began to be implemented with apparent good results. However, after a year, the city had not created the promised full-time companies. The union ordered its members to withdraw from the part-time companies.\textsuperscript{31} The accords disintegrated. Ironically, the agreed formula for workload
reductions, which was tenable for both sides during the crisis negotiations, proved vulnerable as the realities of the city’s budget and union politics reassured themselves. RAND’s Fire Department work, both before and after the negotiations, was generally judged as valuable. However, the fate of its bargaining proposals, as with the MIT work in the Law of the Sea, turned on political considerations that were outside its analytic framework.

Development in Obergurgl

By 1974, the Tyrolean village of Obergurgl in Austria had enjoyed some three decades of economic growth, albeit in a haphazard fashion. Hotels were crowding out bottomland, which was essential for farming, and there was extreme pressure from tourism in the summer as well as during the winter skiing season. Future development plans and their potential impact on both the village itself and its fragile alpine ecosystem had for some time been the heated subject of local negotiations.

At this time, research groups at the International Institute for Applied Systems Analysis (IIASA) were concerned with the substance of such ecological problems but, more critically, with how to bring together modelers and users. A team from IIASA with interests in adaptive approaches to environmental management was dispatched to organize a series of workshops designed to explore the village’s interrelated problems.

Howard Raiffa, then the head of IIASA, recently evaluated the process:

The first workshop brought together for a week a small group of ecological modelers, computer specialists, experts on alpine regions, and economists with businessmen, hotel managers, town and regional officials, and some just plain villagers. They joined together to build a model. . . . As can be expected (and was expected) the first week’s work was a fiasco and the model that was developed had to be scrapped. . . . The group tried again and again (but for shorter periods of time). The model improved a bit, but not much. But something important happened: the non-scientific contributors from Obergurgl began to talk and to listen to each other. They gained new deep insights into their problems and they demonstrated that these insights could be translated into operational policies. They began to communicate not via the model but around the model. They felt the effort was worth their while. In appreciation for the IIASA effort, the Obergurglians made our ecologists honorary citizens of Obergurgl and treated them most royally. . . . Months later, President Kischlager, when reviewing the impact that IIASA was having on Austria, talked glowingly about how IIASA got the people of Obergurgl fired up and talking and listening to each other. . . . The exercise was monitored by some skeptical visitors from Czechoslovakia and at the end they wanted a similar study to be replicated in the Tatras Mountains. . . .

The Obergurgl experience is an illustration of the principle that it may be far easier to work on another’s related problem than to
tackle one’s own problem directly. With adversarial elements more in the background than they would be during a direct negotiation, the flow of communication may be improved substantially. In working on the IIASA team’s problem of building the model, the villagers were in fact helping to solve their own. The independence of the IIASA group was important to the process, but the actual results of the modeling, unlike those of the MIT, RAND, or UNCTAD efforts, were relatively incidental. Also, here, the model’s role was not subordinate to a larger, shared, political conception. Rather, the analytic tool served more as a quiet group therapist.

THE LESSONS FROM MODELING
In all cases—MIT/LOS, Secretariat/UNCTAD, RAND/NYC, and IIASA/Obergurgl—the modeling helped one or more sides to learn more about the subject under negotiation. Learning took place indirectly around the model or directly by means of it. The MIT and RAND models offered the negotiators precise terms for the discussion (payment levels, internal rates of return; workload, response times). Each of these models seemed to capture a very complex reality and served as artificial common ground for what otherwise could have been a much more diffuse discussion. Where knowledge of the subject under negotiation really is diffuse, a modeling effort can virtually define many of the issues.

The models also helped to uncover the disputants’ interests and to hold out the possibility of joint gains. In the LOS negotiations, the gains were possible on the basis of a fairly sophisticated use of differences in profitability forecast and risk aversion. Verification of the potential for mutual benefit from new equipment deployment schemes was made possible by means of the RAND simulations. The commodity models at UNCTAD, by contrast, revealed incongruity of interest and threatened coalition unity. Especially in the MIT case, as typified by Minister Evensen’s Cambridge visit, but also in the RAND example, allegedly superior information or analysis allowed relatively costless movement from entrenched positions.

