Analyzing Political Decision Making from an Information-Processing Perspective: JESSE*

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Political behavior is argued to result from interacting political and information-processing mechanisms. Political mechanisms deal with the values, interests, and influence of the political actors, while information-processing mechanisms concern themselves with the actors’ use of knowledge and experience in exploring the space of choices and actions.

Information-processing approaches are argued to provide a language for expressing theories of political decision making with greater precision than before. This language also enables computational experimentation with these theories. The general information-processing approach is illustrated in detail for the specific domain of Japanese energy and foreign policy decision making. A political theory of decision making by the Japanese political and economic elite in the domain of its energy supply security is developed from an information-processing perspective. This theory is embodied in an experimental system called JESSE. JESSE contains multiple modules that perform the generic task of classification and a module that performs the generic task of plan selection. The system is initiated by supplying information about an energy-related situation. It classifies the situation into types of threats posed to Japanese energy supply security and retrieves stored plans from memory. Its output can range from a decision not to take any action to a large number of actions some of which may appear contradictory.

The theory embodied in JESSE is argued to apply to political decision-making situations in which there are limits on institutional rivalry; the members of the decision-making group have been socialized similarly; the problem domain is seen as sacrosanct; and there is substantial prior analysis and planning. The issue of validating the theory is addressed, and JESSE is found to be a plausible model of Japanese decision making in the domain of her energy supply security.

Information-Processing Models of Political Decision Making

Political and Information-Processing Mechanisms

Nation-states are oft-studied political units consisting of individuals, groups, and organizations with values, interests, and varying degrees of influence. Political processes in nation-states lead to decisions about the allocation of resources among subnational actors, or “who gets what, when and where” (Easton

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1953). Various kinds of political mechanisms have been hypothesized to be sources of "pulling and hauling" (Allison 1971) between the competing subnational actors. These mechanisms are intended to explain how the interests of the participants get balanced, compromised, suppressed, or are met to varying degrees. Equally important, these mechanisms are intended to account for whether and how the values and interests of the participants get transformed into the goals of the political unit as a whole.

These political mechanisms, however, are only one part of a full account of the political decision-making process. Political actors are also problem solvers, who make decisions by exploring different choices, who plan and execute various actions, who make use of their knowledge and experience in the pursuit of their interests and goals. These activities can be viewed as information-processing phenomena. The information-processing mechanisms are subject to a number of constraints on computation and memory. As recognized by many political scientists, problem-solving agents are only boundedly rational (Simon 1969, 1985).

Decision-making behavior of political units, we argue, is the result of interactions between these political and information-processing mechanisms. Depending upon the norms of a political culture, the degree of consensus among the actors on a given problem, and previous experience in a particular problem domain, the decision-making process can be located along a spectrum. At one extreme of this spectrum, decision making is dominated by purely political mechanisms, while at the other extreme, information-processing mechanisms play an important role. The information-processing end of this spectrum is exemplified by highly organized problem-solving actors who accept politically dictated values and goals and then carry out the decision-making process with little interference from political mechanisms. Any specific political decision-making instance represents a particular mix of political and information-processing mechanisms, the latter always at the service of the former.

The term "information-processing model" has acquired a set of related but distinct meanings. Newell and Simon (1972) have used this term in the specific sense of an architecture that resembles the von Neumann architecture for digital computers: input and output devices, a processor, and a memory. A criticism of the Newell and Simon view has been that it treats mental information processing as mostly serial and that it treats memory as a large data base whose only role is to supply information to the processor. Alternative proposals have been made that treat memory as an important source of power in intelligence, with an active, self-organizing structure, and with its own complex information processing (e.g., Schank 1982). We use the term "information-processing model" in a more general sense than that of Newell and Simon as requiring simply that information be represented in some form and processed to yield other representations. In this paper, we make the further assumption that the representations are data structures and that processes that manipulate the representations are algorithms. Note that this characterization does not make any specific commitments about the degree of parallelism or the precise architecture of the information-processing machine. Of course, the particular information-processing model that we propose later comes with additional specifications that reflect the nature of the tasks being modeled.
As one would expect, literature in political science contains a number of proposals for studying political mechanisms—what they are and how they work. However, there has been relatively little scholarship on the role of information-processing mechanisms in political decision making. Of course, the forms of these mechanisms are unlikely to be specific to politics. However, the content of the information processing would be dictated by the politics of the decision-making situation being modeled.

**Political Content and Information-Processing Languages**

Theory construction in any discipline involves making choices at two levels: a language (e.g., objects, relations, processes) in which alternative theories can be stated and the content which states a particular theory about some specific phenomenon in that language. In the natural sciences, major breakthroughs are often characterized by proposals that simultaneously make advances in both language and content. Newton invented the differential calculus in which to describe his laws of motion. Maxwell’s equations derive their beauty both from the fact that the language of differential equations is the appropriate one in which to state how the electrical and magnetic properties of light are related, as well as from the particular relations that were proposed in that language.

When a language is invented that fits a class of phenomena appropriately, then a variety of content theories can be proposed in that language for particular instances of that class. Such a language can be judged by its expressiveness, that is, by the primitives and constructs it offers. A more expressive language enables a greater variety of distinctions to be noted and thus makes it possible to express theoretical content more precisely. In contrast, particular theories in that language can be judged on the basis of their correctness or validity.

Over the last few decades, research in the field of artificial intelligence has led to an information-processing language that offers new primitives and constructs for capturing the problem-solving behavior of intelligent agents. In this language, problem-solving agents achieve their goals by representing problem spaces (i.e., the set of choices and possibilities), using knowledge to explore these spaces, and choosing suitable alternatives (Newell 1978). This language, as we shall illustrate, provides a medium for expressing theories of political decision making with greater precision and explicitness than before.

**Illustrating the Information-Processing Approach**

This article describes a research effort in which an information-processing approach is used to model Japanese energy and foreign policy decision making in the domain of its energy supply security. The model is embodied in an experimental computer system called JESSE. There are several goals to this project:
1. To demonstrate the usefulness of the information-processing perspective by showing that it enables one to describe aspects of political decision making that could not be considered in detail before, especially in any kind of formal manner. This facet of the contribution can be judged on the basis of what aspects of the phenomenon can be made explicit using this methodology, aspects which might remain hidden or vague without this formalism. In particular, relatively explicit proposals can be made about the space of possible choices within which the problem-solving mechanisms operate and the kinds of knowledge with which the space of choices is explored.

2. To demonstrate the expressiveness of a particular family of information-processing languages called the generic task languages for capturing many relevant aspects of problem solving and decision making by political units. This family of languages is, however, not argued to be complete in its present form. As more forms of information-processing mechanisms for capturing problem-solving behavior become available, the family can be extended with additional members.

3. To propose a specific theory of Japanese energy-related decision making using the above language. The evidence for this theory will be discussed, as will the issues of validation and scope conditions.

The rest of this paper is organized as follows. Section 2: we discuss our reasons for choosing the domain of Japanese energy supply security and propose a political theory for Japanese energy and foreign policy decision making in this domain. Section 3: we present an information-processing analysis of the decision-making task and propose a functional architecture for the JESSE system. Section 4: we discuss the issues of knowledge, inference, control, and implementation of JESSE. Section 5: we address the validation of the political information-processing model embodied in JESSE. Section 6: we discuss the scope conditions of the model. Section 7: we compare the generic task approach to other information-processing approaches for modeling political decision making. Section 8: we compare the information-processing approaches with other approaches to political decision making. We conclude the paper in section 9 with a discussion of the political content in information-processing models of decision making. An abridged, annotated transcript of a session with the JESSE system for Japanese energy-related decision making soon after the Iranian revolution of 1979 is provided as an appendix to this paper.

**Japanese Foreign and Energy Policy Decision Making**

*The Domain of Japanese Energy Supply Security*

We shall illustrate the information-processing approach to the study of political decision making by analyzing Japanese foreign and energy policy decision
making in the domain of its energy supply security. There are several reasons for the choice of Japan as the political actor and its energy supply security as the decision domain:

1. Japan as an interesting political actor. Scholars and lay observers alike have been impressed with Japanese economic performance in recent decades, especially in the context of its political, military, and natural resource limitations. For this reason alone, the political behavior of Japan is an interesting and important area of investigation for political science.

Moreover, the classical theories of international political economy have been somewhat less than completely satisfactory in explaining the enormous economic success of Japan. For instance, neo-Marxian scholars, such as Wallerstein (1984), tend to offer an explanation of the contrast between the success of any one capitalist nation-state, such as Japan, and the relatively more difficult economic situation of other capitalist nation-states, such as the United States, by focusing almost exclusively on the hegemonic status of these two nations. To us, this appears as an incomplete and somewhat post hoc explanation. Liberal economists (see, e.g., the modeling of economic sectors in Bremer 1987), on the other hand, offer a contrasting, but equally incomplete explanation. Their framework of relatively unconstrained nation-states acting almost solely on the laws of supply and demand omits a great many factors.

Realists and neorealists in international relations from Carr (1946) through Morgenthau (1966) to Krasner (1978) also have difficulty explaining Japanese success and influence, given the lack of large military expenditures. This lack of an adequate theory provides an additional incentive to look for alternative mechanisms and processes that might help explain the success of Japan.

2. Energy as an important domain of investigation. The natural resources of Japan are known to be very limited, especially in the energy sector. Therefore, Japan is critically dependent on energy-exporting countries for its energy needs. A theme of this article’s substantive focus is that the Japanese leadership sees national security as an economic rather than as a military concept. This elevates the energy domain in highly industrialized and export-emphasizing Japan to a central role. Also, the world energy situation has been volatile in recent years, as evidenced by the massive increase in the cost of energy following the Iranian revolution in 1979. For all these reasons, an understanding of Japanese decision making in the energy arena is an important topic for political analysis, and energy is a significant domain in Japanese politics.

3. Domination of information-processing mechanisms. We argued earlier that political behavior of nation-states is the result of an interaction of political mechanisms with problem-solving mechanisms. Depending upon the political culture of the nation and the decision domain being studied, the political behav-
ior may well be dominated by the purely political processes. Alternatively, at the other end of the spectrum, the problem-solving processes may play the major role in determining the behavior of the nation as a whole. Since our goal in the present discussion is to demonstrate the utility of information-processing models of political decision making, we have chosen a domain of decision making—Japanese energy security—that offers evidence of information-processing elements being critical.

Krasner (1972) responded to Allison (1971) and others’ emphasis on the role of bureaucratic politics by arguing and illustrating the point that the rational actor model is not always a “straw man.” Krasner argued that elements of the rational actor model exist in many decisions, and he offered a number of examples from U.S. foreign policy to support his point. Japanese energy policy decision making further emphasizes Krasner’s theme by exhibiting many elements of the rational actor model. Neither Japanese decision making nor our model of it contain such simplistic assumptions of the rational actor model as transitivity, however. Our modified perspective is better captured by the notion of “international inferencing” (see Thorson 1984; Sylvan 1987).

While the common American view of “Japan, Inc.” surely overstates the point, Japanese government and business do not have a deep institutional rivalry (see, e.g., Samuels 1987). Especially in the domain of its energy supply security, Japanese policy decision making is not subsumed by institutional or bureaucratic competition. Additionally, more than is the case in many other countries, Japanese decision makers have similar political socialization patterns. The preponderance of Japanese civil servants, for instance, have been educated at Tokyo University, with most of the remainder having been educated at Kyoto University (see Richardson and Flanagan 1984; Kubota 1969). The self-selection process for those who want to be decision makers leads to the study of law and economics in quite a high percentage of cases. Generally similar foreign policy world views is hardly a surprising result.2

4. Availability of information. Finally, the related issues of availability of information about the actor being modeled and knowledge about the domain being studied must be considered. We garner our information both from the wealth of literature on the subject of the Japanese energy domain and from personal interviews with Japanese political and economic elites.3 The academic, business, and Japanese governmental communities have all produced important literature that has informed us.

2 Similarity of foreign policy world views does not imply that all Japanese actions are consistent with each other. In fact, both our understanding of Japanese energy decision making and our model of it allow for and exhibit Japanese decisions that are inconsistent with each other.

3 Interviews on which the “first cut” of our model was based were conducted by Davis B. Bobrow, who collaborated with us on the early stages of this project.
A Political Analysis of Japanese Decision Making

Decision making under constraint. We have remarked that the classical theories of international political economy have been less than satisfactory in explaining the economic success of Japan. An alternative explanation is more at home in the study of foreign policy decision making than in the study of international political economy. It is based upon a conception of Japan, and other nation-states, as making decisions under constraint. In this view Japan is a nation-state that has very real resource constraints but succeeds more than do other nation-states by approaching the constraints in a novel manner. This view serves as the starting point for our analysis of Japanese decision making in the domain of its energy supply security.

Economically centered concepts of national security. On a "substantive" level, JESSE begins from the assumption that Japanese leaders are quite concerned with national security but view the concept of national security as a fundamentally economic one. Critiques of Morgenthauian realism as being too concerned with military factors to the exclusion of economic influences would clearly receive a sympathetic hearing among Japanese elites. One of the most significant observations stemming from the initial interviews on which the "first cut" of this model was based is that Japanese leaders tend to view "national security" as an economically-centered as opposed to a militarily-centered concept. The JESSE model attempts to draw out the implications of this distinction. As will be seen, the substantive categories for classification in JESSE are such economic categories as "energy cost" and "energy flow," rather than such military categories as "nuclear weapons state" or "military ally." The political content of our theory, then, is based on observing that Japanese decision makers who deal with foreign energy policy act more similarly toward nations that happen to be energy suppliers, for instance, than they do toward nations that happen to have similar military capabilities.

Anticipatory policies. We posit that Japan has prepared policy options for anticipated threats to its energy supply security (Bobrow, Sylvan, and Ripley 1986; Sylvan, Bobrow, and Ripley 1987). Some of the stored policy options are unilateral (e.g., buy energy shares in the stock market); some are bilateral (e.g., purchase energy from reliable energy exporting countries); and others are multilateral (e.g., support multilateral energy consumer cartels). How does Japan select appropriate policy options in response to an energy-related event? It begins by choosing from a menu of these anticipated policies. We have observed that certain domestic economic means have been followed on a number of occasions. Those are found in the "unilateral adjustments" portion of Figure 1. Both political and economic means, including concentrating on the United States, fall under
the conceptually distinct bilateral domain. Finally, a set of options that are mostly economic in nature are stored in the multilateral portion of Figure 1. Unilateral, bilateral, and multilateral options may be pursued simultaneously, with a slightly more political emphasis—consistent with our understanding and theorizing about Japanese energy decision making—in the bilateral category.

State of foreign relations. Japanese energy policy decision making takes place in the context of its foreign relations in general. At the time of the Iranian revolution, for instance, Japan’s relations with some Far East Asian countries were strained. What is the role of Japanese foreign relations generally in its energy policy decision making?

The specific aspects of Japanese foreign relations represented in JESSE are Japanese relations with Far East Asian countries, Japanese-U.S. security relations, openness and stability of the international economic order, U.S. support for the international economic order, and access to foreign markets for Japanese
exports. Figure 2 illustrates these categories. We argue that it is reasonable to characterize Japanese energy policy decision makers as classifying specific international incidents into at least one of these categories. Interviews with Japanese leaders together with such literature as Samuels (1987) and MITI (1985) lead us to hypothesize that such a classification scheme is consistent with Japanese leaders’ conceptualization of that decision domain.
JESSE: Function and Architecture

Above, we described a model for Japanese energy and foreign policy decision making in the domain of its energy supply security. The discussion thus far has been confined to purely political aspects. We have not yet talked about the role of information-processing mechanisms in the given decision-making instance. The model, as described thus far, makes certain commitments about the decision-making actor (Japanese political and economic elite), the choices available to this actor (anticipatory policy options), the constraints on the selection of these policy options (the Japanese foreign relations situation), and to some of the concepts in terms of which the actor analyzes an energy-related event (economically-centered concepts).

However, the political aspects of the model provide only an incomplete and inexact description of Japanese energy-related decision making. The model, as explicated thus far, does not specify, for instance,

1. how the anticipatory policies are stored, indexed, and retrieved;
2. how the constraints imposed by the Japanese foreign relations situation are accommodated in the decision making; or
3. how the economically-centered concepts are represented, organized, and used.

Moreover, the concepts, as introduced thus far in our discussion of the politics of the model, are specified by their label only (e.g., "cost"); neither the content of these concepts nor the relation between them is clear. Thus, it is not clear whether the concept of "an increase in the cost of energy due to an energy flow problem" is analyzed as a cost problem, a flow problem, or both.

In information-processing terms, while the political aspects of our model of Japanese energy-related decision making partially characterize the problem space to be explored, they do not specify how this problem space is represented and explored, what knowledge is used to explore this space, and how this knowledge is represented and organized. These issues are obviously important for providing a full account of Japanese energy-related decision making. Below, we present an information-processing model of Japanese decision making in regard to its energy supply security that seeks to address some of these issues. The model has been implemented in an experimental computer system that we call JESSE (for Japanese Energy Supply Security Expert)\(^4\) (Goel, Chandrasekaran, and Syl-

^4While the term expert fits well as part of our acronym, the rationale for our research is not building a usable expert system for policy making, although that may be a useful by-product. Instead, we seek to explore the usefulness of information-processing approaches in constructing, testing, and refining theories of political behavior.
van 1987). Note, however, that the problem space has (by and large) already been specified by the previously explicated political aspects of the model. The information-processing model embodied in JESSE accepts this politically dictated problem space as a given.

**Theory of Generic Tasks**

Our information-processing analysis of Japanese energy-related decision making is based on the theory of *Generic Tasks* (Chandrasekaran 1983, 1986, 1987). This theory recognizes that complex problem-solving tasks, such as political decision making, often are computationally very hard and expensive. An obviously important question is how boundedly rational actors can perform these complex tasks with limited information, processing time, and memory space. The theory proposes that complex tasks are often performed by decomposition into a small set of generic tasks. A generic task is a "natural kind" of information-processing task, corresponding to which is a strategy that provides a basic building block of intelligence. Classification (Gomez and Chandrasekaran 1981) and plan selection (Brown and Chandrasekaran 1989) are two examples of such generic tasks. A generic task is specified by the information it takes as input and the information it gives as output. The strategy corresponding to a generic task is characterized by the primitive types of knowledge, inference, and control needed for a computationally efficient transformation of the input to the output. Thus, if knowledge is available in the required forms, then the strategy corresponding to the generic task of classification ensures an efficient mapping of the input (a description of a specific situation) to the output (concepts that pertain to the specific situation) (Goel, Soundaranajan, and Chandrasekaran 1987).

Below, we first characterize the task of Japanese energy-related decision making and then present a functional architecture for it. The architecture uses generic tasks as the building blocks. We discuss the strategies (i.e., knowledge, inference, and control) for performing the generic tasks in the architecture in the next section.

**The Decision-Making Task**

Characterizing a specific *problem-solving task* in Japanese energy and foreign policy decision making in the domain of its energy supply security is the starting point of our analysis. We argue that a goal of the Japanese political and economic elite in the domain of Japanese energy supply security is to maintain the state of low-cost supply of imported energy commensurate to its energy needs. Often, this goal is threatened by the occurrence of certain energy-related events in the world. An important task in maintaining the goal state is deciding
on what actions to take in response to a given energy-related event. The input information for this task is a description of the Japanese energy situation following the energy-related event as well as a description of the Japanese foreign relations situation at that time. The output information is some subset of the set of anticipatory policy options stored in memory.

The task of transforming the given input information into the desired output information in Japanese energy-related decision making can be viewed as a special form of routine planning. In routine planning (Chandrasekaran et al. 1989), the problem-solving actor typically has access to partial plans that are indexed over the specifications of anticipated goals. Given an explicitly specified goal to be achieved, the actor uses the goal specifications as indices to retrieve the appropriate partial plans and then deliberately synthesizes them into an overall plan that can accomplish the goal. In the specific instance of Japanese energy-related decision making, however, the appropriate stored plans are retrieved from memory in response to specific situations, where a situation can be described in terms of certain states in the environment of the problem-solving actor. We may call this form of planning situation-reactive routine planning. In situation-reactive planning, the goal of the problem-solving actor is not explicitly represented; instead, it is implicit in the mechanism for retrieving the stored plans. Moreover, there is no deliberative synthesis of the stored plans; instead, the actor potentially can invoke each plan retrieved in response to a given situation. The stored plans in Japanese energy-related decision making, of course, are the policy options that it has prepared in anticipation of certain types of energy supply and foreign relations situations that it is likely to face.

A Functional Architecture

The next step in the construction of an information-processing model of Japanese energy-related decision making is to analyze the functional architecture for computationally efficient retrieval of stored plans from memory. In principle, it may be possible directly to index the stored plans over specific states in the decision-making actor's environment. However, since the number of relevant states that may occur in the environment is potentially very large, a direct mapping of the states onto the stored plans can be computationally very expensive (Chandrasekaran and Goel 1988). This mapping may be performed more efficiently by decomposing it into two tasks. First, the relevant states in the environment may be classified onto a small number of stored concepts, where each concept represents an equivalence class of some subset of the states. Next, these concepts may be used as indices for retrieving the plans.