The analytic results themselves varied in importance. In the MIT case, initial results were of great interest to the negotiators for their seeming certainty; later, the precise figures assumed less importance as the model became a vehicle for exploring the effects of inherent uncertainty on payoffs from long-term investments. The RAND results were directly relevant to the concerns of the negotiators and were central in the model’s use. A model’s results may do more than inform, deflate extreme positions, and suggest gains: The UNCTAD results were divisive. By contrast, where a model effectively removes communication barriers, as with the IIASA model, the results may turn out to be of secondary importance.

Part of the reason that negotiators may accept a given model is its expected potential benefit in these areas of unimpeded learning.
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communication, and discovery of gains. To be useful, however, the model needs to be seen as independent and to be closely identified with the norm of superior knowledge. The relationship of a model's source to the negotiators, its reputation, the external verifiability of its methods and results, and the implications of its results for the positions of the involved parties are all factors that may enter into the evaluation of a model's independence. The IIASA team was clearly independent of the Obergurglians' dispute; the MIT effort seemed independent through aspects of its builders, construction, content, sponsorship by outside groups, and results which appeared to contradict the positions of all sides; the RAND work took on some of the same characteristics. The UNCTAD modeling efforts, however, were independent from the points of view only of their sponsors; the other sides saw those efforts as suspicious.

The MIT and RAND efforts were especially valuable because of their proximity to the negotiations and their easy modification as the talks progressed. The constant presence of an MIT member at the LOS Conference apparently stimulated much of the model's use. The benefits of the IIASA effort at Obergurgl crucially relied on interaction among the village disputants during the model's construction. A model created apart from the negotiations may be seen as quite independent of the process. If it is unable to be modified, however, its relevance and ability to foster learning and to suggest joint gains in an evolving negotiation may be weakened.

Of course, no side need accept a proffered model, even one that appears independent and credible: That side may fear loss of negotiating advantage for a variety of reasons. The introduction of an apparently credible model, however, can link the norm of superior knowledge to the proceedings. While a party may seek to reject such a model for joint use, that party will face the costs of being seen as unreasonable. These costs will be proportional to the model's credibility and independence with the other parties. Thus, the very introduction of a credible model may generate pressure for its acceptance. Whether those pressures prevail depends on other perceived benefits and costs of acceptance or rejection.

Predictions of how a model may be used in a given policy negotiation hinge, then, on how much is known in the general area, on whether the work is sponsored by or to be used by more than one side, on the source of the work, on the process for its construction and modification, and on the nature of its expected results. Models can be the modern tools of pragmatism where a larger, perhaps political conception is shared, where an overall negotiating "formula" is maintained by the parties, or where divisive factors outside elegant, analytic frameworks are held in check. Models can skillfully mediate policy disputes, but their roles are precarious when ideologies or basic values actively clash. As the examples in this article suggest, model rationality may be circumscribed. The knowledge models produce and conciliatory movement they inspire are important, but are hardly the end of the story.

Valuable suggestions were offered by Deborah Dupire, David Lax, Mark Moore, J.D. Nyhart, Howard Raiffa, and Lawrence Susskind. The opinions and inescapably personal interpretations in this article do not necessarily represent the view of the organizations with which the author is affiliated.

NOTES


10. "Calling it a happy day, the chief American delegate, Elliot L. Richardson, said it was 'all but certain' that the text would be ready for signing in 1981. 'Historians looking back on this session of the conference,' he added, 'are likely to see it as the most significant development of the rule of law since the founding of the United Nations itself.'" New York Times, 30 August 1980, p. 1.


13. For example, see U.S. Department of Interior, Ocean Mining Administration, Ocean Mining: An Economic Evaluation, by Rebecca L. Wright, Washington, DC: May 1976.


23. Ibid., pp. 69, 109, 123.


25. Ibid., p. 69.

26. Ibid., p. 112.

27. This account is based on Greenberger et al., pp. 231 - 285.

28. Ibid., p. 275.

29. Ibid., p. 276.

30. Ibid., pp. 273, 279.

31. Ibid., pp. 276 - 277.


33. Raiffa, unpublished transcript.