5 Clearly, there are other aspects to this problem, e.g., monitoring the energy situation, executing selected actions, etc. In this paper, however, we focus on the task of deciding on appropriate actions in a given energy situation.
Now, according to our political theory of Japanese energy-related decision making, there are two kinds of states in the environment that are relevant to the decision-making task: the states that describe the Japanese energy supply situation and the states that refer to the Japanese foreign relations situation. These two different kinds of states can be classified separately into concepts that are semantically relevant to them. Thus, the states describing the Japanese energy supply situation can be classified into concepts that represent specific types of threats to its energy security. Similarly, the states that describe the Japanese foreign relations situation can be classified into concepts that represent specific types of problems in its foreign relations. Next, the threats to Japanese energy supply security and the problems in Japanese foreign relations can be further classified into indexical categories. These indices may now be used for selecting appropriate plans in storage.

This analysis leads to the functional architecture for the JESSE system shown in Figure 3. The architecture contains four modules, three of which perform the generic task of classification, while the fourth performs the generic task of plan selection.

Classification of the Japanese Energy Situation

Let us now consider the identity of the modules in the functional architecture of Figure 3 and the rationale for their content more closely.

The first classification module takes as input a description of the Japanese energy situation following an energy-related event and maps it onto hypotheses about the threats posed to Japanese energy supply security. The organization of these hypotheses* in JESSE is shown in Figure 4. The label EnergyCost in the figure refers to the hypothesis "an increase in the cost of energy." Similarly, EnergyFlow refers to the hypothesis "a reduction in the flow of energy." Note that this organizational scheme makes clear the relations between the various concepts. Thus, FlowDueToChangeInExportCapability ("a reduction in the flow of energy due to a decline in the energy export capability of some country") is a subhypothesis of EnergyFlow and a superhypothesis of CostDueToChangeInExportCapability ("an increase in the cost of energy secondary to a reduction in the flow of energy due to a decline in the export capability of some country").

A reasonable question for the reader to ask is how this content of the classification scheme, as opposed to alternative content, has been chosen. Earlier in

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*Technically, those portions of Figure 4 that are not compound in nature, such as "energy cost," are actually hypothetical scenarios rather than hypotheses. Those compound boxes, such as "FlowDueToSupplyRouteCutoff," are hypotheses, since they are relational in nature (i.e., flow is hypothesized to be due to supply route cutoff). Even the hypothetical scenarios, though, become hypotheses when taken together with arrows to other boxes. Therefore, for the sake of simplicity, we shall use the term "hypothesis" to refer to all parts of this classificatory hierarchy.
In this article, we discussed the notion of an economically centered conception of national security as playing an important role as Japanese foreign policy leaders view the world. Both the interviews with Japanese leaders that served as the basis for JESSE’s initial content and literature and observation since those interviews were conducted have convinced us of the centrality of that economic conception of national security. As a result, for example, the classification scheme contains such concepts as “flow due to supplier boycott” and “flow due to supply route cutoff,” rather than “domestic threat to military ally” or “reduction in political...
influence due to arms embargo.” Those latter concepts have often been more common in discussions of international politics than the concepts found in Figure 4 and also in Figures 2 and 5. Our political theory, in contrast, sees the specific concepts found in those figures as more appropriate for understanding Japanese foreign policy decision making. We assert, in other words, that Japanese international political behavior will be more patterned across such classes as “flow due to supplier boycott” than across such classes as “domestic threat to military ally.”

We note that CostDueToChangeInExportCapability is in the EnergyFlow branch of the tree in Figure 4 instead of the EnergyCost branch. This is because an increase in the cost of energy to Japan can occur in two ways. First, the cost of energy can increase, for instance, if some energy-exporting country decides to increase the price per unit of energy it exports to Japan. Second, the cost of energy can increase, for instance, if an energy-exporting cartel decides to reduce the amount of energy it exports. Now, deciding that the threat of increased cost is of the second kind first requires a decision that there is a threat of reduced flow. However, deciding that the cost threat is of the first kind requires no analysis of energy flow. Of course, once it has been judged that there indeed is a cost threat, then the response to it is likely to be the same irrespective of whether the threat is of the first or the second kind. For this reason, we collapse the two kinds of cost concepts in the first classification module into a single indexical category in the third classification module of JESSE.

Selection of Stored Plans

The second classification module of Figure 3 takes as input a description of the Japanese foreign relations situation and maps it onto hypotheses about various types of problems in Japanese foreign relations. We have already described the organization of these hypotheses in the previous section. What is appropriate here, though, is further explicating our rationale for why we have chosen the particular subdivisions of Japanese foreign relations that are illustrated in Figure 2. The concepts of Figure 2’s slice of the second classification module find their genesis in the type of terms often used by Japanese leaders in expressing options and classifying problems they face. Those terms and elaborations of reasoning by Japanese leaders are the basis of giving Japanese-Asian relations and Japanese-U.S. security relations greater classificatory attention than other sets of foreign relations.

The third classification module of Figure 3 takes as input the hypotheses established in the first classification module as well those established in the second classification module and maps them onto indexical categories. The organization of these indexical categories in JESSE is shown in Figure 5. The label BothEnergyAndOtherIssuesImportant refers to the index of “there is a serious threat to Japanese energy security and there is also a serious problem in Japanese
FIGURE 4
A Slice of the Classificatory Hierarchy I
foreign relations." The thesis is that Japanese response to an energy-related event depends on the relative importance of the threat that the event poses to its energy supply security and also to problems in its foreign relations. That is, Japanese response to a threat to its energy supply security varies depending on whether it faces an even more pressing foreign relations problem at that time. In the extreme case, if the energy threat is minor and not immediate while the foreign relations problem is major and current, then Japan might not devote much im-
mediate attention to the threat. This explains why OtherIssuesDominant has no subconcepts in the classification hierarchy.

The fourth module of Figure 3 takes as input the indexical categories established in the third classification module above and gives as output an appropriate subset of the set of anticipatory policy options. We have already described these anticipatory policies in the previous section (see Figure 1). Here we would like further to address two aspects of our political theory incorporated in Figure 1: why a distinction between unilateral, bilateral, and multilateral, and why these plans as opposed to others.

We see Japanese foreign policy decision makers as having prepared in advance for many contingencies. This is the basis for building into our model the notion that many plans are “stored.” The interviews on which we based the initial cut of JESSE led us to believe that many Japanese decision makers viewed options according to whether and with whom they had to deal or coordinate. The “unilateral, bilateral, multilateral” distinction follows from that feature of the initial interview responses. Plans from each of these three categories can and are at times pursued simultaneously in JESSE.

Why we chose the particular set of general plans illustrated in Figure 1 is a question with an answer similar to the question just addressed. Those initial interviews and our understanding of Japanese reasoning in the energy supply arena consistently point to many of the specific contingent options listed on the right side of Figure 1. For example, time and again Japanese elites have referred to “stockpiling energy,” “inducing technological dependence,” and “using foreign shipping.” We do not claim that we have captured all stored plans, only that there is evidence that the plans summarized on the right side of Figure 1 seem to be developed and “on the shelf” for future use by Japanese foreign policy decision makers.

**JESSE: Knowledge and Inference**

In the previous section, we presented an information-processing model of Japanese energy and foreign policy decision making in the domain of its energy supply security. Specifically, we developed a functional architecture for the JESSE system and proposed a conceptual organization for each module in JESSE’s architecture. Although the hypotheses, indices, and plans were, by and large, set by the political theory of Japanese energy-related decision making, their functional organization was based on an information-processing analysis of the decision task. In this section we discuss the representation of these concepts and the inference mechanisms and control of processing in JESSE.

**Classification of Japanese Energy Supply Situation**

Each of the hypotheses in the first classification module in JESSE is really a schema that is represented as a frame (Minsky 1975). The frame correspond-
FIGURE 6
Schema for the Hypothesis of
"Threat to Energy Flow Due to a Change in Export Capability"

**Hypothesis:** FlowDueToChangeInExportCapability
**Superhypothesis:** EnergyFlow
**Subhypotheses:** MajorChangeInExportCapability
  ImmediateChangeInExportCapability
  CostDueToChangeInExportCapability

Ask (Yes, No, Unknown);

Q1: Has there been a decline in the energy production capability of an energy-exporting country?
Q2: Has there been a decline in the energy transportation capability of an energy-exporting country?

**Rule 1:** If (Q1 = Yes) or (Q2 = Yes), then hypothesis very likely, otherwise Rule 2.
Ask (Yes, No, Unknown);

Q3: Is there likely to be a decline in the energy production capability?
Q4: Is there likely to be a decline in the energy transportation capability?

**Rule 2:** If (Q3 = Yes) or (Q4 = Yes), then hypothesis likely;
else if (Q3 = Unknown) or (Q4 = Unknown)
then hypothesis is uncertain;
otherwise hypothesis is unlikely.

**Actions:** If hypothesis is very likely or likely,
then establish hypothesis;
activate subhypotheses;
else reject hypothesis.

According to the hypothesis of FlowDueToChangeInExportCapability (i.e., reduced energy flow to Japan due to a change in the export capability of some energy-exporting country) is shown in Figure 6. The frame specifies its superhypothesis as EnergyFlow, and its subhypotheses as MajorFlowDueToChangeInExportCapability, ImmediateChangeInExportCapability, and CostDueToChangeInExportCapability.

The frame shown in Figure 6 also contains knowledge in the form of questions about the energy situation that JESSE asks of the user to decide whether the hypothesis of FlowDueToChangeInExportCapability is established as being plausible for a given energy situation. Thus, when the hypothesis of FlowDueToChangeInExportCapability is considered, JESSE asks the user about the decline in the energy production and transportation capabilities of the energy-exporting country in question.

The knowledge for combining the answers to these questions into decisions about the plausibility of the hypothesis is represented in the form of production rules (Newell 1973). Thus, the first rule in Figure 6 combines the answers to the
questions regarding decline in the production and transportation capabilities of an energy-exporting country into a plausibility value for the hypothesis that there is a threat of reduced energy flow to Japan (see the Appendix to this paper for a detailed transcript of a session in which JESSE deals with the energy situation following the Iranian revolution of 1979). Note that it is possible for the user to answer JESSE's questions with "unknown." JESSE accommodates the incompleteness of input information by choosing a lower plausibility value for the hypothesis. If the plausibility value in the hypothesis is high enough ("likely," or higher), then the hypothesis is established; if the plausibility value is in intermediate range, then the hypothesis is uncertain; otherwise the hypothesis is rejected.

Finally, the frame in Figure 6 contains control knowledge that specifies what to do if the hypothesis of FlowDueToChangeInExportCapability is established and what to do if it is not established. If the hypothesis is established, then it is refined; the hypothesis sends invocation messages to its subhypotheses and transfers the control to them. Now, the above process repeats itself at the next level in the classification hierarchy. If, however, the hypothesis is not established, then it is not refined any further. Instead, the control of processing is returned to its superhypothesis, in this example to EnergyFlow. This strategy for classification has been called establish-refine (Gomez and Chandrasekaran 1981).

Preparation of Complex Indices

The knowledge representation and inference mechanisms in the second and third classification modules of JESSE are the same as in the first classification module; each concept is represented as a frame that contains rules for combining evidence and determining plausibility values. The control of processing is also the same: establish-refine. However, the content of the representations is different in each classification module. The schema corresponding to each hypothesis in the second classification module (see Figure 2), for instance, contains knowledge that enables it to acquire relevant information about the Japanese foreign relations situation and to decide on a plausibility value for that hypothesis.

The plausibility value for each concept in JESSE is stored in a data object (a list) that is placed on a shared memory. Thus, the plausibility value of a concept in one module is accessible to other concepts in the same module, as well as to concepts in other modules. The default plausibility value for each concept is set very low (e.g., "very unlikely"). As the plausibility value of various concepts in the different modules of JESSE are determined, these values are updated. The schema corresponding to each indexical category in the third classification module contains knowledge about what concepts in the first and second classification modules are relevant to it, and how to combine their plausibility values into a confidence factor for that index. The frame representing EnergyIssueDominant in the third classification hierarchy (see Figure 5) is shown in Figure 7. It shows
that first the plausibility values of the relevant concepts in the first and second classification hierarchies are fetched from the shared memory, and then a confidence factor for the index is determined.

All three of the classification modules in JESSE have been implemented in the Conceptual Structures Representation Language (CSRL) (Bylander and Mittal 1986) on a Xerox 1108 workstation. CSRL is a high-level knowledge representation language that embodies the strategy of establish-refine. CSRL it-
self is implemented in Interlisp-D/LOOPS, where Interlisp-D is a version of the LISP language and LOOPS is an environment that supports object-oriented programming.

Selection of Stored Plans

We turn now to the issues of knowledge and control in the fourth module of the JESSE system. The control of processing that JESSE uses for the task of plan selection can be called *instantiate-expand*. First, each plan (i.e., each anticipatory policy option), starting from the top node in the hierarchy of Figure 1, uses the indices established in the third classification module to check whether it is suitable for a given energy supply and foreign relations situation. If so, the plan is instantiated (or sponsored); if not, it is rejected. Second, the sponsored plan is expanded by considering lower-level plans in the hierarchy, which repeat the process.\(^7\)

Associated with each plan sponsor is a schema that is represented in JESSE as a frame. The frame for the sponsor of the plan for *EnergyShares* (i.e., buy energy shares on the world energy stock markets) is shown in Figure 8. It specifies the plan that is being considered for suitability for a given situation. It also contains knowledge about the indexical categories in the third classification hi-

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\(^7\) Actually, the control regime for plan selection is a little more complicated than what we have described here. In certain decision-making instances, it is possible that a number of plans are sponsored for the same situation, but only one of them, the most suitable plan, is invoked. Thus the control for the task of plan selection is really sponsor-select-expand. That is, the instantiation of a plan involves two steps: first, the suitable plans are sponsored; then one of the sponsored plans is selected. However, according to our political theory of Japanese energy-related decision making, Japan typically pursues a number of different policy options in response to an energy-related event, often including contradictory policy options. Thus, for this particular decision-making instance, the instantiation of a plan involves only the sponsor step.
erarchy that are relevant for the specific plan. Finally, the frame in Figure 8 contains knowledge in the form of production rules that determine, based on the confidence factors of the indices, whether or not the plan is suited to a given situation. Thus, when the plan EnergyShares is considered for sponsorship, the confidence factors of the relevant indices are fetched from the shared data structures, and the suitability of the plan is determined. If the plan is found to be suitable, then it is sponsored, automatically instantiated, and, if possible, expanded. Note that although we have not implemented it, it is possible, at least in principle, to use the strategy of instantiate-expand to further expand the plan EnergyShares. However, this would require that additional knowledge be available for representation in the system.

The module for plan selection has been implemented in Design Specialists Planning Language (DSPL) on a Xerox 1108 workstation, as were the classification modules. DSPL is a knowledge representation language that supports\(^8\) the strategy of plan instantiation and expansion (Brown and Chandrasekaran 1986). Like CSRL, DSPL is implemented in Interlisp-D/LOOPS.

**Validation of the Model**

**Validation of JESSE**

Validating complex-information-processing models such as JESSE is fraught with methodological problems. The main problem is that the model has far too many parameters to be truly validated by any reasonable implementation. The language of classification and plan selection is almost too expressive from the viewpoint of validation, that is, there are many ways in which these languages could be used to fit the data points, and it would be difficult to argue, at this state of the implementation, that JESSE has been "validated" in the scientific sense of the term. Notice that the problem is not a logical problem but one of size. One could ask a number of questions of JESSE, about what would JESSE recommend as action in various situations. However, in order to do it in a manner really to validate JESSE, the scope of JESSE would have to be increased considerably, that is, a much larger infusion of knowledge would have to be given to JESSE. This is an expensive undertaking, possible in principle, but likely in practice only after the plausibility of models such as JESSE is demonstrated, and that, too, only for problems whose importance or significance can justify the cost of the knowledge-engineering effort.

Despite these caveats, we have worked on validating our model in several different ways.

1. We have tested our model against the outcomes of different situations that have actually occurred in the recent past. Two examples are the Iranian

\(^8\)Actually, the DSPL language supports several strategies that are useful in design problem solving. Plan instantiation and expansion is one of these strategies.
revolution (see Appendix A) and the removal of Sheik Yamani from the post of the oil and petroleum minister of Saudi Arabia. Our results show that the performance of JESSE is reasonable. By this we mean that the outcomes of JESSE are generally in line with what actually transpired. Nothing resembling "contradictory" circumstances took place. Although buoyed by such results, we should point out that building a performance system is not our major objective; we are more interested in understanding the process by which national elites arrive at policy decisions.

2. We also have tested our model on hypothetical situations. An example is a hypothetical situation in which Indonesia and Malaysia are at war, and Malaysia has threatened to close the Strait of Malacca to all international shipping. As with others who have undertaken counterfactual analysis (e.g., Thorson and Sylvan 1982), checking process validity has been our focus here.

3. We have demonstrated the system to a few domain experts. This, too, has been an attempt to check the process validity of our model. Their judgment so far has been that the energy policy decision-making process followed by JESSE is plausible.

4. We have conducted a literature survey to determine if there is some evidence that Japan actually does follow the energy decision-making process modeled by JESSE. Japanese language documents (e.g., MITI White Paper 1985) are part of this survey. Since the model itself is based upon interviews with Japanese political and economic elites, we are not checking the model against information from which we built it. Our literature "tests" suggest that Japan indeed does classify energy-related events into the types of threats that they pose to its energy supply security and does select and refine stored plans. Also, the temporal ordering of information sought by the Japanese government and business interests suggested by JESSE fits with such documents in the few cases in which information that specific is available. For example, queries about the feasibility of collective action seem to have been made only after the collection of flow and cost information. This temporal ordering is consistent with the process posited in JESSE.

While the four tests of our model described above are clearly empirical in nature, we have chosen not to undertake any quantitative statistical tests. Our reasoning is similar to that of Alker (1975) in his discussion of computational hermeneutics. We think that for empirical validation of a model such as ours, the tests that we have just described are more appropriate than statistical tests. One reason for this conviction is that our model allows for such a broad base of multiple outcomes. In other words, Japan, in our model, can undertake no actions in response to an external event, or they could undertake a dozen or more actions, simultaneously, some of which would seem contradictory. Therefore, statistical tests such as those offered by Bueno de Mesquita (1981) are inappropriate.
In the process of testing JESSE's validity through the literature survey briefly described above, we have clarified the time horizon for the applicability of the group information-processing aspect of JESSE. Writings such as Samuels (1987), Chapman (1984), and Hiragawa (1976) indicate that group information processing in Japanese energy policy is a relatively accurate characterization during World War II and from 1974 to the present, but not necessarily from 1945 through 1973. Chapman, for instance, has argued that during the 1973 oil crisis there was no evidence of the kinds of contingency plans posited by JESSE. Since the evidence during World War II and since 1974 points to a decision-making elite (with both the government and MITI as participants) that has acted as though they are guided by such plans, we see the basic group information-processing premise of JESSE as being validated by these works for those time periods. Ebinger (1984) and Goodman (1982) further substantiate this point.

Performance and Validation

JESSE is not a performance system in two senses. In one sense, following the competence/performance distinction that was originally made by Chomsky (1965), JESSE is a competence model, not a performance model. It sets out the “virtual machine” that characterizes the options and the knowledge that underlies the exploration of options, but does not make a commitment to a direct mapping between its parts and the decision-making units in the real world of Japanese energy policy decision making. It also is not a performance model in another sense; namely, it does not have sufficient knowledge represented in it to be really put to the test of seeing if its decisions correspond to the ones that were in fact made by Japan in a wide enough variety of cases. Of course, such a model would not be simply a validation of a theory, but also could be a potential source of information about future decisions by the political unit being modeled. In other domains investigators in AI have constructed systems that play precisely these multiple roles.

We earlier have discussed the knowledge-intensiveness of such a “real” model for the domain of politics. Does this mean we are permanently restricted to undervalued models that also are not practically of much use as predictors of decisions? Our answer is that domains of political decision making that have the following properties are appropriate candidates for the construction of performance models, that is, for the expenditure of energy necessary for a more complete knowledge representation:

1. The domain is of sufficient importance to be worth the investment.
2. The knowledge requirements can be circumscribed, that is, open-ended world knowledge is not called for, or the problem can be decomposed so that human problem solvers can interactively solve certain subtasks. This is more realistic in foreign policy problems when the number of relevant international actors is relatively few in number.
3. The knowledge structures and strategies are sufficiently slowly changing that, for the questions posed to the system, they can be assumed to be fixed. For example, in Japanese energy-related decision making, the standard operating procedures and plans incorporated in the bureaucratic structures, and national goals and assumptions together compose the knowledge and strategies that are modeled in JESSE. However, as a result of changing national perceptions and the evolving nature of society, the knowledge and strategies themselves may change. That, however, is not modeled by any of the processes in JESSE. In fact, few information-processing models are available that realistically explain how this sort of change takes place. Thus, given the current state of the art, building performance—or policy—systems for domains that require modeling policy and strategy changes would be unrealistic at present.

Scope Conditions on the Model

Generalizability

In discussing the issue of generalizability of our model, some of the characteristics of Japanese foreign energy policy decision making become relevant as potential sources of scope conditions for a more comprehensive information-processing theory of foreign policy decision making.

1. We argue that since World War II Japan has pursued a largely economically-centered as opposed to a largely military-centered foreign policy.
2. Japan is quite dependent on energy imports, and thus energy supply security is a major concern.
3. Japan is believed to have prepared policy options in advance for anticipated threats to its energy supply security.
4. Japan, it is argued here, adopts multiple policy options even when fewer may suffice, where each policy option represents a possible course of action.

The "substance" of our model, then, is generalizable to other decision-making domains that have characteristics similar to the four above. We hope that it will generate insights for still other domains, but it would not, of course, be able to generalize its results directly to such domains.

When considering the issue of generalizability, it is important to note that what we see as the core of the model is the way in which information is processed and is not the substance of the plans in the planning section of the model. In other words, while our vision of progress in science is not in full agreement with Lakatos (1970), we see the "hard core" of our theory as the notion and the mechanisms of information processing, not as particular plans or actions that the model predicts.

This means that in addition to generalizing the substance of our model as
described above, we believe that the idea of modeling decision making by focusing on information processing can generalize to all decision domains (with varying degrees of utility as noted earlier in this paper) and modeling group information processing can generalize to at least the domains that have these four characteristics: homogeneous elite political socialization, sacrosanct domain, limits on institutional rivalry, and evidence of prior planning.

Group Decision Making

To elaborate upon this point, we look back on our study of Japanese energy decision making and identify four salient features of that policy domain that lead to our choice of a group information-processing model. They are the political socialization of Japanese elites, the sacrosanct nature of the energy domain, the willingness to put aside institutional rivalries while making many energy decisions, and the wealth of Japanese energy plans “on the shelf.”

Elite socialization is a significant factor in Japanese foreign and energy policy decision making. We mentioned the similarity of educational backgrounds of Japanese civil servants in section 2 of this article. Generally similar foreign policy world views is hardly a surprising result. We would expect the group information-processing perspective of our model to generalize to other cultures that also exhibit relatively homogeneous decision-making elites.

The degree to which a decision domain can be accurately characterized as sacrosanct is a second criterion to use in determining whether to generalize the group information-processing aspect of JESSE. In other words, is a domain in question seen as being essential to the existence of the decision-making body or the nation-state it represents? If so, we see a greater likelihood that information processing by a group can be said to exist. An example of this prototype can be found, we argue, in Japanese energy-related foreign policy decision making. Energy supply, after all, plays a crucial role in a nation that produces virtually no energy domestically yet relies so heavily on energy for its economy and security. As a result, the energy domain is virtually sacrosanct in Japan. In other decision environments where decision makers perceive an external threat or for other reasons see themselves as maintaining an essential function of a polity, their domain, too, will be seen as sacrosanct. A unity of purpose may well pervade decision making. Information will be processed as though the group were an individual.

A third characteristic for assessing the generalizability of our group information-processing approach is that decision making in the domain in question is not subsumed by institutional or interagency rivalry. It would be a grand overstatement to characterize all Japanese decision making as exhibiting supremely efficient singlemindedness of purpose that would make serious conflict unthinkable. Nevertheless, business and government do not have a deep institutional rivalry that diminishes the possibility of acting in consort (see, e.g.,
Samuels 1987). This does not mean that the actions of decision makers in a domain being modeled as a group information processor need be consistent with each other. In fact, both the reality of Japanese decision making and our model allow for and produce quite inconsistent Japanese decisions. What it does mean, though, is that where institutional or interagency rivalry are minimized, decisions are more likely to exhibit a traceable pattern of information processing. “Pulling and hauling” of bureaucratic politics is less common in Japanese energy policy decision making than in many other nations’ foreign policy decision domains. Similarity to this circumstance is another scope condition for generalizing a group information-processing perspective.

A fourth item on our checklist for generalizing a group information-processing approach is the existence of prior planning and organization in the policy domain in question. As we have noted earlier in this article, contingency plans are quite likely to be “on the shelf” in the domain of Japanese energy decision making. In domains where such plans are common, a decision group has a common base from which to process information.

The more these four characteristics exist, the more reasonable it is to argue for a single model of information processing in the domain being examined. The core of our argument is that some domains of political decision making—including the one we address here—seem to behave as an information-processing model would predict. Some of the fundamental conflictual elements of politics have been resolved either prior or exogenously to the onset of the decision domains in question. Goals are often quite clear in this subset of decision environments, often because they include maintenance of what are perceived to be essential functions of the polity. As a result, the process of group decision making unfolds almost as though an individual were processing information. We see this notion of group information processing as more likely to generalize to decision domains that exhibit some of the four characteristics we have just discussed.

Relation to Artificial Intelligence Approaches

There is a small but growing body of literature on information-processing models of political cognition. We shall not attempt to provide here a comprehensive survey of this literature. Instead, we shall confine our attention in this section to the relation between the generic task approach and some of the other information-processing approaches to modeling political behavior. In the next section, we shall compare the information-processing model for political decision making developed in this paper to some other kinds of computational models.

Computational Linguistic Models

Computational models of politics can be broadly classified into computational linguistic models and computationally modeled theories of political deci-
sion making. The computational linguistic models are based on text interpretation and discourse analysis that map a political discourse into a set of arguments. Political science use of such models varies from attempts to understand how political terminology relates to ideology in a particular domain (Carbonell 1981) to attempts to build a parser for general use with political texts (Duffy 1988).

The computationally modeled theories of political decision making attempt to capture the problem-solving and planning activities of political actors (Thorson 1984; Mefford 1987; Sylvan 1987; Majeski and Sylvan 1987; Job, Johnson, and Selbin 1987). We believe that it is important first to have a good theory of the mechanism by which political decisions are made, that will then yield the proper set of arguments into which a political discourse may be mapped by linguistic analysis. As one can imply from this brief description, computational linguistic and political decision-making models are solving two different problems. The former begins with a political text and attempts to interpret it, while the latter attempts to express a theory of political decision making. The latter category, which includes information-processing models such as the one presented in this article, does not necessarily challenge the computational linguistic enterprise: it is simply a different activity.

Logic-based Decision Models

Symbolic logic (McCarthy 1959) offers one framework for modeling decision making. In this approach decision making is viewed as a form of theorem proving; that is, the decision-making task is couched in terms of determining the truth values of sentences in some logic such as predicate calculus. This is often done by first representing the factual knowledge of the decision maker as premises in the language of logic. The rules of deductive inference such as modus ponens are then applied on these premises to determine the truth values of other sentences expressed in the same language. This process is carried on until the truth value of the target sentence has been determined (assuming that it is possible to do so in the given logic). Gaucas and Brown (1987) have used a variation of the logic-based approach for modeling the way in which South Korea analyzes the strategic threat from North Korea.

The logic-based approach to modeling political decision making has important advantages as well as critical drawbacks. Logic offers an elegant formal language for representing the decision maker's knowledge of the world as sentences that have a well-defined semantics. However, the theorem prover itself is a syntactic manipulator of these sentences. More important, logical theory tends to view the decision maker as a rational actor who has complete information and unbounded computational resources for processing the information. Complex decision making (e.g., planning) by the technique of theorem proving is typically

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9One computational model of politics that does not fit comfortably into either of these categories is Schrodt (1987), which seeks to identify patterns within a set of events.
computationally intractable. That is, as the size of the decision problem grows from small to large, the computational resources required by the theorem prover grow very rapidly. In contrast, we subscribe to Simon's (1969, 1985) view of decision-making actors as only boundedly rational agents. Therefore, we believe that while logic provides one language for characterizing the decision maker's knowledge, it does not provide a computationally feasible mechanism for productively modeling real world decision making, except perhaps for some simple, small-scale problems.

**Rule-based Decision Models**

Production rules\(^{10}\) (Newell 1973) offer another language for the expression of theories of political decision making. In this framework the knowledge of the decision-making actor is represented as rules of the form *antecedent* → *consequent* or *condition* → *action*, where typically the antecedent is some pattern and the consequent is either some other pattern or some action. When a specific pattern of data is presented as input to a rule-based system, the rules whose antecedents match the given pattern are activated. The activation of these rules can lead to the instantiation of other patterns that in turn can activate other rules, and so on. At some point in the processing, the instantiated patterns cease to activate more rules, at which stage the system yields some patterns, or possibly some actions, as the output. Lenat, Clarkson, and Kiremidjian (1983) have used the production rule methodology for analyzing the signs, indications, and warnings of a strategic threat posed by North Korea to South Korea.

At first glance it might appear that the theory of generic tasks for modeling political decision making is similar to that of rule-based systems, since a portion of JESSE's knowledge is represented as production rules as we described earlier. In fact, there are several important differences between the two approaches:

\(^{10}\)The term "rule-based system" is often a source of confusion because of somewhat different usages in different disciplines. In the philosophical and cognitive science literature, rule-based is meant to refer to systems that have an explicit representation of knowledge and to contrast them with systems that have the knowledge encoded implicitly, for example, as weights in a threshold network. There is, for example, an ongoing debate in cognitive science about whether knowledge of language is ever abstracted into a grammatical rule that is then available as an abstract piece of knowledge during parsing or whether the knowledge is only implicit. Explicit representation of knowledge in this sense of "rule based" is equivalent to the system being viewed as an algorithm operating on discrete symbol structures. Because of the mathematical system known as Post production systems, which are systems of rule interpreters and which are known to be universal languages in which to represent algorithms, the equivalence between algorithmic systems and rule-based systems in this sense is straightforward. However, in computer science and AI, the term rule based is used to refer to a specific architecture (Newell 1973; Feigenbaum 1977) for building knowledge-based expert systems. This architecture consists of a knowledge base of rules and an inference engine. Here the specific additional assumption often is that the rules in the knowledge base are associational or heuristic. This sense of rule-based systems is meant to be contrasted with other approaches to knowledge representation such as frames or logical formulas, and also with approaches that emphasize the use of models. In this paper we use the term rule-based systems in the AI sense.
First, our analysis of Japanese energy-related decision making is at the level of the generic information processing tasks it performs. This analysis leads to a functional architecture for the JESSE system in which the decision-making actor is viewed as classifying the Japanese energy supply and foreign relations situation at one stage, preparing complex indices at another, and selecting plans at yet another stage of the processing. Since the language of production rules is at a lower level of abstraction altogether, it does not offer any constructs for capturing these task-level distinctions.

Second, the knowledge in JESSE is organized around concepts that are represented as frames. The concepts themselves are organized in hierarchies. This leads to a more “molecular” form of knowledge representation and information processing. Rule-based systems, in contrast, have a more “atomic” representation of knowledge.

Third, the semantics of the concepts is different in the various modules of JESSE: the concepts are hypotheses in the first and second classification modules, indexical categories in the third classification module, and plans in the fourth module. Again, the language of production rules offers no primitives to capture these semantic differences at the conceptual level.

Fourth, the generic task framework explicitly specifies the abstract control of processing for each generic task. For instance, the abstract control structure is establish-refine for the classification task and instantiate-expand for the task of plan selection. In contrast, in rule-based systems, the higher-level control is implicitly embodied in a control formalism at a lower level of abstraction. The latter formalism is, additionally, uniform across tasks.

Finally, the generic task methodology enables more efficient processing, easier knowledge acquisition, and more perspicuous explanation of knowledge and processing; Chandrasekaran (1987) provides a more detailed discussion of these issues.

Of course, it is possible to implement JESSE as a rule-based system. The point, however, is that the theory of generic tasks offers a higher-level vocabulary that allows the political theorist to capture certain functional and conceptual distinctions that might remain opaque in the language of production rules.

Case-based Decision Models

Case-based reasoning (Schank and Abelson 1977; Schank 1982) offers a different approach to modeling decision making. In this approach, decision-making instances are stored in memory as cases. When the decision-making actor is faced with a new decision-making situation, the case(s) that best match the description of the situation are retrieved from memory. The actor’s response to the new situation is derived by analogy with the previously encountered situations. Mefford (1987) suggests how case-based reasoning can be used for modeling certain types of political decision making.
Case-based reasoning offers a computationally attractive alternative to approaches that emphasize reasoning from "first principles" for every new decision-making situation. We are in general agreement with this approach to modeling political decision making. However, we would like to argue that cognitive agents store their experiential knowledge not only in the form of cases in memory but also as more abstract compiled knowledge. That is, often they operationalize and optimize their experiential knowledge for use in performing specific tasks in specific domains. They do so because it is typically computationally more efficient to use knowledge in compiled form whenever it is available and applicable. We are, of course, not suggesting that all knowledge is stored in compiled structures, or that knowledge gets used only in compiled form. We only suggest that if the knowledge needed to perform specific tasks in specific domains is available in compiled form, it is computationally more efficient to use it in that form. Of course, if the required knowledge is not available in compiled form, then other forms of knowledge and types of reasoning (e.g., case-based reasoning) can be used. In reality, most real world examples of reasoning by cognitive agents include a combination of both case-based reasoning and reasoning with compiled and abstracted knowledge structures.

In the JESSE system, the compiled structures are the concepts, the indices, and the plans stored in memory. When JESSE encounters a new decision-making situation, it classifies the description of the situation, establishes appropriate indices, and instantiates the stored plans that are suitable to the situation. We do not see this approach to modeling decision making as inconsistent or incompatible with that of case-based reasoning. While JESSE is not a case-based reasoner, it would be very interesting and useful to investigate how knowledge is compiled from individual cases into the kind of structures present in JESSE.

**Comparison with Other Formal Models of Political Behavior**

*Global Models*

Since the early 1970s a number of *global* political and economic models have been developed (Meadows, Richardson, and Bruckman 1982; Bremer

"Compilation is another term that is afflicted with multiple meanings. The sense in which we use the term can be clarified by a simple example. Consider a slice of knowledge in JESSE such as "Energy flow problems can result from supply route cutoff, supplier boycott, or changes in export capability or policy." This knowledge could have come about in a number of ways. There may have been a number of past cases corresponding to each of the above types of flow problems. Abstracting from these cases might result in the knowledge mentioned. Another way in which this knowledge could have come about is by an analysis of the underlying world model of energy supply, the agents, the routes, and so forth. In either case, the knowledge slice described is compiled from other types of knowledge and has a specific role to play in the classificatory problem solving that was described earlier."
In this approach political and economic variables of interest are identified, and a formal model of the relationship between variables of interest is hypothesized, typically in the form of continuous dynamical systems. The model is, as a rule, very complex because of the number of variables involved; computer simulation is often the only way to determine the actual behavior of such systems. Such a simulation can often point to interesting behavioral regions of the variables. Especially if these regions persist under a wide variety of assumptions about input variables, then an understanding about the stability of systems can be obtained by this methodology. The goals of this class of models are rather different from that of our work. They do not seek to understand the process by which decisions are made, but rather to predict the long-term values of important variables. The work reported in this paper, however, is concerned with the information-processing mechanisms of political decision making.

Domain-specific Models

The work presented in this article has much in common with earlier works by Hayward Alker and a number of his students at MIT (see, e.g., Bennett and Alker 1977; Tanaka 1984). Those models attempted to capture the way in which nations (or national elites or decision makers) view the elements of their decision environment. In other words, they model the perceived relationship between nations and foreign policy circumstances that could affect the modeled nation's decisions. This work can be thought of as providing a content theory of decision and perception spaces in specific political situations. In order to build JESSE-like systems, such content theories need to be constructed as well. The classificatory hierarchy in JESSE, for example, itself is a content theory of how energy-related situations are perceived and analyzed, and the plans similarly describe the decision space. However, information-processing theories go further. For example, the set of building blocks used in JESSE allows us to model more systematically an actor's understanding of a problem and the mechanisms that actually produce the decisions.

Bureaucratic Politics "Model"

Allison (1971) describes behaviors of individual bureaucrats and foreign policy organizations and argues that they influence foreign policy. Again, the information-processing approach complements the role of these mechanisms. Decisions in politics arise as a result of interaction between political and organizational mechanisms—some of which are described by Allison—and information-processing mechanisms. Allison's theory can be completed by the addition of a component that deals with foreign policy decision making. The

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12 The term global model is offered by Ward and Guetzkow (1979) and others to describe this category of research products.
information-processing constructs such as those used in JESSE could provide the language in which to describe the decision-making component. Such a computational modeling exercise would clarify both our differences and similarities. The particular subject of our model (the Japanese foreign energy policy elite) processes information quite differently from Allison’s bureaucrats.

Cybernetic “Model”

Steinbruner (1974) introduced a “cybernetic” paradigm. His work is largely compatible with most of the notions of information processing. However, Steinbruner offered more of a catalog of variables that influence decisions, while our work attempts to incorporate those and other variables in a specific model. We are trying to move beyond a catalog to an applied theory of specifically how such variables interact to produce decisions in a particular domain.

Operational Code

Operational code is a term popularized in political science by Leites (1951), George (1969), and Holsti (1970). This approach categorizes individual political leaders in terms of the principles and the perceptions that seem to guide their decision making. If one were fully to draw out the implications of an individual’s operational code (i.e., “Now that we’ve filled out this coding form, what does the overall pattern mean for how the leader will reason through a particular situation?”), one could represent such a theory in information-processing terms. One could also represent the theory at a “deeper” level of abstraction (i.e., dealing more with cognitive structure than cognitive content) than does an operational code approach.

In summary then, while the substance of JESSE may differ in content from some of the above-cited works, we argue that Allison, Steinbruner, and operational code approaches all could benefit from using the language of information processing.

Political Decision Making and Problem Solving

Political Content in the Information-Processing Model

What does the information-processing model that is JESSE have to do with the political part of Japanese energy-related decision making? That is, where is the “politics” in it? What proposals, even tentative ones, are possible after the experiment reported in this article?

The politics in the theory occur at two levels. First, the knowledge structures and the problem spaces—the classification hierarchies, the plans—have political content. That is, the language of classification and plan selection provides some of the constructs to describe the options and the knowledge in this political decision-making problem. Thus, any proposal in this language, including the one realized in JESSE, implicitly provides a theory about how the
problem-solving mechanisms, internal politics, and international politics come together both to create and to delimit the options. The information-processing language provides a level of precision for the description of the options and strategies of coping with the problem. The proposal may then be critiqued on these terms. Alternative theories with different classification hierarchies, or plans with different political content may be proposed to characterize the politics of the situation. Additional problem-solving mechanisms may also be proposed; for instance, Japan's response to a given situation is really better explained by its institutional memory of a similar previous event and its consequences, the so-called case-based reasoning paradigm. Such proposals can and have been evaluated on the basis of evidence about the knowledge needed and the intermediate steps in the problem-solving process called for by the theory.

The second level at which the theory has political content is the degree to which the proposed model uses problem-solving mechanisms to the exclusion of the political mechanisms. (The reader is reminded of our discussion in section 1 about how the political decision-making process is an interaction of purely political mechanisms with the problem-solving mechanisms of the groups and individuals composing the political unit.) In fact, we chose the Japanese energy policy as the domain precisely because of our intuition that this may be a decision-making instance where the problem-solving components dominate the process. A statement is being made that in this case Japan has so “rationalized” its decision making that politics at best provides constraints for the space of alternatives (e.g., plans) and knowledge structures (e.g., plan schemas), but does not enter in the form of political mechanisms. That is, goals and available options are politically set, but once they are given, the process is largely one of problem solving, rather than one of political pushes and pulls.

Alternative models at this level may propose a collection of actors (e.g., interest groups). Each of the actors is a problem-solving entity and could be modeled using JESSE-like constructs, but the interaction of the actors is modeled by political mechanisms. While some of these mechanisms can have information-processing components, such as negotiation, they are largely modeled in other languages that have the expressiveness for the pushes and pulls of political accommodations. The attractiveness of the family of approaches embodied in this paper arises from the new methodological possibilities that they offer.

Competence Models and Explanatory Power

The model presented here is not a process model focused on an individual political actor. It is a model of group information processing. One way of converting JESSE into a performance or policy model of group information processing would be to discover a one-to-one correspondence between parts of the classification and planning structures, on the one hand, and parts of Japanese energy
policy-making organizations. While such a study has not been undertaken and it is possible that some partial correspondences could be found, JESSE has not been developed with the goal of providing such a performance or policy model.

JESSE is really more in the realm of a competence model of the decision-making process as a whole, that is, it proposes a virtual space of alternatives, the kinds of knowledge that are considered to be available, and so on. The specific knowledge structures proposed incorporate the political content of the theory. One might say that the interaction of political and information-processing mechanisms that we described earlier has resulted in the proposed set of problem spaces and knowledge structures.

Broadly speaking, the explanatory power of information-processing models can lie in a spectrum roughly marked by the following possibilities:

1. The situation determines the options. With minimal assumptions about rationality of the actors, one can determine what choices will be made from a knowledge of the problem faced by the actor. An example in individual human psychology is that of the problem of multiplying two numbers: the identification of the multiplicands pretty much determines what answer will be given by most people. No theory of information processing of the individual is necessary for it, even though such theories may have their intrinsic psychological interest. Following this example, one might say that the energy-related event, the objective world situation, and Japan's needs to a great degree determine the possible actions and options and also the final choices. No account of politics or detailed information-processing analysis is needed. This option seems unlikely in the Japanese energy policy case for the same reason that we argued against relying solely on a Marxian explanation earlier: there are many behavioral features for which such an explanation cannot account.

2. A variation on the above where the political dynamics of Japan and the international situation together with the objective reality of the world situation and the energy-related event determine the options and the decisions. Politics, yes, but information-processing accounts add no exploratory power. Even neorealists are beginning to doubt the validity of this option in many cases, especially where "objective reality" becomes more elusive and less identifiable.

3. Information processing imparts its own flavor to the options as conceived and the final decision in political decision making. For example, one might be able to argue that no complex politically charged problem is rationally solved de novo as in the multiplication example. JESSE-like models not only reflect political realities, but without understanding concepts such as schemas and stored plans that specifically arise from information-processing considerations, a complete account of decision making cannot be given. These constructs explain how, at least in the short term, the responses of political units tend to be suboptimal even given the goals and the political constraints. While JESSE does not include case-based reasoning, one might be able to use the notion that many units arrive
at the decisions that they do because these decisions are driven by past experience in certain limited ways.

The problem of choosing definitively among the above three possibilities for modeling political decision making in general, and for Japanese energy-related decision making in particular, is really another variant of the validation problem. We have offered arguments for at least the plausibility of the third scenario in many politically interesting cases, including Japanese energy-related decision making. We, therefore, view experiments such as JESSE to be the needed precursors for larger efforts. They help explore the potential of the information-processing methodology and offer the possibility of expanding our understanding of what is termed "political decision making."

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APPENDIX A
A Session with JESSE

Below, we present an annotated transcript of a session with the JESSE system. In this session JESSE deals with the energy situation following the Iranian revolution of 1979. The transcript specifies in detail the information that JESSE acquired as input as well as the information it yielded as output for this particular decision-making instance. It also shows how JESSE transformed the given input information into its output.

For the sake of clarity and brevity, we present here only a simplified and abridged English-language version of the actual transcript. In the following, JESSE’s queries for the purpose of acquiring information about the situation at hand begin with JESSE, the responses to these queries begin with A.G., and our explanations of the proceedings begin with Comment. The messages that various knowledge sources in JESSE sent to another in the course of JESSE’s decision making are prefaced by their numerical order.

1. Classification of Japanese Energy Supply Situation

JESSE: Has there been an occurrence of an event that may concern the energy supply security of Japan?
A.G.: Yes.
JESSE: Is there an energy shortage in the world energy markets at present?
A.G.: Yes.

1. From EnergyImport
To EnergyImportCost: Establish and refine

JESSE: Has an energy-exporting country increased the price per unit of energy that it exports?
A.G.: No.

1A.G. Stands for one of the authors.
11See Figure 4 for the classification hierarchy. Also, see Figure 6 for the schema for FlowDueToChangeInExportCapability.
JESSE: Is an exporting country likely to increase the price per unit of energy that it exports?
Comment: The answers to JESSE's queries need not be merely yes or no. If the required information is not available, then it is possible to answer a query with "unknown." Of course, this incompleteness of information may cause a local uncertainty in JESSE's decisions.

I(2). From EnergyImportCost
To EnergyImport: Rejected

I(3). From EnergyImport
To EnergyImportFlow: Establish and refine

Comment: Since the concept of EnergyImportCost has been rejected as relevant to the situation at hand (i.e., the hypothesis that the cost of imported energy will increase has not been found to be plausible), all of its subconcepts are rejected as well, and the control is returned to its superconcept.

JESSE: Can the energy-related event affect the flow of energy to Japan?
A.G.: Yes.

I(4). From EnergyImportFlow
To FlowDueToChangeInExportPolicy: Establish and refine

JESSE: Has an energy-exporting country reduced the volume of its energy exports?
A.G.: No.

JESSE: Is an energy-exporting country likely to reduce its energy exports?

I(5). From FlowDueToChangeInExportPolicy
To EnergyImportFlow: Rejected

I(6). From EnergyImportFlow
To FlowDueToSupplyBoycott: Establish and refine

JESSE: Has an energy-exporting country imposed an energy boycott on Japan?
A.G.: No.

JESSE: Is an energy-exporting country likely to impose an energy boycott on Japan?
A.G.: No.

I(7). From FlowDueToSupplyBoycott
To EnergyImportFlow: Rejected

I(8). From EnergyImportFlow
To FlowDueToSupplyRouteCutoff: Establish and refine

JESSE: Has some country blocked a passage through which the energy exports of at least one country pass?
A.G.: No.

JESSE: Is some country likely to try to block a passage through which the energy exports of at least one country pass?
A.G.: No.

I(9). From FlowDueToSupplyRouteCutoff
To EnergyImportFlow: Rejected

I(10). From EnergyImportFlow
To FlowDueToChangeInExportCapability: Establish and refine
JESSE: Has there been a decline in the energy production capability of an energy-exporting country?
A.G.: Yes.

JESSE: Has there been a decline in the energy transportation capability of an energy-exporting country?
A.G.: Yes.

I(11). From FlowDueToChangeInExportCapability
To MajorChangeInExportCapability: Establish and refine

JESSE: Does Japan import a significant portion of its total energy imports from this country?
A.G.: Yes.

JESSE: Has the energy export capability of this country declined significantly?

I(12). From MajorChangeInExportCapability
To FlowDueToChangeInExportCapability: Uncertain

I(13). From FlowDueToChangeInExportCapability
To ImmediateChangeInExportCapability: Establish and refine

I(14). From ImmediateChangeInExportCapability
To FlowDueToChangeInExportCapability: Established

I(15). From FlowDueToChangeInExportCapability
To CostDueToChangeInExportCapability: Establish and refine

Comment: Note that processes corresponding to the concepts of MajorChangeInExportCapability
and the ImmediateChangeInExportCapability arrived at their conclusions without requesting
any additional information. This can happen because, in JESSE's classification scheme, the
process corresponding to a concept reaches its conclusions in the context of its superconcepts.
Often, this contextual information is sufficient to reach a conclusion.

JESSE: Will some other energy-exporting country (or countries) increase its energy exports?

JESSE: Are the energy exports of this country a significant portion of world's total energy trade?
A.G.: Yes.

I(16). From CostDueToChangeInExportCapability
To MajorCostDueToChangeInExportCapability: Establish and refine

I(17). From MajorCostDueToChangeInExportCapability
To CostDueToChangeInExportCapability: Established

I(18). From CostDueToChangeInExportCapability
To ImmediateCostDueToChangeInExportCapability: Establish

I(19). From ImmediateCostDueToChangeInExportCapability
To CostDueToChangeInExportCapability: Established

I(20). From CostDueToChangeInExportCapability
To FlowDueToChangeInExportCapability: Established

I(21). From FlowDueToChangeInExportCapability
To EnergyImportFlow: Established

I(22). From EnergyImportFlow
To EnergyImport: Established
Comment: At this point, the first classification module has finished its work. At this stage in its processing, JESSE has established the hypotheses of EnergyImport, EnergyImportFlow, FlowDueToChangeInExportCapability, CostDueToChangeInExportCapability, MajorCostDueToChangeInExportCapability, and ImmediateCostDueToChangeInExportCapacity (and rejected all others).

2. Classification of Japanese Foreign Relations Situation

JESSE: Is there a problem in Japanese foreign relations?
A.G.: Yes.

II(1). From ForeignRelations
To JapaneseAsianRelations: Establish and refine

JESSE: Is there a problem in Japanese relations with an East or Southeast Asian country?
A.G.: Yes.

II(2). From JapaneseAsianRelations
To CurrentProblemInJapaneseAsianRelations: Establish and refine

JESSE: Is the problem in Japanese relations with an East or Southeast Asian country a current problem?
A.G.: Yes.
Comment: This query by JESSE contrasts a current problem with a potential one.

II(3). From CurrentProblemInJapaneseAsianRelations
To JapaneseAsianRelations: Established

Comment: Since JapaneseAsianRelations has been established (i.e., the hypothesis that there is a problem in Japanese foreign relations with some East or Southeast Asian country has been found to be plausible), the hypothesis will now be refined.

II(4). From JapaneseAsianRelations
To MajorProblemInJapaneseAsianRelations: Establish and refine

JESSE: Is the problem in Japanese relations with an East or Southeast Asian country a major problem?
A.G.: No.

II(5). From MajorProblemInJapaneseAsianRelations
To JapaneseAsianRelations: Rejected

II(6). From JapaneseAsianRelations
To ForeignRelations: Established

II(7). From ForeignRelations
To JapaneseUSRelations: Establish and refine

JESSE: Is there a problem in Japanese security relations with USA?
A.G.: No.

II(8). From JapaneseUSRelations
To ForeignRelations: Rejected

See Figure 2 for the classification hierarchy.
II(9). From ForeignRelations
To InternationalEconomicOrder: Establish and refine

JESSE: Is there a problem with the openness and stability of the international economic order?
A.G.: No.

II(10). From InternationalEconomicOrder
To ForeignRelations: Rejected

II(11). From ForeignRelations
To USSupportOfEconomicOrder: Establish and refine

JESSE: Is USA strongly supportive of the international economic order?
A.G.: Yes.

II(12). From USSupportOfEconomicOrder
To ForeignRelations: Rejected

II(13). From ForeignRelations
To ForeignMarketsForExports: Establish and refine

JESSE: Is there a problem with easy access to foreign markets for Japanese exports?
A.G.: Yes.

II(14). From ForeignMarketsForExports
To CurrentProblemInExports: Establish and refine

JESSE: Is the problem in access to foreign markets for Japanese exports a current problem?
A.G.: Yes.

II(15). From CurrentProblemInExports
To ForeignMarketsForExports: Established

II(16). From ForeignMarketsForExports
To MajorProblemInExports: Establish and refine

JESSE: Is the problem in access to foreign markets for Japanese exports a major problem?
A.G.: No.

II(17). From MajorProblemInExports
To ForeignMarketsForExports: Rejected

II(18). From ForeignMarketsForExports
To ForeignRelations: Established

Comment: At this point, the second classification module has finished its work. At this stage of processing, JESSE has established the hypotheses of ForeignRelations, JapaneseAsianRelations, CurrentProblemInJapaneseAsianRelations, ForeignMarketsForJapaneseExports, and CurrentProblemInExports (and rejected all others).

3. Preparation of Complex Indices

III(1). From EnergyIssuePresent
To NeitherEnergyNorOtherIssuesImportant: Establish and refine

^6See Figure 5 for the classification hierarchy. Also see Figure 7 for the schema for EnergyIssueDominant.
III(2). From \textit{NeitherEnergyNorOtherIssuesImportant} \\
To \textit{EnergyIssuePresent}: Rejected

Comment: The third classification module does not acquire any new information. Instead, it reads in its input from the shared data structures that contain the results of the first two classification modules.

III(3). From \textit{EnergyIssuePresent} \\
To \textit{OtherIssuesDominant}: Establish and refine

III(4). From \textit{OtherIssuesDominant} \\
To \textit{EnergyIssuePresent}: Rejected

III(5). From \textit{EnergyIssuePresent} \\
To \textit{BothEnergyAndOtherIssuesImportant}: Establish and refine

III(6). From \textit{BothEnergyAndOtherIssuesImportant} \\
To \textit{EnergyIssuePresent}: Rejected

III(7). From \textit{EnergyIssuePresent} \\
To \textit{EnergyIssuesDominant}: Establish and refine

III(8). From \textit{EnergyCostIssueDominant} \\
To \textit{MajorCostIssueDominant}: Establish and refine

Comment: The indexical category of \textit{EnergyCostIssueDominant} has been established; it will now be refined.

III(9). From \textit{MajorCostIssueDominant} \\
To \textit{EnergyCostIssueDominant}: Established

III(10). From \textit{EnergyCostIssueDominant} \\
To \textit{ImmediateCostIssueDominant}: Establish

III(11). From \textit{ImmediateCostIssueDominant} \\
To \textit{EnergyCostIssueDominant}: Established

III(12). From \textit{EnergyCostIssueDominant} \\
To \textit{EnergyIssueDominant}: Established

III(13). From \textit{EnergyIssueDominant} \\
To \textit{EnergyFlowIssueDominant}: Establish and refine

III(14). From \textit{EnergyFlowIssueDominant} \\
To \textit{MajorEnergyFlowIssueDominant}: Establish

III(15). From \textit{MajorEnergyFlowIssueDominant} \\
To \textit{EnergyFlowIssueDominant}: Uncertain

III(16). From \textit{EnergyFlowIssueDominant} \\
To \textit{ImmediateEnergyIssueDominant}: Establish

III(17). From \textit{ImmediateEnergyIssueDominant} \\
To \textit{EnergyFlowIssueDominant}: Established

III(18). From \textit{EnergyFlowIssueDominant} \\
To \textit{EnergyIssueDominant}: Established
III(19). From EnergyIssueDominant
To EnergyIssuePresent: Established

Comment: At this point the third classification module has finished its work. At this stage of processing, JESSE has established the concepts of EnergyIssuePresent, EnergyIssueDominant, EnergyCostIssueDominant, MajorEnergyCostIssueDominant, ImmediateEnergyCostIssueDominant, EnergyFlowIssueDominant, and ImmediateEnergyFlowIssueDominant.

4. Selection of Stored Plans\footnote{See Figure 1 for the hierarchy of stored plans (policy options). Also, see Figure 8 for the schema corresponding to the sponsor of the plan \textit{BuyEnergyShares}.}

IV(1). From AnticipatoryPolicy
To AnticipatoryPolicySponsor: Instantiate

Comment: As we described in section 4, the JESSE system uses the strategy of instantiation and expansion for the task of plan selection. In general, instantiation of a plan may involve two steps: sponsorship and selection. First, the sponsor corresponding to a plan decides whether the plan is applicable for a given situation, and then a selector selects a specific plan from the sponsored plans and instantiates it. In the implementation of JESSE, however, the selector plays no effective role; each sponsored plan is instantiated, since, according to the political theory of Japanese energy-related decision making, Japan pursues multiple policy options in any given situation. For this reason, in the following, we suppress the activities of the plan selectors.

IV(2). From AnticipatoryPolicySponsor
To AnticipatoryPolicy: Instantiated

IV(3). From AnticipatoryPolicy
To UnilateralAdjustments: Instantiate and expand

Comment: Since the policy option of UnilateralAdjustments has been instantiated, it will now be expanded. Note that the module for plan selection does not acquire new information. Instead, it reads, from the shared data structures, the confidence factors of the complex indices established by the third classification module.

IV(4). From UnilateralAdjustments
To UnilateralAdjustmentsSponsor: Instantiate

IV(5). From UnilateralAdjustmentsSponsor
To UnilateralAdjustments: Instantiated

IV(6). From UnilateralAdjustments
To StockpileEnergy: Instantiate and expand

IV(7). From StockpileEnergy
To StockpileEnergySponsor: Instantiate

IV(8). From StockpileEnergySponsor
To StockpileEnergy: Instantiated

IV(9). From StockpileEnergy
To UnilateralAdjustments: Instantiated
IV(10). From UnilateralAdjustments
To ReduceEnergyDemand: Instantiate and expand

IV(11). From ReduceEnergyDemand
To ReduceEnergyDemandSponsor: Instantiate

IV(12). From ReduceEnergyDemandSponsor
To ReduceEnergyDemand: Instantiated

IV(13). From ReduceEnergyDemand
To UnilateralAdjustments: Instantiated

IV(14). From UnilateralAdjustments
To ImproveEnergyEfficiency: Instantiate and expand

IV(15). From ImproveEnergyEfficiency
To ImproveEnergyEfficiencySponsor: Instantiate

IV(16). From ImproveEnergyEfficiencySponsor
To ImproveEnergyEfficiency: Instantiated

IV(17). From ImproveEnergyEfficiency
To UnilateralAdjustments: Instantiated

IV(18). From UnilateralAdjustments
To DevelopRenewableResources: Instantiate and expand

IV(19). From DevelopRenewableResources
To DevelopRenewableResourcesSponsor: Instantiate

IV(20). From DevelopRenewableResourcesSponsor
To DevelopRenewableResources: Instantiated

IV(21). From DevelopRenewableResources
To UnilateralAdjustments: Instantiated

IV(22). From UnilateralAdjustments
To SubsidizeDepletableResources: Instantiate and expand

Comment: SubsidizeDepletableResources stands for the plan for subsidizing the production of indigenous depletable energy resources.

IV(22). From SubsidizeDepletableResources
To SubsidizeDepletableResourcesSponsor: Instantiate

IV(23). From SubsidizeDepletableResourcesSponsor
To SubsidizeDepletableResources: Instantiated

IV(24). From SubsidizeDepletableResources
To UnilateralAdjustments: Instantiated

IV(25). From UnilateralAdjustments
To BuyEnergyShares: Instantiate and expand

IV(26). From BuyEnergyShares
To BuyEnergySharesSponsor: Instantiate
IV(27). From BuyEnergySharesSponsor
To BuyEnergyShares: Instantiated

IV(28). From BuyEnergyShares
To UnilateralAdjustments: Instantiate and expand

IV(29). From UnilateralAdjustments
To AnticipatoryPolicy: Instantiated

IV(30). From AnticipatoryPolicy
To BilateralRelations: Instantiate and expand

IV(31). From BilateralRelations
To BilateralRelationsSponsor: Instantiate

IV(32). From BilateralRelationsSponsor
To BilateralRelations: Instantiated

IV(33). From BilateralRelations
To PurchaseEnergyElsewhere: Instantiate and expand

IV(34). From PurchaseEnergyElsewhere
To PurchaseEnergyElsewhereSponsor: Instantiate

IV(35). From PurchaseEnergyElsewhereSponsor
To PurchaseEnergyElsewhere: Instantiated

IV(36). From PurchaseEnergyElsewhere
To BilateralRelations: Instantiated

IV(37). From BilateralRelations
To InduceTechnologicalDependence: Instantiate and expand

IV(38). From InduceTechnologicalDependence
To InduceTechnologicalDependenceSponsor: Instantiate

IV(39). From InduceTechnologicalDependenceSponsor
To InduceTechnologicalDependence: Instantiated

IV(40). From InduceTechnologicalDependence
To BilateralRelations: Instantiated

IV(41). From BilateralRelations
To AvoidAlliances: Instantiate and expand

IV(42). From AvoidAlliances
To AvoidAlliancesSponsor: Instantiate

IV(43). From AvoidAlliancesSponsor
To AvoidAlliances: Instantiated

IV(44). From AvoidAlliances
To BilateralRelations: Instantiated

IV(45). From BilateralRelations
To EncourageUSAction: Instantiate and expand
IV(46). From EncourageUSAAction
   To EncourageUSAActionSponsor: Instantiate

IV(47). From EncourageUSAAction
   To EncourageUSAAction: Instantiated

IV(48). From EncourageUSAAction
   To BilateralRelations: Instantiated

IV(49). From BilateralRelations
   To AnticipatoryPolicy: Instantiated

IV(50). From AnticipatoryPolicy
   To MultilateralManagement: Instantiate and expand

IV(51). From MultilateralManagement
   To MultilateralManagementSponsor: Instantiate

IV(52). From MultilateralManagementSponsor
   To MultilateralManagement: Instantiated

IV(53). From MultilateralManagement
   To BolsterReliableExporters: Instantiate and expand

IV(54). From BolsterReliableExporters
   To BolsterReliableExportersSponsor: Instantiate

IV(55). From BolsterReliableExportersSponsor
   To BolsterReliableExporters: Instantiated

IV(56). From BolsterReliableExporters
   To MultilateralManagement: Instantiated

IV(57). From MultilateralManagement
   To SupportCollectiveAction: Instantiate and expand

IV(58). From SupportCollectiveAction
   To SupportCollectiveActionSponsor: Instantiate

IV(59). From SupportCollectiveActionSponsor
   To SupportCollectiveAction: Rejected

IV(60). From SupportCollectiveAction
   To MultilateralManagement: Rejected

IV(61). From MultilateralManagement
   To UseForeignShipping: Instantiate and expand

IV(62). From UseForeignShipping
   To UseForeignShippingSponsor: Instantiate

IV(63). From UseForeignShippingSponsor
   To UseForeignShipping: Rejected

IV(64). From UseForeignShipping
   To MultilateralManagement: Rejected
IV(65). From MultilateralManagement
To SupportConsumerCartel: Instantiate and expand

IV(66). From SupportConsumerCartel
To SupportConsumerCartelSponsor: Instantiate

IV(67). From SupportConsumerCartelSponsor
To SupportConsumerCartel: Rejected

IV(68). From SupportConsumerCartel
To MultilateralManagement: Rejected

IV(69). From MultilateralManagement
To FundInternationalR&D: Instantiate and expand

IV(70). From FundInternationalR&D
To FundInternationalR&DSponsor: Instantiate

IV(71). From FundInternationalR&DSponsor
To FundInternationalR&D: Instantiated

IV(72). From FundInternationalR&D
To MultilateralManagement: Instantiated

IV(73). From MultilateralManagement
To AnticipatoryPolicy: Instantiated

Comment: At this stage, the JESSE system has finished its processing. For the given Japanese energy supply and foreign relation situation, JESSE decides to invoke the policy options instantiated by the plan selection module.

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